ADAPTATION TO CLIMATE CHANGE AND COASTAL GOVERNANCE IN URUGUAY

Mónica Gómez Erache

ECOPLATA PROGRAMME

September 2009

3 September 2009

0 REPORT ON COASTAL AREA

ADAPTATION TO CLIMATE CHANGE AND COASTAL GOVERNANCE IN URUGUAY

Mónica Gómez Erache
EcoPlata Coordinator

CONTENTS

I. A Diagnosis focused on Adaptation to Climate Change

I.1. Global Climate Change and threats to coastal areas throughout the world

There is scientific consensus at present regarding the fact that the increase in the atmosphere of greenhouse gases leads to an increase in the temperature of the air and the sea. The most immediate and significant consequences of climate change for the world's coasts include coastal erosion, variations in the volume of water levels, saltwater intrusion and ecosystem alterations (Table 1). During the 20th century the increase of the mean sea level (MSL) contributed to the increase of flooding, erosion and the loss of ecosystems (IPCC 2007). Table 1 lists the impact, principal processes expected and trends projected at a global level which may affect the coastal areas of Uruguay.

Table 1. Summary of climate change observations and trends in the world's coastal areas. Adapted from IPCC 2007.

COASTAL IMPACT	PRINCIPAL PROCESSES EXPECTED	PROJECTED TRENDS
Increase of Mean Sea Level	In the 20th century the mean sea level reached a rate of increase of 1.7 -1.8mm per year $^{-1}$ In the last decade the average rate worldwide was 30mm a year $^{-1}$ An increase of coastal erosion is observed all over the world.	By the end of the century an increase of 0.6 mm is expected, which could be even greater due to the melting of glaciers. Flooding in coastal areas could increase tenfold or more in the 2080s, affecting more than 100 million people a year, especially in Southeast Asia.
Change of the mean temperature of the ocean	Between 1970 and 2004, the ocean's mean temperatures increased by between 0.2º and 1.0ºC, with an average increase of 0.6ºC. Observations carried out since 1961 show that the ocean has absorbed more than 80% of the temperature rise added to the climate. An increase was reported in the tropical cyclone, hurricane and typhoon categories (between 4 and 5) throughout the 20th century	An increase is projected for 2100 in the temperatures of the tropical Atlantic (2º - 4ºC), Pacific (1.5º - 3.5ºC) and Indian (3ºC) oceans.
Increase in the frequency of extreme climatic events	Tropical cyclone activity has increased since the 70s with the occurrence of storms of greater intensity and frequency. In comparison with the past 100 years, El Niño events have become more frequent, persistent and intense over the last 20 years.	Models project increase peaks in wind intensity as well as peaks in torrential precipitations in future tropical cyclones. Populations exposed to flooding caused by severe storms will increase throughout the 21st century.
Changes in precipitation patterns	The frequency and severity of droughts has increased in some regions (Asia and Africa) Desertification has doubled since the 70s Precipitations have increased 10% in the northern hemisphere and diminished in others.	Projections for Latin America show an increase in annual seasonal precipitations of over 60% (Mexico and Central America) Changes in precipitation patterns will increase the frequency of flash floods and the extension of flooding areas.
Ocean acidification	Since 1750 average ocean pH has diminished by 0.1 units	A drop in global ocean pH to 0.3 - 0.4 units is projected for 2100, thus reaching the lowest value in 20 million years.

I.2. Analysis target: the Uruguayan Coastal Area

The Uruguayan coastal area, with an extension of approximately 670 km, of which 450 are on the Río de la Plata and the remaining 220 on the Atlantic Ocean, constitutes a natural interface where the terrestrial and aquatic media meet and interact. It contains a variety of environments with unique characteristics, where sandy beaches spreading out in wide arches and alternating with outcrops of rocks are the dominant form. This diversity of landscape, together with the biological diversity it sustains, are the basis of the country's economic development, due to its capacity to provide goods and services in a variety of activities, such as fishing, tourism, navigation, harbour development, agriculture and mining. Three basins exist in the coastal area; the Río de la Plata basin (12,400 km^2), the Santa Lucía river (13,250 km^2) and the Atlantic Ocean (8,600 km^2). Their principal uses are irrigation, public supply and industry. With regard to water exploitation, the most controversial areas are located in the coastal zones of the departments of San José, Canelones, Maldonado and Rocha.

Uruguay follows the global trend with 68% of its population living in the coastal areas. Urban centres occupy 34% of the coast (Table 2). Demographic growth has differed in each of the six coastal departments, with higher growth within the last ten years in Maldonado and Canelones, and to a lesser extent in San José, which means that these departments face the need to increase investment and adapt existing services and infrastructure (Robayna 2009).

Table 2. Population and extension of the coastal departments. Source: Robayna 2009, produced with information from the national statistics institute (INE) 2004.

Department	Department Population	Area (km^2)	Pop. Density (inhab/km^2)
Canelones	485,240	4,536	107.0
Colonia	119,266	6,106	19.5
Maldonado	140,192	4,793	29.2
Montevideo	1,325,968	530	2,501.8
Rocha	69,937	10,551	6.6
San José	103,104	4,992	20.7
Total coastal depts.	2,243,707	31,508	71.2
Total Uruguay	3,240,676	176,215	18.4
% Uruguay	69.2	17.9	–

According to Peña (1997), the attractions to be found in Uruguay are the chain of beaches, the city of Montevideo, and the group of attractions around Colonia del Sacramento and the river coastal region. The country's main tourist area is the region known as the *eastern beaches*, which attracts the largest number of tourists. This includes the city of Montevideo and the beaches of Ciudad de la Costa, Costa de Oro, Maldonado and Rocha. This is also the area which offers the greatest number of attractions for tourists, which receives the largest amount of foreign currency, which creates the largest number of jobs and, undoubtedly, generates the greatest pressure on the coast (Robayna 2009).

I.3. Definition of climate change and variability scenarios

Global Climate Models (GCMs) are currently the tools used to estimate future climate scenarios. In order to construct them in Uruguay, the 30ºS-40ºS and 62ºW-50ºW region has been selected, as well as temporal horizon outputs for the 2020s, 2050s and 2080s, for socio-economic scenarios SRES A2 (high) and B2 (middle-low) and the climate models best adapted to the region (HADCM3, ECHAM5) (Bidegain 2005, 2006; School of Science 2009).

Table 3 shows the heating rates expected for the south of the country; mean values for average annual precipitation in the south of the country vary between 900 and 1,100 mm (2.5 mm per day^{-1}). Future precipitation fields anticipated by HADCM3 and ECHAM5 models for A2 and B2 scenarios do not foresee significant changes in rainfall (School of Science 2009).

Table 3. Future annual mean temperature and precipitation fields anticipated by HADCM3 and ECHAM5 models for scenarios A2 and B2 in the south of the country. Source: School of Science, 2009.

	ANNUAL MEAN TEMPERATURE ºC	PRECIPITATIONS mm day $^{-1}$
2020	18 – 18.5	2.5 – 3.5
2050	19 – 19.5	2.6 – 3.6
2080	19.5 – 20.5	2.7 – 3.7

With regard to atmospheric pressure, the south of the country is under the influence of the western edge of the semi-permanent subtropical anticyclone, the climate reference value for pressure varies between 1015 hPa along the coast of the Río de la Plata and 1015.5 hPa along the Atlantic coast (School of Science 2009). There is a difference in the future estimates of both models regarding the evolution of the absolute values of atmospheric pressure at sea level. While the HADCM3 model foresees a SLP drop during the 21st century of -1.0 hPa in the region, the ECHAM5 model shows a slight SLP increase of +0.5 hPa on the Atlantic coast (School of Science 2009).

Surface atmospheric circulation in the southeast of South America is dominated by the wind direction of the South Atlantic subtropical anticyclone; therefore, on the Uruguayan coast there is a predominance of winds from the first quadrant (north to east). There are also local coastal winds, particularly during the warmer half of the year (October to April), while during autumn and winter there is an increase in the frequency of winds from the third quadrant (south to west) due to the displacement towards the north of the west winds. The evolution of the mean wind speed measured at surface level (10 m above ground level) in the coastal region of the south of the country has in general terms shown a tendency to drop during recent periods. This decrease has been observed in the three coastal stations which are part of the analysis (in Colonia, Carrasco and Punta del Este), particularly as from the early 90s, and has been linked to a drop in wind frequency from the southern and western sectors (third quadrant), which usually display the highest average speeds (School of Science 2009).

The evolution of annual accumulated precipitation in the south of the country has increased from 1961 to 2008. This trend has been observed along the length of the coast, but has been relatively higher along the Atlantic coast (Rocha) where there has been an increase of 200 mm in annual rainfall over the last 47 years (Liebmann et al 2004, Bidegain et al 2005, Haylock et al 2006).

One of the most important changes brought about by climate warming will be the increase of mean sea levels. Scenarios suggest an average future global increase in sea levels of between 2 and 10 cm per decade. It should be pointed out that changes anticipated in mean sea levels along the coast will also be influenced by possible changes in the pressure systems in the region and by the frequency and direction of predominant winds. MSL increase during the period 1902-2003 at Punta Lobos rose from 0.093 mm per year^{-1} to 0.107 mm per year^{-1}, which places it within the global range of 10 to 20 cm (IPCC 2007, Verocai 2009). The evolution of MSL along the length of the Uruguayan coast – data from the stations at Colonia, Montevideo, Punta del Este and La Paloma – shows that since 1934 levels have increased by 10 cm in Colonia and 15 cm in La Paloma (Verocai 2009). It should be noted that MSL estimates for the coast of Montevideo display interannual fluctuations linked to the variability of discharge volumes mainly related to El Niño (positive deviations) and La Niña (negative deviations) events. Furthermore, a preliminary analysis of future precipitation and temperature distribution and magnitude in the basins of the Paraná and Uruguay rivers seems to agree with observations of the last few decades indicating that there will be a slight increase in volume in the future, which will add an extra centimetre or so to the MSL, as well as in their interannual fluctuations due to a greater frequency of the El Niño phenomenon (Bidegain et al 2009). Although there is a marked interannual variability in the discharge volumes of the Paraná and the Uruguay, a positive trend has been shown to exist in the increase of discharge volumes as from the 70s (School of Science 2009). This information should be borne in mind when making cross correlation calculations for discharge volumes and MSL recorded for Montevideo (1961-2008). Other aspects to be considered are sea swells brought about by storms which would be generated under conditions of higher average MSL values, and wind speed changes which would have an impact further inland than at present, leading to increased erosion.

I.4. Diagnosis and determination of the impact produced in the sector under consideration

I.4.1. Threats to the coastal area and the vulnerability estimate for critical areas

An international analysis has been carried out with regard to the principal impacts and concerns in coastal sectors in the face of climate change (USAID 2009). Based on the situation in Uruguayan coastal areas and on scenarios projected by the climate models described above, a variety of threats emerge (Table 4). It must be pointed out that similar patterns of development occur in Uruguay as in the rest of the world, which result in the loss of habitats, overfishing, pollution and other environmentally harmful activities. Climate change combines and aggravates current stressful factors and makes coastal communities more vulnerable.

Table 4. Identification of global threats in coastal environments. Adapted from USAID (2009) for the Uruguayan coast.

SECTOR	CLIMATE CHANGE THREATS	HUMAN THREATS
Wetlands and coastal ecosystems	Loss or migration of ecosystems and wetlands. Run-off caused by increased precipitation causes erosion rates and sedimentation to escalate, which is prejudicial for estuaries. The rise of the surface temperature of the sea and nutrient over-enrichment generates hypoxia and dead areas in coasts and estuaries. Changes in the distribution and abundance of marine species of commercial value. Increase of invasive and exotic species.	Intense coastal development and loss of habitats. Pollution and dead coastal and estuary areas. Disruption of the quantity, quality and regularity of freshwater input in estuaries. Oil spills from shipping. Increase of invasive species. Reinforcement of the disruption of dynamic coastal processes. Extraction of sand and gravel in coastal tributaries.
Fishing resources	Decline of ocean productivity. Loss of marine life habitats. Temperature changes affect the abundance and distribution of marine pathogens. Episodes of extreme temperature increase and depletion of dissolved oxygen reduce the spawning and breeding areas of commercial species.	Destructive fishing practices (trawling). Pollution from terrestrial sources (industrial waste, sewage, nutrient input). Sedimentation of coastal systems due to terrestrial input.
Recreation and tourism	Damage to infrastructure and loss of beaches caused by storms, erosion and precipitation. Quality of sea water at risk and increase of number of days beaches must be closed.	Inappropriate location of tourist resources. Alteration of the coast line, coastal processes and habitats.
Water resources	Saltwater intrusion in drinking water sources. Storms and high seas foster coastal flooding. Decline of precipitation exacerbates the problem of freshwater availability.	Discharge of untreated sewage and chemical contamination in coastal waters. Water damming. Dredging in coastal areas.
Human settlements	Coastal flooding. Damage to construction and infrastructure due to increase of storm intensity and exposure to flooding. Increase of mean sea level, erosion and severe climatic events generate the natural degradation of the defences of coastal structures.	Inappropriate location of infrastructure. Shielding of coast line. Transformation and loss of habitats.
Human health	Thermal stress due to extreme temperatures for extended periods. Disease and loss of life caused by extreme climatic events. Increase of the area of influence of vectors such as those which cause dengue, gastroenteritis and toxic algae.	Water pollution and contamination.

SECTOR	CLIMATE CHANGE THREATS	HUMAN THREATS
Conflict	Loss of coastal territory gives rise to human migration. Water shortages generate usage conflicts. Population migration to urban coastal areas due to the decline of ocean productivity, reduction of fishing and decrease of the availability of food.	Displacement and loss of access to the coast as a result of tourism and coastal development.

It is assumed that climate change will affect current risks rather than create new ones, and will exacerbate the natural processes of coastal erosion and flooding. Climatic impacts will have local effects in keeping with the magnitude of the climate vectors (pressures), the natural characteristics of the coast and the influence of human activity.

I.4.2 Health and function of coastal ecosystems

An ecological evaluation of the aquatic biodiversity of the Río de la Plata and its maritime front has recently been carried out (Brazeiro et al 2003), focused on the identification of priority areas for conservation and management. On the basis of the superposition of thematic layers and indicator weighting, nine high-priority regions were detected for conservation, which represent 39% of the surface of the area under analysis. Within these regions, ecologically relevant areas were identified, representing 8% of the total area. The priority sites selected in national jurisdictional waters were:

1. The west coast of Colonia
2. The Ortiz sandbank
3. The turbidity front, particularly at the mouth of the Santa Lucía river.
4. The saltwater front
5. The shallows of the Solís river – from La Tuna island to Piriápolis – and area around Punta Ballena, Punta del Este and Isla de Lobos
6. The mouth of the Maldonado river
7. Cabo Polonio area of influence
8. Cerro Verde and Verde island

The order of importance of these sites was determined on the basis of an ecological relevance index (ERI) composed of fourteen biological variables organised according to three criteria; wealth of species, the presence of species of particular interest and ecological processes. EcoPlata wishes to carry out an analysis of the terrestrial coastal area of the Río de la Plata and the Atlantic Ocean, applying the same methodology. As a result of their study, Brazeiro et al (2009) proposed effecting a bio-regionalisation of the coastal strip from Punta Gorda (Colonia) to Barra del Chuy (Rocha), with three main regions:

1. The western area which covers the coast of the departments of Colonia and San José
2. The intermediate area from Montevideo up to, and including, Punta del Este
3. The eastern area from Punta del Este to Chuy

Of these, the first is clearly part of the river coast of the Río de la Plata, and the third is ocean coast, whereas the intermediate area is a transition area with a high rate of species exchange which constitutes an ecotone. The authors analysed fifteen types of vegetation formations and five zoological groups, indicators of coastal diversity, identified a coastal environmental relevance index (CERI) and defined areas with a common biota, characterised by the existence of a group of exclusive or typical species. This study determined that the area of greatest environmental relevance on the Uruguayan coast is the eastern area, followed by the intermediate area and lastly the western area, which showed the lowest CERI.

Furthermore, taking fishing management plans into account and including conservation criteria, a spatial analysis of disaggregated information was carried out of the coastal system, which led to the identification of three ecoregions; the inner estuarine zone, the outer estuarine zone and the oceanic zone (Defeo et al 2009). On the whole, these sensitive zones are important for the protection of spawning areas and/or the recruitment of valuable coastal fishing resources for the country and the following sensitive areas were prioritised in each zone:

1. The inner estuarine zone: mouth of the Santa Lucía river and area between the mouths of the Pando and Solís Chico rivers.
2. The outer estuarine zone: mouths of the Solís Grande and Maldonado rivers, both of which are considered to be moderately to highly affected by urban development.
3. The oceanic zone: the system of coastal lagoons and the systems between Cabo Polonio, Valizas river, Cerro Verde and Barra del Chuy.

All of these areas had been previously identified as priority areas for conservation. In conclusion, it is possible to see that all of these studies, which have applied priority criteria in keeping with measures for the use and conservation of resources, have given priority status as sensitive zones to the same areas. Therefore, basic information exists in the country regarding the function of coastal ecosystems. An analysis of the health of each zone should be promoted next, on the basis of appropriate monitoring for the handling of resources and the conservation of these areas which have a high environmental value. In addition, it is recommended that with the generation of new information on the natural and physical system, the coastal area should be zoned in keeping with the expected future climate change scenarios described above.

Invasive exotic species (IES) are recognised to be one of the principal threats for the conservation of coastal biological diversity, as well as for the geomorphology of the chain of sand dunes, affecting the natural processes of the sea-continent interface (Brugnioli et al 2009). The six coastal departments show the greatest number and sighting records of IESs in the whole of the Uruguayan territory. It has been observed that most exotic species reported along the coastal area are terrestrial (222), with only 17 aquatic life forms reported. Herbaceous species, trees and shrubs predominate amongst the terrestrial forms, and molluscs, crustaceans and fish amongst the aquatic fauna (Brugnioli 2009).

I.4.3. Protected sea coast areas

In Uruguay, the establishment of stringently protected areas has been a key element in the conservation of nature and the State has, in this regard, established a clear and conclusive conservation strategy on the basis of Law Nº 17,234 and Parliamentary Decree 52/005 (National System of Protected Areas; SNAP in Spanish), as its basic instrument. The country currently has fourteen protected coastal areas organised into eight categories (national parks, coastal and state islands, sanctuaries, ecological beaches, protected landscapes, national historical monuments, forest reserves and biosphere reserves). These are not included within a SNAP which will ensure the adequate conservation of biodiversity and which will serve as the basis for sustainable environmental, social and economic development. As a result of the creation of SNAP, the incorporation of four coastal-sea area proposals has been requested (Cabo Polonio, Cerro Verde, Laguna de Rocha and Santa Lucía wetlands). It should be pointed out that protected coastal areas on the Río de la Plata coast are noticeably lacking, compared to the ocean coast, and several coastal habitats such as beaches, psammophilous plant communities, rocky headlands and estuaries are still unprotected (Brazeiro and Defeo, 2006). Brazeiro and Defeo (2006) suggest that the objectives to be defined should aim at promoting the sustainable exploitation of fishing resources, as well as at the conservation of biological biodiversity and its associated natural and cultural resources. They also advise zoning the marine environment into ecoregions, the identification of priority areas to be protected and the implementation of a monitoring and adaptive management programme (see heading I.4.2).

I.4.4. Exposed environments

The Atlantic and Río de la Plata coast of Uruguay has a relatively diverse geological configuration (Goso and Mesa 2009) constituted by a series of ancient igneous and metamorphic crystalline basement rocks. At several points along the coast line there is evidence of erosion caused mainly by the relative elevation of the sea, a deficit in sedimentary balance and the consequences of some of the infrastructure constructed some time ago. Amongst the coastal processes it is possible to observe that erosion caused by the waves and the action of phreatic strata leads to the retreat of cliffs at an average of between 50 and 110 cm per year^{-1} (Colonia, San José, Maldonado, Rocha) (Panario 2000, Goso and Goso 2004, Goso et al 2007).

<u>Beach system and chain of dunes</u>

The effect of coastal sedimentation caused by the wind, with the advance of dunes upon urbanised areas is quite well known along the coast of Uruguay (the beaches of Carrasco, Punta Gorda, Malvín in Montevideo; Parque Roosevelt, El Pinar, Parque del Plata, Las Toscas, La Floresta in Canelones; Punta del Este in Maldonado and Valizas and Punta del Diablo in Rocha). In recent years, the flooding of beaches has also occurred, due to outflow from unconfined aquifer phreatic strata (the beaches at Villa Argentina, Atlántida, Costa Azul in Canelones; Portezuelo in Maldonado).

Measures employed in an attempt to stabilise and recover the dunes have included the installation of fencing (sand traps) and access walkways, the planting of exotic vegetation such as grass, acacia or tamarisk on the dunes, and even the planting of pine trees adjoining the coastal roads (Canelones and Maldonado). Such measures have been successful in strengthening the development of dune fields (FREPLATA 2005).

In addition, the supply of sand has diminished noticeably in some areas, due to the direct extraction of beach sand, submerged sand and sand dunes, activities which are concentrated in the departments of Colonia, San José and Canelones.

Different attempts to stabilise river mouths have been carried out in coastal areas (FREPLATA 2005); opening direct exits to the sea and constructing sand dykes (Solís Chico river), breakwaters (Sarandí river), intersection dykes (Pando river) (Gutiérrez and Panario 2006), metal cofferdams (Carrasco river) and tetrapods (Chuy river). Of these, only in the last two examples have satisfactory results seem to have been obtained (López Laborde 2003). The instability of the Pando and Solís Grande river mouths continues to cause significant alterations.

The morphological analysis of the coast, monitoring its evolution over time, observing the wave climate, and the wind and tides system, and obtaining information regarding the sedimentary transfer process are essential for the implementation of climate change adaptation measures (EcoPlata 2000). It is necessary to develop a comprehensive, long-term strategy for the treatment of the problem of erosion and other alterations of coastal geomorphology, together with an updated information system for decision making (FREPLATA 2005). In order to achieve this it is essential to carry out regular surveys of beach profiles and to have updated information at hand regarding the natural agents which affect the modelling of the coast (GEO Uruguay 2008).

Coast urbanisation

Uruguay's coast has played a leading role in the country's development, throughout its history. At present, 70% of the country's entire population is concentrated in the coastal departments, as well close to 71% of private homes and just over 72% of the dwellings in Uruguay (Fernández and Renischenko 2005). The spatial distribution of the coastal population is very heterogeneous; in each of the departments there is at least one city in which a high percentage of the total population of the coastal area is concentrated (Colonia del Sacramento 71%, Ciudad del Plata 63%, Ciudad de la Costa 71%, Maldonado 42% and Rocha 49%) (Robayna 2009). Of all of the departments, Canelones has the highest urban occupation on the coast (1,779 inhab km^{-1}, 1,113 dwellings km^{-1}; Robayna 2009), which is far higher than the average along the whole of the coast and the other departments. In the department of Maldonado, the second highest, the number of dwellings is almost double the number of permanent inhabitants, and similar figures are to be found in Rocha, where the number of dwellings exceeds the number of residents. Along a narrow strip of the territory sites of a high natural value coexist with man-created landscapes creating some degree of fragility and dynamic imbalance. Most touristic localities, which are identified by the dwellings per kilometre indicator, are situated along the coast. Of the 135 localities in the area, 80 of them (59%) are predominantly touristic. In relative terms, it may be observed that rates of growth have varied in every intercensal period. Except for Maldonado, all of the departments experienced their highest rate of growth between 1963 and 1975, and the tourist localities with the highest growth, in which the number of dwellings had doubled by 1996, are in the departments along the ocean coast (with the sole exception of Guazú-Virá).

The initial environmental impact of construction is increased due to human activity associated with right-of-way (Gudynas 2000), changes in the use of soil for afforestation, dwelling and hotel infrastructure, and other uses. The construction of highways is fostered by influential urban agents. Problems which are common to road development are erosion and changes in drainage patterns. The construction of roads following the coast line (*ramblas*) implied advancing into the sea through the elimination and embankment of dune fields and the construction of retaining walls for the protection of the works from the impact of the waves. In general terms, these roads contributed to indirect erosion through the input of sand (dune fields) and direct erosion as a result of the construction of retaining walls (Piriápolis) (López Laborde 2003).

Structural stabilisation of the coast line

In Uruguay, the development of coastal infrastructure was mainly carried out at the beginning of the 20th century and the dynamics of the coastal environmental were not considered, which generated interference in the processes of morphological evolution and sedimentary transfer. According to Panario (2000), the displacement of dunes advancing upon the continent due to the action of SSE winds prompted several land owners to plant forests along the coastal dunes. These successful pioneer afforestation projects and the increase of the value of the land, led to the almost uninterrupted afforestation of the whole of the coast line. Once the dunes were conquered and with the advent of the recreational use of the coast, numerous urban developments emerged, which were particularly successful in the department of Canelones and Maldonado (FREPLATA 2005).

The coast line can adopt a stable profile or shape when the processes for the input and removal of sediments are balanced. However, external factors such as storms often induce morpho-dynamic changes which disrupt the state of balance. Climate change and the increase of the MSL affect the transfer of sediment in complex ways; non-linear and abrupt changes can occur when certain thresholds are exceeded. If the increase of the MSL is gradual and slow, the balance can be maintained, even with morphological changes, but an acceleration in the rate of increase can make it difficult to maintain, particularly where sedimentary input is limited, such as in coastal lowlands with a tendency to flood (IPCC 2007).

In a recent report produced within the framework of the EcoPlata programme (Medina 2009) there is an orderly and systematic description of coastal infrastructure, with an identification of its principal impact. The territorial outline for the comprehensive evaluation of existing or possible territorial impact was determined. In most cases, the infrastructure does not comply with the 250 m established as a defence strip by Article 153 of the Water Code. Although the impact depends on the type of infrastructure, the territorial boundaries of the study are those determined by the National Policy for Coastal Space, which is included in the National Guidelines for Coastal Space (www.mvotma.gub.uy), and which focuses on sectors of varying width adjoining the coast line of the Río de la Plata and the Atlantic Ocean. In view of this, sections have been identified for coastal management, in an attempt to set up a coastal management and planning unit in each section, in the light of current and applicable legislation. Some of the criteria used in order to establish these sections include an estimate of the principal processes to be expected, speculating on some of the processes which are likely to follow emerging trends which could be consolidated in years to come (Table 5, Medina 2009) and which should incorporate the concept of adaptation to climate variability and the increase of the MSL.

Lastly, in the search for solutions to the problems of erosion and alteration of the coast line, special attention should be given to the uses and services of the coastal area, with the purpose of seeking an appropriate balance between these services and the environmental functions of the coast.

Table 5. Estimate of the principal processes expected with regard to coastal infrastructure. Source: Medina 2009.

SECTIONS	PRINCIPAL PROCESSES EXPECTED
Nueva Palmira – Colonia del Sacramento	Colonia bylaw "Territorial legislation decree" 1997 Planning for the western area of the department: Nueva Palmira – Carmelo – Conchillas, Agreement between IMC (Municipality of Colonia) and DINOT (National Directorate of Territorial Legislation) Protection of the heritage value of the original buildings of Conchillas and Puerto Conchillas. National Declaration.
Colonia del Sacramento – Cufré river	Increase of tourism in the city of Colonia and surroundings Expansion of the city towards the east, with urbanisation New interventions in the country club style Improvements in the chain of resorts to the west of Colonia Completion of the Bocas de Cufré jetty and the river port
Cufré river – Playa Pascual	Despite the rural nature of this stretch of the coast, it is feasible to expect some coastal urbanisation projects of the country club type Port infrastructure at Puerto Arazatí Consolidation of Kiyú Ordeig
Playa Pascual – Santa Lucía river	Increase of the use for industry and logistics of this stretch Creation of a coastal recreation area Extension of the Santa Lucía marina
Santa Lucía river – urban Montevideo	Increase of informal and formal urbanising pressures from the edges of urban Montevideo and Santiago Vázquez Growing degradation of ecosystems caused by depredation (wood cutting, sand and gravel extraction, solid waste, fires) Increase of mixed uses
Urban Montevideo – Ciudad de la Costa	Gradual consolidation due to saturation of the residential network of Ciudad de la Costa Increase of the use of beaches and coastal recreational activities Construction work following municipal plans and policies
Ciudad de la Costa – Solís Grande river	Gradual occupation of empty lots Emergence of specific enterprises including residential developments for the coastal area Port infrastructure connected to Atlántida, expansion of central urban area
Solís Grande river – Punta Negra	Progressive consolidation of the coastal residential network Emergence of specific touristic installations and services Improvement of recreational facilities on the coast
Punta Negra – Manantiales	Completion of coastal stretches not yet urbanised Intensive projects along the coastal strip with the use of heavy equipment (Puntas del Chileno, Playa Chihuahua)
Manantiales – Laguna Garzón	Ten urbanisation projects on both sides of Route Nº 10 under construction or being planned Bridge over Laguna Garzón Completion, with residential network along the coast Improvement of recreational facilities on the coast
Laguna Garzón – Laguna de Rocha	Completion with coastal urbanisation along the whole stretch Bridge over Laguna Garzón Improvement of recreational facilities on the coast Construction of tourist installations and services
Laguna de Rocha – Aguas Dulces	Deep water port at La Paloma, with associated logistics area Alternative deep water port to the east of La Pedrera or at La Coronilla, with associated logistics wing Growing urbanising pressure on the sandbanks of Laguna de Rocha Urbanisation project at Garzas Blancas confirmed Completion, with residential network along the La Paloma-La Pedrera stretch Improvement of recreational facilities on the coast Construction of tourist installations and services

SECTIONS	PRINCIPAL PROCESSES EXPECTED
Aguas Dulces – Chuy	Expansion of urbanising process of Punta del Diablo Completion of existing resorts Improvement of recreational facilities at tourist centres Construction of tourist installations and services

I.4.5. Productive sectors

Fisheries

Analyses carried out by INFOPESCA (2001) and Defeo et al (2004) show a negative progression of the exploitation phases of most of the resources. In most cases, from being virgin or under-exploited resources in the 80s, they are now being over-exploited. Milessi et al 2005 showed that the drop in fishing performance may be an indication of the impact of the fishing sector on the trophic structure of marine fauna communities in Uruguayan waters. The species which are mainly exploited in coastal areas are freshwater, sea-estuarine and marine (GEO Uruguay 2008). Fish resources exploited in the inner and middle zones of the Río de la Plata are shad, boga (*Leporinus obtusidens*) and catfish. The principal settlements are in Carmelo, Nueva Palmira (Colonia) and Kiyú (San José). In the outer Río de la Plata and the Atlantic Ocean, the major species in commercial terms is the sea bass, followed by whiting, red cod and shark. The principal fishing settlements are in Montevideo (Pajas Blancas) and Canelones (San Luis resort).

Scientific information and statistics available on the resources exploited non-industrially is on the whole insufficient, particularly with regard to biomass estimates. The extensive distribution of the resources, some of which cannot be handled only by Uruguay, adds a component of uncertainty to such estimates (Amestoy 2001). In order to provide foundations for management, it is necessary to implement long-term monitoring, establish protected areas and implement spatial-temporal close seasons for fishing activity (GEO Uruguay 2008). In view of the extension of continental bodies of water, as well as their greatly varied habitat and fish, successful monitoring will depend on the hierarchisation of sites according to bio-socio-economic criteria as well as criteria based on environmental sensitivity and ecosystemic impact risk (GEO Uruguay 2008). Non-industrial fisheries in the Río de la Plata are connected to the placement of frontal zones, which are expressions of hydrodynamic processes whose displacement is linked to predominant wind patterns (E-SE, W-NW) and seasonal and interannual fluctuations of river water volume respectively (Nagy et al 2007). These frontal zones are key habitats for biodiversity and the functional integrity of this ecosystem. Increased productivity and the concentration of aquatic life in them makes the fish colonies associated to these zones particularly vulnerable to exploitation. There is evidence that climate change will continue to affect biological diversity, with consequences for distribution, the increase of extinction and changes in reproduction times.

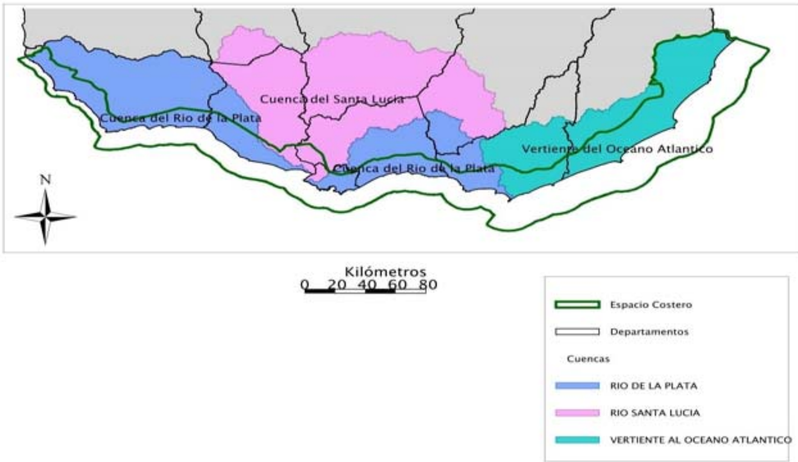
Tourism

Robayna (2009) has established with regard to the arrival of tourists that the coastal areas of Montevideo and Maldonado undergo the greatest levels of “tourist pressure”. In addition to the large numbers of tourists arriving in these departments, it is also important to consider tourist/local population and tourist/vehicle ratios, since such comparisons provide a greater dimension to the impact of tourism on the Uruguayan coast. With regard to the former, in 2008 Canelones reached a ratio of 6 tourists per inhabitant, which reflects a great increase of the pressure already exercised by the resident population (Robayna 2009). Although Rocha displays a negative ratio; that is, the coastal population exceeds the number of tourists, an analysis of this indicator for certain specific resorts shows that it differs with regard to the indicator for the department as a whole. Thus, for example, in Punta del Diablo there is a ratio of almost 90 tourists per inhabitant, whilst in Cabo Polonio-Valizas the ratio is 20 to 1. With regard to the second indicator, tourist/vehicle, Maldonado is the department with the largest number of vehicles per tourist (72), with Rocha in second place with 62 private vehicles per tourist (Robayna 2009).

Economic assessment of the coastal area

Economic assessments of the coast have analysed local and multi-sectorial levels, but only a few take climate impact into account. Sención (2009) has considered the coastal area of Uruguay in the delimitation in Figure 1. The study analysed the coastal area affected by an increase in the sea level of one metre, employing the Digital Elevation Model at a scale of 1:50,000, the analysis of secondary information and the evaluation of experts.

Sención (2009) calculated the total cost of the economic impact at 2,178.9 million US dollars, which represents 10.9% of the GDP for 2006 (Table 6). The urban areas affected by the increase of the sea level by one metre according to the application of the digital elevation model represent almost 50% of the total cost. The loss of coastal areas (urban + non-urban) is approximately 40% and loss of infrastructure in ports, sanitation and highways constitute 19% of the total economic impact. Not included in the estimates is the loss of biodiversity. In order to do so, it would first be necessary to classify the areas of biological and environmental significance along the coast and include them in the model. In addition, the physical information base with regard to associated coastal ecosystems should be improved and their capacity to adapt to the new natural stress should be studied.



blue: Río de la Plata basin – pink: Santa Lucía basin – green: Atlantic Ocean basin
dark green outline: coastal area – black outline: department boundaries
Scale in kilometres

Figure 1. Delimitation of the coastal area considered in this analysis and of the basins of the Río de la Plata and the Santa Lucía rivers and of the Atlantic Ocean. Source: Session 2009

In order to calculate the impact on port zones, the author took a first approximation, which means that the values obtained may be underestimating the situation. Losses associated with impact to trade and services provided, as well as the need to relocate productive facilities and infrastructure were not analysed.

According to Sención (2009), infrastructure and population would not be seriously affected by flooding due to the increase of the sea level by one metre during the next 20 and 40 years in the most probable scenarios, A2 and B2, with the exception of those which are already vulnerable or which undergo impacts mainly caused by extreme events. However, Sención (2009) considers that coastal erosion will be one of the problems which will affect the coast significantly during these periods, due to the combination of sea swells caused by storms and natural causes associated with erosion-sedimentation cycles in areas with infrastructure development, human settlements and extractive activities (EcoPlata 2000; Panario and Gutiérrez 2006). The study identified 55 km of coast in a state of conflict with the principal highways and urban areas of the coast.

Table 6. Total economic impact on the coastal resource sector. Source: Sención 2009.

ITEM	COST (USD)
Urban	**1,114,921,871**
Non-urban	**469,230,000**
Ports	**342,000,000**
Sanitation	**60,000,000**
Highways	**189,500,000**
Population	**3,252,400**
TOTAL	**2,178,904,271**
% of GDP 2006	***10.9%***

Sención (2009) states that results of the physical and economic quantification from the application of the Economic Impact Assessment Method, due to the elevation of the sea level by one metre, are 10.8% of GDP and that adaptation measures both for A2 and B2 are 3.82% and 0.66% of GDP for 2008 respectively.

I.5 Analysis of the vulnerability of the sector

In Uruguay there is a certain amount of awareness of the problem of climate change amongst technicians who work on coastal matters on a national scale and in some of the municipalities (UCC 2004), while management and research programmes connected to the coast of the Río de la Plata have contributed basic diagnoses in several natural and social disciplines (CNCG, 1997; EcoPlata, 2000, UCC, 2004, 2005).

Climate change will exacerbate the impact of the threats to coastal areas and marine biodiversity, either by magnifying current stress sources or by directly destroying habitats and causing the loss of species. These changes will be expressed in a variety of ways and intensities in the different coastal regions of this complex riparian-marine system. Table 7 shows a summary of the effects related to climate change in three key environments along the coastal areas of the Río de la Plata and the Atlantic Ocean.

Uruguay will probably be affected by climate change. Initial research results (Nagy et al 2006) highlight the high level of vulnerability of coastal resources in the face of changes in precipitation, discharge from Río de la Plata tributaries, wind patterns and localisation of the subtropical anticyclone of the Southwest Atlantic. As a result, adaptability to change on the part of ecosystems and populations at risk will be exceeded, which will probably lead to significant losses. Table 8 shows a general evaluation of vulnerability by system and sector (Nagy et al 2007).

Table 7. Principal characteristics of the coastal areas of the Río de la Plata and projected vulnerability to climate change. Source: GEO Uruguay 2008.

	INNER (0.3 USP) Colonia - Playa Pascual	MIDDLE (15 USP) Playa Pascual - Pando river	OUTER (29 USP) Pando River - Piriápolis
Silicates (M)	16.0-175	70-85	22.0-27-00
DIP (M)	1.5-1.7	0.7-0.8	0.4-0.5
DIN (M)	27.0-33.0	0.7-0-8	1.0-2.0
N/P	16.0-22.0	3.0-4.0	1.0-2.0
Production (mgCm3h-1)	14.79	16.29	28.38
Phytoplankton (1) SW	13	22	11
Zooplankton (2) SW	17	22	22
Bentos (3) SW	27	21	34
Fish (4) SW	53	46	60
Biological Relevance and Diversity	Transition and feeding area for freshwater species	Feeding, breeding and growth area for estuarine and marine species	Transition and feeding area for marine species
Susceptibility to Eutrophication	Moderate - High	High	Low to Moderate
HAB	High	Moderate - High	Moderate - High
Vulnerability to storms	High	High	Moderate - High
Vulnerability to discharge	High	Moderate - High	Moderate
Anthropogenic impact	High/Agriculture	Urban, Domestic and Agriculture	Land occupation, Agriculture

Specific wealth values (SW). Main taxonomic groups (1) Chlorophyta, Chlorococcales, Desmidiaceae, Diatomes and Dinoflagellates; (2) Copepods, Cladocerans; (3) Annelida, Molluscs, Crustaceans, Nematodes; (4) Pelagic fish. Harmful algal blooms (HAB).

Climate change will exacerbate the impact of current threats to coastal areas and marine biodiversity, either by magnifying current stress sources or by directly destroying habitats and species. As a result, adaptability to change on the part of ecosystems will be surpassed, which will probably lead to significant losses.

Table 8. Sectors vulnerable to increase in sea levels (eustatic, storm surges, river flooding) of the Uruguayan coast of the Río de la Plata. Source: Nagy et al (2007).

VULNERABILITY / SECTORS	Low	Moderate	High
Population affected		■	
Population at risk	■		
Biodiversity (wetlands, beaches, bird habitats)			■
Capital at risk / infrastructure			■
Coastal fisheries		■	
Tourism			■

I.6 Conclusions and proposals to improve the adaptation of the sector

The scenarios described above call for coastal management and planning which consider the vulnerability of major systems and sectors in the face of climate change and sea level increase. The main obstacles to this which have been detected are:

- The lack of genuine public awareness regarding climate change, comprehensive coastal management, public participation, sustainable local development, and the protection of biodiversity. A positive trend has been observed which should be encouraged and systematised.
- Information gaps and a lack of inventories, monitoring networks and economic environmental evaluation.

These barriers could be overcome by means of measures which foster adaptation, such as:

- Reinforcement of monitoring, modelling and forecast systems with information on sea levels, climatology, water volumes of coastal tributaries, beach profiles, coast line regression, delimitation of flooding areas, salinity fields and marine temperature, delimitation of wetland areas and calculation of migration buffer areas.
- Determination of the thresholds of physical, environmental, economic and human impact.
- Development of a multivariate early warning system for storm surge and flooding risks based on access and analysis of forecasts and models, a geographic information system and real-time communication with local actors.
- Evaluation of the coastal area's goods and services and their resources, in current scenarios and after the increase of the sea level.
- Management of habitats and species at risk of extinction using the creation of buffer zones as a tool, together with the establishment of a system of coastal-marine protected areas which take projected climate changes into account.
- Strengthening of participatory adaptive management processes for the coastal area.

The accelerated change trends over the last 35 years and the continuous improvement of climate models demand constant monitoring and early warning, as well as the permanent evaluation of vulnerability and the assessment of multi-sectorial impacts under a variety of scenarios, in order to generate updated knowledge for the process of adaptive management. The importance of fostering and developing comprehensive management is emphasised, as a context and an institutional contract, and as an essential tool for the sustainable development of the coastal area and in proactive adaptation strategies (see heading II.3).

II. A diagnosis focused on existing capabilities in the country

II.1. A survey of existing capabilities and strengths

The paper produced by the National Strategic Plan on Science, Technology and Innovation (PENCTI, in Spanish) and published recently by the National Agency for Research and Innovation (ANII, in Spanish, 2008), includes an analysis of environmental conservation and the natural resources of the coastal area. This study underlines the fact that conserving the diversity of resources and the economic activities of the coastal area depends on the preservation of coastal ecosystems. As we have already noted, the coastal area's problems are the result of natural phenomena associated with extreme events, but are also caused by human activities. The coastal area in particular has been subjected to a great deal of tourist development.

It has been recognised that activities associated with development give rise to impacts which affect the environment and natural resources and cause coastal erosion, contamination and the deterioration of biodiversity. The PENCTI paper points out several strategic priorities for the Integrated Management of Coastal Areas (GIZC, in French) whose application would promote the adaptation of the coastal area to climate change. Some of these priorities are:

- The application of territorial legislation in order to prevent the process of deterioration of the coastal area from worsening.
- Increased efforts for the recovery of coastal ecosystems
- Carrying out research on fishing resources in order to optimise management and achieve sustainable extraction

II.2. Sectorial investment and projects in the coastal area

Existing projects, programmes and initiatives intended to promote the coastal area encompass a variety of effects. The first recognition of the need for an environmental management model in order to prevent the problems which arise in coastal areas was stated in the Stockholm Convention on Human Environment (1972). However, it was during the conference held in Rio de Janeiro (1992) that the subject was explicitly included in Agenda 21 (Chapter 17) and in the Climate Change (UNFCCC, 1992) and Biological Diversity (1992) Conventions. In the second of these, as well as in the Jakarta Mandate (CBD 1995), a global consensus was reached on the importance of marine and coastal biodiversity and of the adoption and implementation of a management model, which was called Integrated Management of the Coastal Area (GIZC). Uruguay has ratified all of these international agreements and also adheres to regional treaties such as the Río de la Plata Basin Treaty (1969), the Treaty of the Río de la Plata and its Maritime

Front (1974) and the MERCOSUR Framework Agreement on Environment (2001), all of which have sustainable development and the protection of the environment as their objectives.

Within the framework of these agreements, the country receives support from multilateral organisations such as the IDRC (EcoPlata) and the Canadian Government (MCI-SUR), the Global Environment Fund (GEF), the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), UNESCO and the One UN Programme.

On a national scale, the recent Territorial Legislation Act (Law Nº 13,308) has established a general framework for territorial legislation and sustainable development, and has established jurisdiction and instruments for planning, participation and action with regard to this matter. Article 4, in particular, underlines the need to identify areas which are at risk due to the existence of natural phenomena or sites for human settlement which pose a threat. Amongst the instruments available at a national level, the production of Guidelines for the Coastal Space has been determined, based on the principles of respect for and promotion of the diversity and singularity of the coastal area and the promotion of cooperation between public and private initiatives to encourage activities within a framework of integrated coastal management.

In line with this new regulatory context, the coastal area and its resources need a new model of management. In this respect, the EcoPlata Programme began to generate political and social commitments amongst national and local authorities by means of the coordination and legitimising process which has been taking place in the country during the last decade. EcoPlata acted as a theoretical framework for the construction of a national GIZC strategy, and achieved national recognition for the implementation of this concept. At present, EcoPlata focuses on generating conceptual foundations, as well as areas for dialogue and discussion for the institutionalisation process. Thus, the Programme has accompanied the policy development process both at national and at municipal levels, generating social commitment amongst administrators and acting as a theoretical framework for the construction of a national GIZC strategy. EcoPlata is now involved in institutionalising and strengthening the GIZC process in order to consolidate the effective protection of sensitive areas and ensure the sustainability of the various social and productive uses of the coast.

The Government of Uruguay, through the Ministry of Housing, Territorial Legislation and Environment, has obtained the help of the Global Environment Fund in order to strengthen the country's adaptive capacity to face climate change and contribute to the resilience of its coastal ecosystems in the face of climate change, bearing in mind the risks arising from climate change and the coastal management which Uruguay is carrying out at present. The project (URU/07/G32) is focusing on the development of a planning structure through which – in keeping with future climate change scenarios – anthropogenic pressures on key coastal ecosystems will be maintained at levels which do not exceed the range of tolerance of key species and habitats. In order to achieve this, the project is working at three parallel yet interdependent levels. The first is on a nationwide scale and incorporates climate change considerations in the regulation and processes of territorial use which govern the coastal areas. The second consists in the implementation at municipal levels of specific measures which can be included in present territorial planning processes in order to protect ecosystems which are particularly vulnerable to climate change and which are relevant to the conservation of biodiversity. The third level of activity consists in promoting the launching and replication of successful pilot project measures implemented at municipal levels and the widest possible community practices for adaptation. Pilot interventions will focus on the estuarine context and on the Laguna de Rocha and its surroundings, due to their vulnerability to climate change and the value of their biodiversity and coastal resources. Cross-sectionally at all levels, adaptation and climate risk management experiences will be disseminated and replicated in coastal areas, by spreading knowledge and employing evaluation and monitoring systems.

II.3. Assessment for the adaptive management of coastal areas

The sustainable development of coastal areas is a strategically valuable target for any government and requires rather more than a project, and rather more than one generation within a GIZC cycle at one specific location (Olsen et al 1999). The management of ecosystems which can withstand complex human and natural pressures is a challenge which requires good sense and appropriate science. Time and persistence are also required in order to obtain lessons, implement them, develop and consolidate them within a context of experience. The experience gained from mature programmes suggests that GIZC efforts are often measured in decades. It is already widely accepted that the development of governmental GIZC programmes follows a cycle which is similar to the development of other wide-ranging State policies (GESAMP, 1996). This cycle includes the following phases (Figure 2):

1. First step: the identification and evaluation of key matters, including the evaluation of environmental, social and institutional matters and their implications, as well as the corroboration of feasibility and government and non-government leadership on selected matters.
2. Second step: programme preparation, during which research determined to be a priority in the previous step must be carried out, and the management plan as well as the institutional structure for its implementation must be prepared, with the development of technical capabilities and the planning of financial sustainability.
3. Third step: formal adoption and provision of funds, which implies obtaining government approval for the various institutional agreements and promoting the fulfilment of the programme’s policies.
4. Fourth step: implementation of activities for the strengthening of management and technical capacity, as well as for the financial administration of the programme; fostering of the open participation of programme backers and the presence of the programme on the agenda of major national issues.
5. Fifth step: evaluation, which implies monitoring programme performance and ecosystem trends and adapting the programme to new and changing environmental, political and social conditions.

The cycle proposes the steps in a sequence which helps to clarify the complex relations between the many elements involved in adaptive coastal management. Experience shows that there are essential activities in each step of the cycle and that if any of these is out of place, the project places the successful achievement of its long-term objectives at risk. In this respect, the steps listed act as a “route map” for a scenario which is in itself highly complex and dynamic and which calls for constant adaptation. Within the context of climate change, the GIZC cycle (Fig. 2) can be applied to the production and evaluation of Adaptation Programmes (USAID 2009).

The coastal planning process does not substantially change when it is applied under the perspective of climate change, since some of the GIZC operative strategies must take climate change adaptation measures into account (Bizikova 2008, USAID 2009).

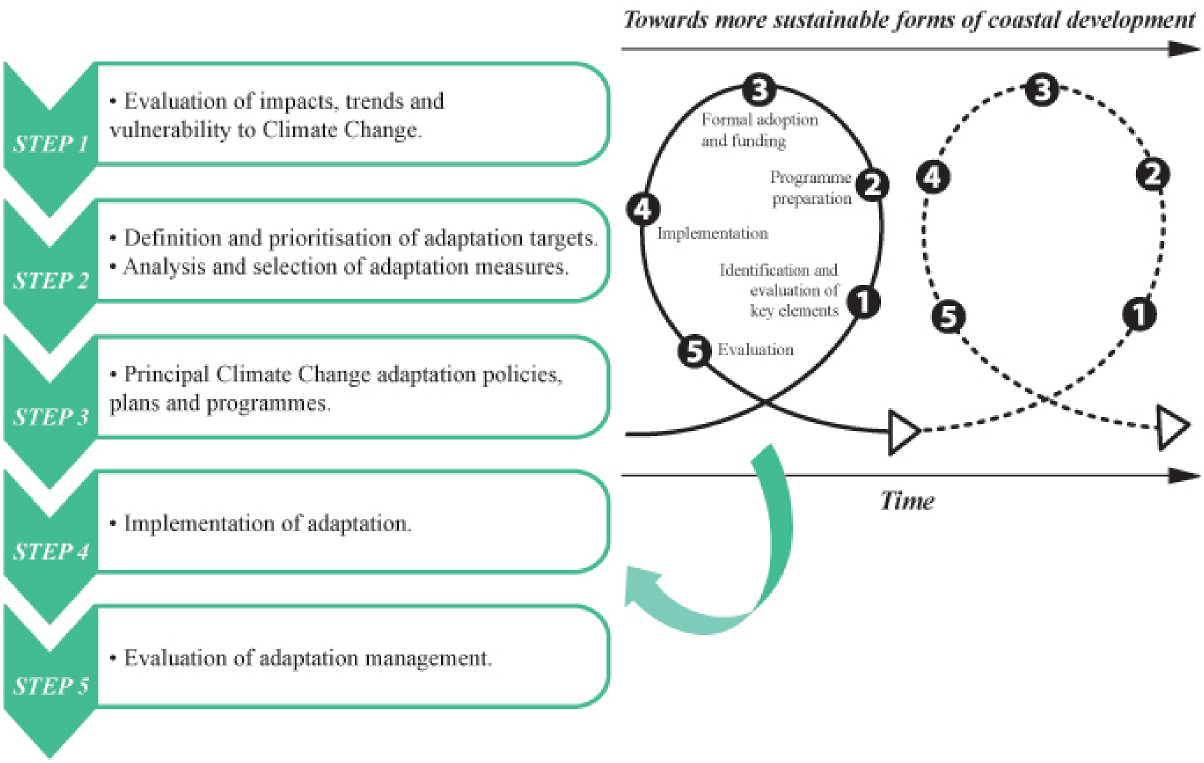


Figure 2. Route map for planning the coastal area's adaptation to climate change (USAID 2009), with relation to the GIZC cycle (GESAMP 1996).

The assessment of execution implies evaluating the quality of the administration of the project and the extent to which its objectives have been fulfilled. Outcome evaluation is the determination of the impact of the GIZC initiative on coastal resources and/or on human society through the analysis of adaptation to climate change. The assessment of management and adaptation capacity involves evaluating the quality and opportunity for response of a programme to govern changes in the allocation and use of environments and resources, according to internationally accepted experience and management standards.

The adaptive capacity to vulnerability is the property of a specific system and implies the ability to design and implement effective adaptation strategies or response models, in order to confront stress and threats (Burton et al 2005). Adaptation requires technical knowledge which must be structured in order to swiftly apply scientific progress and lessons learnt regarding the adaptive management cycle to alternative solutions and thus arrive at short-term management decisions (Mirfenderesk 2008). The evaluation of environmental, social and economic impact provides decision makers with tools for strategic planning which go beyond a search for solutions.

III. Bibliography

Amestoy, F. 2001, ‘Hacia una cuantificación de estrés ecológico en el embalse de Rincón del Bonete (Uruguay)’ Tesis de Doctorado PEDECIBA, Universidad de la República, Uruguay.

ANII 2008. Informe final de la consultoría sobre Medio Ambiente en el marco del Plan Estratégico Nacional en Ciencia, Tecnología e Innovación. Coordinador Robert E. Uhlig, 68 pp.

Bidegain M 2005. Tendencias climáticas, hidrológicas y oceanográficas en el Río de la Plata y costa Uruguaya. En: El Cambio Climático en el Río de la Plata, Cap. XIV. Proyecto AIACC LA 32/26. Ed. Barros, Méndez y Nagy, Buenos Aires.

Bidegain M y Camillioni I 2006. Performance of GCMs and Climate Change Future Scenarios for Southeastern South America. Annals of 8th International Conference of Southern Hemisphere Meteorology and Oceanography. Foz de Iguaçu, Brasil 2006.

Bidegain M , V Severova y B De Los Santos 2009. Climatología regional de base. En: Escenarios climáticos futuros y del nivel del mar, basado en los modelos climáticos globales y efecto de los vientos y caudal sobre las fluctuaciones del nivel del mar. Informe Nº II: Información sobre los resultados de los productos 3, 6 y 8 del Convenio FCien – Proyecto URU/07/G32, Montevideo J.nio 2009.

Bizikova L, Neale T y Burton I2008. Canadian communities’ guidebook for adaptation to climate change. Including an approach to generate mitigation co-benefits in the context of sustainable development. First edition. Environment Canada and University of British Columbia, Vancouver, 100 pp.

Brazeiro A, Acha EM, Mianzán HW, Gómez M y Fernández V 2003. Aquatic priority áreas for the conservation and management of the ecological integrity of the Río de la Plata and its Maritime Front. Technical Report PNUD Project/GEF RLA /99/ G31, 81 pp. www.freplata.org.

Brazeiro A y Defeo O 2006. Bases ecológicas y metodológicas para el estudio de un Sistema Nacional de Áreas Marinas Protegidas en Uruguay. En: Menafra R, Rodríguez-Gallego L, Scarabino F & Conde D (eds). Bases para la conservación y el manejo de la costa uruguaya. VIDA SILVESTRE URUGUAY, Montevideo. Pp: 379-390.

Brazeiro A, Toranza C y Bartesaghi L 2009. Poryecto de Biodiversidad costera. Informe final del Convenio Facultad de Ciencias – ECOPLATA 46 pp.

Brugnioli E, Masciadri S y Muniz P 2009. Base de datos de especies exóticas e invasoras en Uruguay, un instrumento para la gestión ambiental y costera. Informe Convenio Facultad de Ciencias – ECOPLTA 23 pp.

Burton I, Lim B, Spanger Siegfried E, Malone EI y Hug S 2005. Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Cambridge University Press, Cambridge.

CNCG 1997. Assessment of Climate Change Impacts in Uruguay. Uruguay Climate Change Country Study Final Report, Comisión Nacional sobre el Cambio Global, Montevideo.

Defeo, O., de Álava, A., Gómez, J., Lozoya, J.P., Martínez, G., Riestra, G., Amestoy, F., Martínez, G., Horta, S., Cantón, V. y Batallés, M. 2004, 'Hacia una implementación de áreas marinas protegidas como herramientas para el manejo y conservación de la fauna marina costera en Uruguay' *1ª Jornada de Comunicación Científica del PDT*: pp. 81-87.

Defeo O, Horta S, Carranza A, Lercari D, de Alava A, Gómez J, Martínez G, Lozoyola JP, Celentano E. 2009. Hacia um manejo ecosistémico de Pesquerías. Áreas Marinas Protegidas em Uruguay. Facultad de Ciências – DINARA, Montevideo, 122 pp.

ECOPLATA 2000. Diagnóstico Ambiental y Socio-Demográfico de la Zona Costera Uruguaya del Río de la Plata. López Laborde J, Perdomo A, Gómez-Erache M (Eds). CIID-PNUD-MVOTMA-UNESCO-EcoPlata.

Facultad de Ciencias 2009. Escenarios climáticos futuros y del nivel del mar, basado en los modelos climáticos globales y efecto de los vientos y caudal sobre las fluctuaciones del nivel del mar. Informe Nº II: Información sobre los resultados de los productos 3, 6 y 8 del Convenio FCien – Proyecto URU/07/G32, Montevideo J.nio 2009.

FREPLATA 2005. Análisis de Diagnóstico Transfronterizo del Río de la Plata y su Frente Marítimo. Capítulo II Litoral costero sobre el Río de la Plata y el Océano Atlántico: Caracterización y Diagnóstico. Proyecto PNUD/GEF/RLA/99/G 31. www.freplata.org/documentos

GEO URUGUAY 2008. Informe del Estado del Ambiente. PNUMA, CLAES, DINAMA (eds) 350 pp.

GESAMP (IMO/FAO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) (1996). The Contributions of Science to Integrated Coastal Management, *GESAMP Reports and Studies,* No. 61. 66p.

Goso C y H Goso 2004. Medio ambiente, riesgos geológicos y los registros cenozoicos de Uruguay. Cuencas sedimentarias de Uruguay. Geología, Paleotonlogía y Recursos naturales. Cenozoico 297-314, DIRAC- Fac. de Ciencias, Montevideo.

Goso C y R Muzio 2006. Geología de la costa uruguaya y sus recursos minerales asociados. En: Menafra R, Rodríguez Gallero, Scarabino y Conde (eds). Bases para la conservación y el manejo de la costa uruguaya. 9-19, Vida Silvestre, Montevideo.

Goso Aguilar C y V Mesa 2009. Mapas de riesgo geológico a la escala macro de la costa uruguaya y para los sitios piloto frente-salino – franja costera y Laguna de Rocha. En: Escenarios climáticos futuros y del nivel del mar, basado en los modelos climáticos globales y efecto de los vientos y caudal sobre las fluctuaciones del nivel del mar. Informe Nº II: Información sobre los resultados de los productos 3, 6 y 8 del Convenio FCien – Proyecto URU/07/G32, Montevideo J.nio 2009.

Gutiérrez O y D Panario 2006. Evolución de la desembocadura del Arroyo Pando (Canelones, Uruguay): ¿Tendencias naturales o efectos antrópicos? En: Menafra R, Rodriguez-Callero L, Scarabino, F y Conde D (Eds). Bases para la conservación y el manejo de la costa uruguaya (pp 391-400). Vida Silvestre, Uruguay, GRAPHIS, Ltda., Montevideo.

Haylock MR, TC Peterson, LM Alves, T Ambrizzi, YMT Anunciaçao, J BAez, VR Barros, MA Berlato, M Bidegain, G Coronel, V Corradi, VJ Garcia, AM Grimm, D Karoly, JA Marengo, MB Marino, DF Moncunill, D Nechet, J Quintana, E Rebello, M Rusticucci, JL Santos, I Trebejo y LA Vincent 2006. Trends in total and extreme South American rainfall 1960 – 2000 and links with sea surface temperatura. Jour. of Climate 19:1490 – 1512.

INFOPESCA, 2001, 'Informe Proyecto Gestión Marítima - Componente Pesquero. Diagnóstico de los recursos pesqueros en Uruguay' *Informe presentado a Banco Mundial, Washington*: 289 pp.

IPCC 2007. Cambio Climático 2007. Base de Ciencia Física. Informe del Grupo de Trabajo I para el 4to informe del Grupo Intergubernamental de Expertos sobre Cambio Climático. Solomon S. D. Qin, M. Manning, Z Enhen, M Marquis, K B Averyt, M Tignos and H l Miller. Cambridge University Press, Cambridge, United Kingdom.

Liebmann B, CS Vera, L Carvalho, I Camilloni, MP Hoerling, D Allured, M Bidegain, J Báez, V Barros 2004. An observed trend in Central South American precipitation. Jour. Climate 17:4357 – 4367.

Medina M 2009. Diagnóstico y Evaluación de Infraestructuras e la Zona Costera Uruguaya (Colonia – Rocha). Informe EcoPlata: Estado de situación de la infraestructura existente en la zona costera (www.ecoplata.org\documentos).

Milessi, A., Arancibia, H., Neira, S. y Defeo, O. 2005, 'The mean trophic level of Uruguayan landings during the period 1990–2001', *Fisheries Research*, vol. 74, pp. 223-231.

Mirfenderesk H y Corkill D 2009. The need for adaptative strategic planning. Sustainable management of risks associated with climate change. International Journal of Climate Change Strategies and Management 1d(2):146 – 159.

Nagy G, Gómez Erache M y Fernández V 2007. El aumento del nivel del mar en la costa uruguaya del Río de la Plata: Tendencias, vulnerabilidades y medidas de adaptación. Medio Ambiente y Urbanización. Cambio Climático Vulnerabilidad y Adaptación en Ciudades de América Latina, IIED- AL 67: 77-93

Nagy G, M Bidegain, RM Caffera et al (2006). *Assessing Climate Variability and Change Vulnerability for Estuarine Waters of the Rio de la Plata.* AIACC Working Paper Nº 22, www.aiaccproject.org.

Olsen S, Lowry K y Tobey J 1999. Hacia una metodología común de aprendizaje. Una guía para evaluar el progreso en el Manejo Costero. Versión y Ediciòn E. Ochoa. Centro de Recursos Costeros de la Universidad de Rhode Island CRC-URI, Comisión Centroamericana de Ambiente y Desarrollo (CCAD) a través de su Proyecto, Programa Ambiental Regional Centroamericano PROARCA/ Costas, Centro Regional para el Manejo de Ecosistemas Costeros ECOCOSTAS. Agosto de 1999. Guayaquil, Ecuador.

Panario D 2000. Las playas uruguayas. Su dinámica, diagnóstico de situación actual y tendencias a mediano plazo. En: Dominguez & Prieto (eds). Perfil ambiental del Uruguay. Edinor. 111 – 125, Montevideo.

Panario D y Gutiérrez O 2006. Dinámica de la costa atlántica uruguaya. En seminario: Costa Atlántica. Estado actual del conocimiento y estrategia de investigación de la costa y sus barras lagunares, pp 23-54. Rocha, PROBIDES. Series Documentos de trabajo Nº 21.

Peña, C 1997. El turismo en el Uruguay. En: Revista GeoUruguay, n° 1. Editorial Fin de Siglo. Montevideo.

Puig, P. 2006, 'Una visión de la pesca artesanal en el Río de la Plata y una mirada a su futuro', en Conde, D., Menafra, R., Rodriguez, L. y Scarabino, F., *Bases para la conservación y manejo de la costa uruguaya*, Vida Silvestre, Montevideo.

Robayna A 2009. Presión antrópica en la costa uruguaya. Análisis de indicadores sobre turismo y transporte. Informe EcoPlata, junio.

Sención G 2009. Impactos económicos del Cambio Climático en el sector de recursos costeros. Informe de Consultoría de CEPAL: Estudio Regional de Economía del Cambio Climático en Uruguay. 28 pp.

UCC 2004. Segunda Comunicación Nacional a la Conferencia de las Partes de la Convención Marco de las Naciones Unidas sobre el Cambio Climático; MVOTMA, Dirección Nacional de Medio Ambiente, Unidad de Cambio Climático, Proyecto URU/00/G31,GEF, FMAM, PNUD, Montevideo, Uruguay, Mayo 2004.

UCC 2005. Análisis de la Estadística climática y desarrollo y evaluación de escenarios climáticos e hidrológicos de las principales cuencas hidrográficas del Uruguay de su Zona Costera. MVOTMA-DINAMA-GEF-UNDP and UCC/DINMAA.

USAID 2009. Adapting to coastal climate change. A guidebook for development planners. U.S.A Agency for International Development.

Verocai J 2009. Base de datos de las series de niveles del mar en la costa uruguaya, actualizadas con cuantificación de tendencias y tasas de aumento. En: Escenarios climáticos futuros y del nivel del mar, basado en los modelos climáticos globales y efecto de los vientos y caudal sobre las fluctuaciones del nivel del mar. Informe Nº II: Información sobre los resultados de los productos 3, 6 y 8 del Convenio FCien – Proyecto URU/07/G32, Montevideo Junio 2009.