The Framework Program for the Sustainable Management of La Plata Basin's Water Resources, with respect to the effects of climate variability and change

Transboundary Diagnostic Analysis (TDA) and Strategic Action Program (SAP) for the La Plata Basin

Executive Summary

CIC Cuenca del Plata

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UN environment United Nations Environment Programme

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Preface

The La Plata Basin is one of the most important in the world, due to its surface area and socioeconomic characteristics. It encompasses over three million square kilometres, is currently inhabited by over 110 million people and produces over 70% of the GDP of the five Basin countries.

The Basin is a hydrological system with a remarkable biological diversity and productivity; it is home to the largest wetland corridor in South America and it is recognised as one of the most important basins in the world as a result of the amount, variety and endemism of its ichthyofauna. In spite of its richness, it is one of the most socially and economically affected basins by cyclic flooding and persistent drought periods. The relationship between hydrology, changes in land use and the uncertainties with respect to the future climate poses a number of challenges to reduce the vulnerability to natural disasters and address environmental management and the needs of the economically marginalised people. In this scenario, the required social and economic development, within the regional integration framework that contains it, suggests the need for a great effort in the valuation, awareness and education in relation to nature.

In 2001, the governments of the five countries that make up the Coordinating Intergovernmental Committee of the La Plata Basin Countries (CIC) decided to incorporate into the organisation the technical capacities to address these challenges and agree upon an Action Plan to guide management, where water resources, including the relationship between surface and ground waters and their links with land use and climate, play a key role. In this effort, which, for the first time, developed an integrated approach, the participating institutions agreed on the need to strengthen a common Basin vision, with the goal of identifying and prioritising common problems and their main causes so as to address them on a joint and coordinated basis.

Based on this background, and with the support of the GS/OAS and UNEP, funding was requested and obtained from the Global Environment Facility (GEF) to conduct the *Framework Programme for the sustainable management of the water resourses of the La Plata Basin*, with respect to the effects of variability and climate change (Framework Programme). The Programme was created as a long-term management process, to be executed by the five countries in a coordinated way, within the framework of the CIC. During the initial phase of the project formulation (2003-2005), and based on a participatory process, the main challenges at basin level were identified and the preliminary management proposals aimed at solving or mitigating the identified problems were drafted.

In phase 1 of the Framework Programme -executed between 2010 and 2016- the conducted diagnosis was expanded, and the Basin problems were characterised more precisely and thoroughly, thus obtaining a comprehensive vision of the status of the hydrological systems. Using this better knowledge, the Transboundary Diagnosis Analysis (TDA) was consolidated and the Strategic Action Programme (SAP) was formulated as a document of priority policies and actions agreed upon by the five countries to solve the main identified problems, particularly those of transboundary character.

The tasks were carried out with the active participation of each country's national institutions, through specialists appointed to constitute the Thematic Groups, which acted as the platform of planning and technical consensus in the implementation of the different sub-components in which the execution of the Framework Programme was organised. The products obtained from this effort are sumarised in a series of publications - to which the present document belongs.

The Coordinating Intergovernmental Committee of the La Plata Basin Countries would like to thank every person and institution that supported and participated in the execution of the Framework Programme for their commitment and effort. It also recognises the valuable cooperation and contribution made by the Organisation of American States (OAS), through its Department of Sustainable Development, which collaborated and supported the CIC in the Programme execution, and the United Nations Environmental Programme (UNEP), which acted as the implementing agency of the Global Environment Facility (GEF).

The work developed during this first phase of the Framework Programme was a pioneer experience, where over 150 institutions and 1,500 experts of the region were able to articulate each country's interests and wills in search of a common interest, aimed at the integrated water resources management within the context of variability and climate change. It its expected that the management experience and the developed technical tools will nurture and strengthen the will for regional cooperation and integration so as to make progress towards the goal of achieving sustainable development and the well-being of the inhabitants of the La Plata Basin countries.

Chapter 1:
Description of the La Plata Basin

1.1 Physical Characteristics and Natural Resources

The La Plata Basin (LPB) is located in the southeast part of South America, including territories from five countries: Argentina, Bolivia, Brazil, Paraguay, and Uruguay. It extends for 3,182,000 km², equivalent to 17 percent of the surface of South America. It covers a large part of the south, southeast, and central-western part of Brazil (1,414,000 km²); almost all the north, the Mesopotamia and the Humid Pampas of Argentina (984,000 km²); the entire territory of Paraguay (407,000 km²); the southeast of Bolivia (222,000 km²); and much of Uruguay (155,000 km²). It is formed by three main water systems: those of the Paraguay, Paraná, and Uruguay rivers. For a better analysis, the LPB can be divided into seven sub-basins: the Upper Paraguay, Lower Paraguay, Upper Paraná, Lower Paraná, Upper Uruguay, Lower Uruguay, and the sub-basin of the La Plata River (**Figure 1.1.1**).

- ***Climate***

The LPB has an important diversity of climates, ranging from the dry and very hot ones to the west of Chaqueño, with less than 600 mm/year of precipitation, to the humid regions of the south of Brazil and Southeast of Paraguay, with more than 2,000 mm/year of precipitation. These climates present an inter-seasonal or inter-annual variability that often results in extreme events of droughts or floods of great magnitude. There are also important and interesting meteorological systems that generate severe weather in the LPB, as it is one of the regions of the world with the highest frequency of thunderstorms. In addition, a large part of the basin is part of the South American tornado zone.

The climate of the LPB presents important gradients that determine its hydrological behavior. The northern part of the basin is under the influence of a monsoon rainfall regime, with a pronounced peak in the summer. The great Pantanal wetland plays a key role in storing the runoff from the rains in the Upper Paraguay, delaying its major contributions to Paraná almost six months. In the central and eastern zones of the La Plata Basin the seasonal variation is small, as it is the region with the highest precipitation and contribution to the large rivers. To the west of the Paraguay-Paraná (Gran Chaco Americano) axis, precipita-

Figure 1.1.1

Sub-basins of the La Plata Basin

Table 1.1.1

Surface distribution of the La Plata Basin by country and by water system

Country	Water system area (km²) Paraná	Paraguay	Uruguay	La Plata River (*)	Total by country (km²)
Argentina	583,885 38.6%	186,051 16.5%	63,584 18.0%	150,535 79.2%	**984,055** **30.9%**
Bolivia	–	221,994 19.8%	–	–	**221,994** **7.0%**
Brazil	877,385 57.9%	362,434 32.2%	174,199 49.3%	–	**1,414,018** **44.4%**
Paraguay	53,000 3.5%	353,752 31.5%	–	–	**406,752** **12.8%**
Uruguay	–	–	115,668 32.7%	39,577 20.8%	**155,245** **4.9%**
Total area by water system	**1,514,270**	**1,124,231**	**353,451**	**190,112**	**3,182,064**
% of the La Plata Basin	**47.6%**	**35.3%**	**11.1%**	**6.0%**	**100.0%**
Length of the principal rivers (km)	**4,800**	**2,600**	**1,800**	**700**	
Observed and estimated average flows **m³/s**	**Itatí** **13,916** (Q observed) **Corrientes** **18,989** (Q observed) **Desembocadura** **19,706** (Q observed)	**Puerto Bermejo** **4,696** (Q observed)	**Concordia** **5,725** (Q observed)	**27,225** (Q observed)	

(*) The total area includes the surface of the La Plata River, 30.325 km², shared by Argentina and Uruguay.

tion progressively diminishes to the west, which, together with the high temperatures that determine high levels of evaporation, defines a semi-arid and, in some areas, arid climate. Consequently, the runoff is very small and the contributions of the tributaries of that region to the La Plata system are minimal. The southern part of the LPB presents a temperate climate, although with warm summers and with rains that decrease towards the west.

Regarding its high inter-annual climatic variability, precipitation is conditioned by the El Niño-Southern Oscillation (ENSO) phenomenon in its cold (La Niña) and warm (El Niño) phases, being one of the regions most affected in the world by this phenomenon. For example, during El Niño, high precipitation is recorded in the eastern and central regions of the LPB, which causes huge floods in the Paraguay, Paraná, and Uruguay rivers, with consequent economic and social damages. On the other hand, certain social behaviors, such as unplanned urban expansion and land use in river flood valleys, have led to an amplification of the impacts of these floods. Over the last 30 years, rainfall in the Basin has increased on average between 10 and 15 percent, resulting in higher river water levels, which reached 30 percent, with great benefits for hydroelectricity. This large change in water level rates may have been influenced by the huge change in land use that took place in current years.

- ***Water Resources***

The three main water systems of the La Plata Basin are those formed by the Paraguay River (with an annual average flow of 3,550 m^3/s in Puerto Pilcomayo), Paraná (with 17,200 m^3/s in Corrientes), and Uruguay (4,200 m^3/s in Paso de los Libres). The last two converge in the La Plata River itself, which drains into the South Atlantic Ocean, whose outflow feeds a marine ecosystem very rich in species. The Paraná and Paraguay rivers run from north to south and form an axis that divides the Basin into two parts: to the east is a dense fluvial network with more flowing rivers, while the west is poor in river courses.

The Basin is also rich in groundwater resources. It coincides in large part with the Guarani Aquifer System (GAS), one of the largest subterranean water reservoirs in the world, while to the west is the Yrenda-Toba-Tarijeño Transboundary Aquifer System (YTTAS), which coincides mostly with the semiarid Gran Chaco Americano zone.

- ***Humedales***

The LPB hosts the largest river wetland system on the planet of almost 3,500 km^2, formed by a corridor of wetlands connected by the axis of the great rivers Paraguay, Paraná, and La Plata **(Figure 1.3.5.1)**. The floodplain of the Paraguay River and its continuation to the Paraná River determines a hydrological continuum of wetlands and a biological corridor that extends from north to south from the great Pantanal in the upper Paraguay, passing through the wetlands of the lower Chaco, the wetlands of San Pedro, Ypacaraí, Ypoá, and Ñeembucú in the eastern Paraguay, the broad floodplain of the Paraná River, the Iberá Estuary (Argentina), to the Paraná Delta and the La Plata River Estuary (Samborombón in Argentina, and Santa Lucía in Uruguay).

The main axis of the wetland corridor is a transverse secondary system, with emphasis on the Chaco wetlands associated with the Pilcomayo and Bermejo rivers in lower Paraguay, those of the upper Paraná, and the ones transverse to the Uruguay River, like the Negro and those of the humid pampa region (**Figure 1.1.2**).

- ***Geology***

The geology of the expansive La Plata Basin is made up of raised structures and sedimentary basins, the result of tectono-magmatic and sedimentary events that form a variety of magmatic, metamorphic, and sedimentary rocks from the Precambrian to the Quaternary period. The tectonic behavior has strongly influenced the geology of the area, including the current drainage, such as that of the major water tributaries: Paraná, Paraguay, and Uruguay. In the LPB there are two large geological basins of tectonic origin: the Paraná and the South American Gran Chaco, which until the Mesozoic Era were of a single basin –the Chaco-Paranáense– following its evolution from that period. These two basins are home to the most important aquifer systems in the region, the Yrendá-Toba-Tarijeño Aquifer System (YTTAS) and the Guaraní Aquifer System (GAS) **(Figure 1.1.3)**. The Serra Geral Formation is one of the largest continental volcanic formations on the planet. The rocks produced can be found in the form of lava water levels, whose volume is estimated at 780,000 km³, covering a large part of south and southeastern of Brazil. The post-basalt sediments of sandstone and conglomerates of the Baurú and Caiuá groups were deposited in a semi-arid or desert continental environment: the so-called Caiuá desert.

- ***Soils***

The LPB boasts a great diversity of soils as a result of geological and climatic evolution. As with the vast majority of soils in Latin America, those in this region are poor in nutrients (characteristic of tropical areas), acidic (product of intensive land use in agricultural areas), and affected by erosion processes, surface washing, and high concentrations of iron and aluminum oxide in the subsurface. Large areas with soils influenced by salts are also identified, mainly in endorheic basins where water has no direct outflow to the sea (the Gran Chaco Americano of Paraguay, Bolivia, and Argentina). The origin of these salts is the product of the weathering of rocks with high levels of salt caused by water erosion, old marine sediments, and deposits of saline groundwater evaporation. The arid regions are concentrated near the pre-Andean mountain range characterized by shallow soils and rugged relief.

The current problems related to soil resources are due to inadequate systems of habilitation and change in land use, which have allowed deforestation and overexploitation of natural resources. The LPB has one of the highest rates of suspended solids transport in the world. The largest solid inputs come from the Bermejo River basin, an affluent part of the Paraguay River. Also in the upper Paraguay-Pantanal, there are significant wetland conservation problems related to the increase of sediment. Another critical area is the Gran Chaco, where soil degradation is the main axis of analysis for the integrated management of natural resources.

- ***Biodiversity and Protected Areas***

The Basin comprises a region with remarkable ecosystems, from the Iguazu Falls to the huge wetland corridor that connects the Pantanal with the Paraná Delta, at its mouth in the La Plata River, constituting an important freshwater reserve with a rich biological and cultural diversity, extremely appropriate for the implementation of sustainable development strategies which include ecotourism programs and projects.

Figure 1.1.2

Wetlands of the La Plata Basin

Figure 1.1.3

Transboundary Aquifers of the La Plata Basin

Transboundary Aquifers

- Aquidaban – Aquidauana
- Palermo – Estrada Nova – Río Bonito
- Agua Dulce
- Bauru – Caiuá – Acaray
- Botucatu – Tacuarembó – Misiones – Piramboia – Buena Vista
- Permo Carboniferous System
- Serra Geral
- Pantanal
- Yrendá – Toba – Tarijeño Aquifer System (YTTAS)
- Guaraní Aquifer System (GAS)

The Basin is recognized as one of the most important in the world for the quantity, variety, and endemism of fish species. Its rich ichthyofauna reaches 908 species, 40 percent of which have socio-economic relevance. Some of the species (sábalo, surubí, dorado) are undergoing intense exploitation in some stretches.

In the Basin, 601 protected areas have been created covering 22.8 million hectares, representing a protection of 7.2 percent of its total area. Considering the Aichi Targets from the Convention on Biological Diversity (CBD)—which aim to reach 17 percent protected areas for the period 2011-2020—the current percentage of protected areas is low, practically one-third of the target. There are also 29 Ramsar sites covering almost 85,000 km² and 18 Biosphere Reserves (MAB-Unesco) covering almost 361,000 km².

The Selva Misionera Paranaense (SMP) is part of the Atlantic Forest ecoregion complex, originally covering an area of 47,000,000 ha. Since the mid-twentieth century there has been a gradual loss of forest mass with the aim of replacing it with pastures, agricultural crops, and forest plantations, leading to extraordinary soil degradation, alterations to the hydrological cycles, and causing local climatic fluctuations. This ecoregion continues to be one of the most diverse biological ecosystems on the planet, internationally considered a high priority for conservation because of the ecological importance of its remnants.

1.2 Socioeconomic Characteristics

- ***Population***

In the LPB, where the current population exceeds 110 million people, there are at least 20 cities with more than 500,000 inhabitants, including the capitals of four of the countries that make up the Basin: Buenos Aires, Brasilia, Asunción, and Montevideo. Sucre, the constitutional capital of Bolivia, is also located in the Basin; and one of the largest megalopolis and industrial concentrations in the world, the city of São Paolo (Brazil), which houses more than 20 million people, is located on one of the tributaries of the Paraná River.

The average population density throughout the Basin is 20.2 hab/km², but in Argentina and especially in Brazil, the population density of the Basin is much higher than in the rest of the country. Brazil contributes 44.4 percent of its territory to the Basin and 63.1 percent of its total population. The urban population is 86.3%, with Argentina, Uruguay, and Brazil the countries with the highest percentages of urban population.

- ***Economic Activity***

Agriculture is the main economic activity carried out in the Basin, and soybeans, wheat, and maize are the main crops. It is also worth pointing out the important areas of rice cultivation, produced with flood irrigation, as it is one of the largest water consumers. Industrial activity is diversified and is particularly related to the main urban centers in Argentina and Brazil, such as the metropolitan areas of São Paulo and Buenos Aires. In these regions, the most important industrial production is related to automotive development and petroleum derivatives. The production of the mining industry occupies an important place among the economic activities of the countries of the LPB, although it is not a high-production mineral area.

The LPB has a very important hydropower generation capacity. Its use is a significant portion of the energy generation in the countries involved.

Table 1.2.1

Distribution of the area and population of the La Plata Basin by country

	La Plata Basin Area		La Plata Basin Population		Density
Country	**Km²**	**%**	**Inhabitants**	**%**	**Inhabitants/ km²**
Argentina	984,055	30.9	29,463,029	26.3	24.85
Bolivia	221,994	7.0	2,064,348	1.8	9.30
Brazil	1,414,018	44.4	70,527,416	63.1	49.88
Paraguay	406,752	12.8	6,672,631	6.0	13.70
Uruguay	155,245	4.9	3,105,368	2.8	20.00
Total	**3,182,064**	**100**	**111,832,792**	**100**	

Navigation is carried out on the Paraguay-Paraná waterway, the main route that connects the Basin countries; the Uruguay River; the section downstream of the Salto Grande dam; and Tietê-Paraná, where navigation takes place within Brazil due to the lack of sluices in the Itaipú dam.

- ***Socioeconomic Indicators***

The richness of mineral resources, the value of its forests, and the fertility of its soils have made the LPB a region of strong population attraction that today favors its economic development, which translates into a concentration of 70 percent of the GDP of these countries. The economies of Argentina, Brazil, and Uruguay, with a strong agricultural and livestock component, also show significant industrial production and services, while Bolivia's economy is based on its mineral resources and Paraguay's maintains its development based on agro and hydroelectric power.

As for the share of each sector of the economy within the GDP, agriculture has a relatively small impact on the economies of the countries, with the exception of Paraguay. The water and energy sectors account for between one and 10 percent of the economies, while the combination of water-related sectors (agriculture, transport, and energy) varies between 16 percent and 35 percent **(Figure 1.2.2)**.

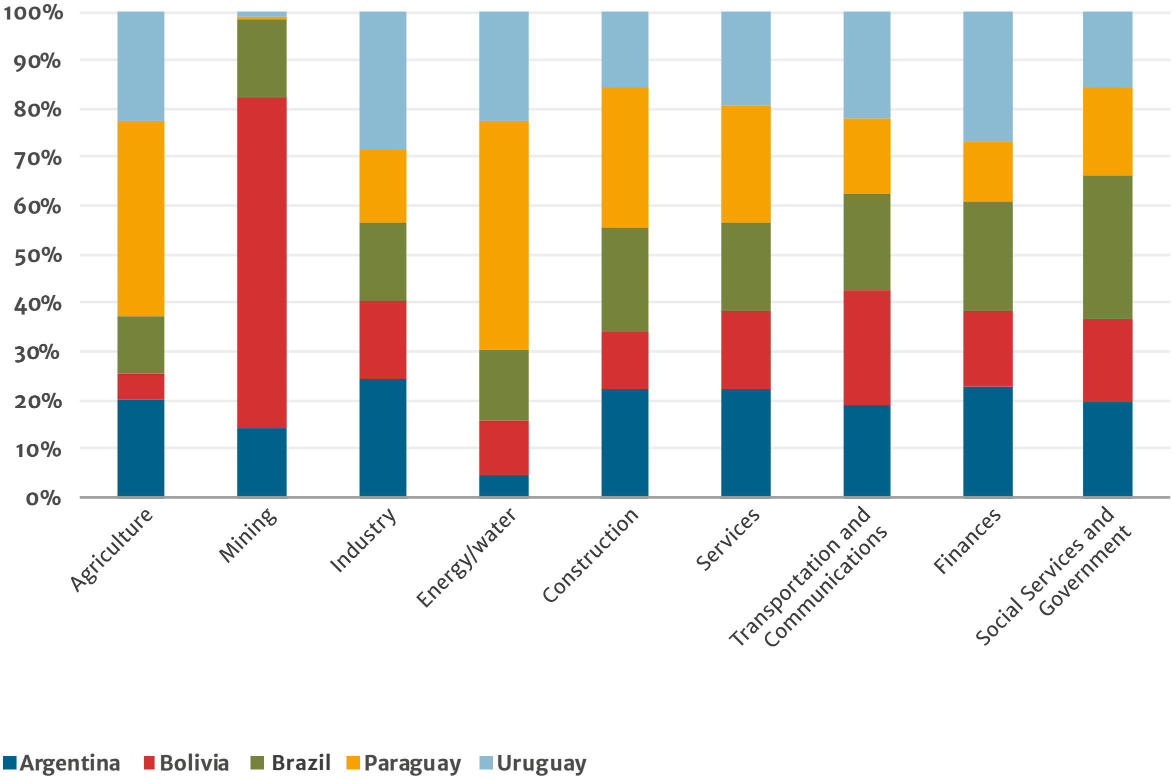
The Basin countries have disparate Human Development Indices, which shows the diversity of their social and economic conditions. In some urban and rural settlements of the Basin there are health afflictions caused by biological contamination from a lack of adequate sanitation and water treatment services.

- ***Health***

The health-related situation in the countries of the LPB can be analyzed in gener-

Figure 1.2.2

Percentage distribution of the participation of the different sectors in the economy of La Plata Basin countries



Source: Statistical Yearbook of Latin America and the Caribbean. ECLAC, 2013.

al terms by indicators such as life expectancy at birth and infant mortality rates. Life expectancy at birth in the respective departments, states, or provinces varies between 70.9 and 77.2 years for Argentina, between 62.0 and 69.5 years for Bolivia, between 74.2 and 76.2 for Brazil, 72.5 years for all of Paraguay, and between 75.1 and 77.2 years for Uruguay. On the other hand, infant mortality rates vary between 8.9 and 14.9 percent for Argentina, between 37.2 and 65.5 percent for Bolivia, between 9.8 and 17.7 percent for Brazil, 15.2 percent for all of Paraguay, and between 5.4 and 11.4 percent for Uruguay.

The biological contamination mentioned above results in episodes of waterborne diseases such as diarrhea, cholera, malaria, and dengue, which are common in certain regions. Regarding the potential health risks in drinking water sources, a number of blue-green algae blooms or toxigenic cyanobacteria have been recorded in different river systems in recent years. If they grow disproportionately, these organisms produce cyanotoxins that can affect the health of the population. Schistosomiasis (especially in Brazil), a water-borne parasitic disease transmitted by freshwater snails that, according to the World Health Organization (WHO), is the second most important parasitic disease after malaria, should be considered due to the damages that it causes to the health and the economy of the countries where it resides.

As for more specific problems, it is important to note that in several areas of Argentina the population must consistently use water with a high arsenic content—a natural element found in the earth's crust—above acceptable limits for drinking water standards. Although significant efforts have been made to minimize or eliminate this contaminant in drinking water through physio-chemical treatments, the problem has arisen in many localities, especially in populations without potable water service networks.

1.3 Legal and Institutional Characteristics

- ***La Plata Basin Treaty***

The La Plata Basin Treaty was signed on April 23, 1969 by the governments of Argentina, Bolivia, Brazil, Paraguay, and Uruguay, the five countries that make up the Basin, with the objective of joining forces to promote the harmonious development and physical integration of the Basin and its areas of direct influence. Within the framework of the Treaty, the countries agreed to identify areas of common interest and to carry out studies, programs and works, as well as to formulate operational understandings and legal instruments that they deem necessary, including: (i) navigation facilitation and assistance; (ii) the rational use of water resources, especially through the regulation of watercourses and their multiple and equitable use; (iii) the preservation and promotion of animal and plant life; (iv) upgrading road, rail, river, air, electrical, and telecommunications connections; (v) the promotion of projects of common interest, especially those related to the inventory, evaluation, and use of the area's natural resources.

- ***The La Plata Basin System***

The La Plata Basin System is a set of organisms created to fulfill the objectives of the La Plata Basin Treaty by the La Plata Basin Treaty. The system formally includes the Meeting of Ministers of Foreign Affairs, the Intergovernmental Coordinating Committee of the Countries of La Plata Basin (CIC), the Intergovernmental Committee of the Paraguay-Paraná Waterway (CIH), and the La Plata Basin Financial Development Fund (FONPLATA).

- ***The Intergovernmental Coordinating Committee of the Countries of the La Plata Basin (CIC)***

The CIC was created in February 1967. After the singing of the Treaty, it became the permanent organ of the Basin, responsible for promoting, coordinating, and following progress of multinational efforts to ensure the integrated development of the La Plata Basin. The CIC's actions are particularly aimed at supporting activities of common interest, including facilitating studies, programs, and infrastructure works on hydrology, natural resources, transport and navigation, soils, and energy. The need for technical management capacity in the LPB was recognized in December 2001 in the agreements from the meeting of Foreign Ministers of the Basin held in Montevideo, which approved a new Statute for the CIC that incorporates two representatives per country—one political, with plenipotentiary authority, and a second technical representative. The technical representatives of the countries constitute the Project Unit of the La Plata Basin System.

- ***Regional Regulatory Framework***

There is sufficient legal framework in the five LPB member countries for the management and protection of natural resources and, in particular, of water resources, which is integrated with constitutional, legal, and regulatory provisions at the national, provincial, state, or municipal level. However, it has been found that in several cases, implementation tools, as well as the institutional capacity to implement and monitor that implementation, need to be strengthened. That is, there is a gap between the legal framework and its practical application. In general, countries have developed an important body of legislation and, following regional and international trends, have incorporated principles and tools in line with the needs for management and protection of natural resources, in some cases also taking climate change into account. Except for specific cases, the normative advances have not been accompanied by effective regulation and implementation of management instruments that require the corresponding allocation of financial, human, and logistical resources.

The five countries of the Basin have ratified the Ramsar Convention on Wetlands, the United Nations Framework Convention on Climate Change, and the Convention on Biological Diversity, among other global agreements. Among the regional ones, mention may be made, among others, of the Convention on the Use of the Uruguay River Rapids in Salto Grande (Argentina-Uruguay), the Treaty of Itaipú (Brazil-Paraguay), and the Mercosur Environmental Framework Agreement (Argentina-Brazil-Paraguay-Uruguay). All countries have national standards in this field, such as the General Environmental Law (Argentina); The Mother Earth Law, which incorporates a framework on climate change (Bolivia); The Water Law (Brazil); The Law on Water Resources (Paraguay); and the Law on National Water Policy (Uruguay).

The legal-institutional framework on specific issues, such as extreme hydrological events, is made up of agreements, such as those referencing Combating Desertification in Countries Affected by Severe Drought (1994); national standards such as Brazil's National Law on Protection and Civil Defense, and national plans such as the Federal National Flood Control Plan of Argentina. Regarding the loss of water quality, the countries have ratified the Stockholm Convention on Persistent Organic Pollutants (1989) and have their own regulations, such as the Law on the granting of effluent discharges (Brazil). In terms of sedimentation of watercourses and bodies, one example is Paraguay’s law on restoration of forests protecting the watercourses of the Eastern Region and their conservation.

To the broad regulatory panorama –of which only the main examples have been cited– agreements and specific norms on other topics such as navigation, hydroelectricity, contingency plans for disasters, alteration and loss of biodiversity, sustainable use of fishery resources, and the sustainable use of aquifers in critical areas, among other topics should be added.

- ***Institutional Framework***

In addition to the CIC, there are other multilateral organizations active in the LPB. A list of the principal entities and their dates of creation is presented in the following list.

Main institutions acting in the La Plata Basin:

- Mixed Technical Commission of Salto Grande (CTM), 1946

- Intergovernmental Coordinating Committee of the Countries of the La Plata Basin (CIC), 1967
- Paraguayan-Argentinian Mixed Commission of the Paraná River (COMIP), 1971
- Binational Itaipú, 1973
- La Plata River Administrative Commission (CARP), 1973
- Joint Technical Commission for the Maritime Front (CTMFM), 1973
- Yacyretá Binational Entity (EBY), 1973
- Administrative Commission of the Uruguay River (CARU), 1975
- La Plata Basin Financial Development Fund (FONPLATA), 1976
- Intergovernmental Committee of the Paraguay-Parana Waterway (CIH), 1989
- Mercado Común del Sur (MERCOSUR/MERCOSUL), 1991
- Brazilian-Uruguayan Joint Commission for the Development of the Cuarein-Quaraí Basin (CRC), 1991
- Binational Administrative Commission of the Lower Basin of the Pilcomayo River, 1993
- Trinational Commission for the Development of the Pilcomayo River Basin, 1995
- Binational Commission for the Development of the Upper Basin of the Bermejo River and Rio Grande de Tarija (COBINABE), 1995
- Brazilian-Paraguayan Joint Commission for the Sustainable Development and Integrated Management of the Apa River Basin (CRA), 2006

To these are added national and interjurisdictional institutions as well as national or basin plans in all countries.

1.4 Monitoring, Alert, and Hydroclimate Prediction Systems

1.4.1 Hydro-meteorological Monitoring Systems

- ***Meteorological Observations***

Meteorological forecasting and observations in general are some of the main activities of the meteorological services of each country; in the LPB each of the five countries has an institution of this type:

National Weather Service (SMN) of Argentina, National Meteorology and Hydrology Service (SENAMHI) of Bolivia, National Institute of Meteorology (INMET) of Brazil, Department of Meteorology and Hydrology (DMH) of Paraguay, and the Uruguayan Institute of Meteorology (INUMET). These institutions are the nexus of each country with the World Meteorological Organization (WMO), which since 1950 is the United Nations agency specializing in meteorology (weather and climate), operational hydrology, and related geophysical sciences. In some countries, meteorological observations are also made by other agencies, including the Institute of Agricultural Technology (INTA) in Argentina; National Spatial Research Institute (INPE), National Center for Natural Disaster Monitoring and Alert (CEMADEN), and the Paraná Meteorological System (SIMEPAR) in Brazil; the Paraguayan Institute of Agrarian Technology (IPTA) in Paraguay;

and the National Institute of Agricultural Research (INIA) in Uruguay. It should be noted that the private sector and nongovernmental organizations also participate in meteorological observations.

- ***Hydrological Observations***

Meteorological services may also include hydrological observations, such as the case of the SENAMHI of Bolivia, where both types of official observations are carried out by the same institution. But in the rest of the countries of the LPB, hydrological observations are made by other national institutions dedicated to solely this. Such is the case of the Sub-secretariat of Hydraulic Resources (SSRH), National Water Institute (INA) and National Directorate of Waterways (DNVN) in Argentina; the National Water Agency (ANA) in Brazil; National Administration of Navigation and Ports (ANNP) and General Directorate for the Protection and Conservation of Water Resources of the Secretariat of the Environment in Paraguay; and the National Water Directorate (DINAGUA) in Uruguay. In addition to these institutions, there are regional or provincial entities that carry out hydrological monitoring and national entities that require information for specific purposes, such as the energy sector.

The water sector also highlights entities that operate hydroelectric plants in the international and domestic rivers of the Basin, which also operate hydro-meteorological stations. These include Binational Itaipú (Brazil-Paraguay), Yacyretá Binational Entity (Argentina-Paraguay), and the Mixed Technical Commission of Santo Grande (Argentina-Uruguay). Hydro-meteorological information is generated by networks operated by different actors—public or private, national or binational—which represents a challenge when integrating information.

- ***Meteorological Radar in the La Plata Basin***

For some years now, countries such as Argentina, Brazil, and Paraguay have had hydro-meteorological observation systems that represent a powerful tool for prediction and hydro-meteorological alert with wide application, such as the risk management of natural disasters.

In Argentina in 2011 the National System of Meteorological Radar (SINARAME) was launched, to develop and construct doppler radar and the design and implementation of an Operations Center with the capacity to receive, process, and analyze the respective. In Brazil one of the strategic objectives of the National Plan for Managing Risks and Responses to Natural Disasters is to expand the weather and climate observation network within the national territory; the radars integrate a system of prevention and alert on extreme climatic conditions, a network that is being expanded with the acquisition of new radars with the latest technology. In Paraguay a meteorological radar system located in Asunción is in operation, and there are plans to expand the network with a new radar in the center of the eastern region of the country in order to obtain better regional coverage. The possibility of having a meteorological radar functioning in Uruguay and integrated regionally would help to close the gaps in current meteorological radar observations in the Basin.

- ***Meteorological Satellites***

The information from meteorological satellites is extremely useful for hydro-meteorological purposes as it provides up-to-date data on meteorological conditions affecting large areas, and it constitutes a complementary observation tool for obtaining information from geographic areas with little or no information, as well as for the monitoring and development of meteorological systems of synoptic scale, precipitants or not, that can provide information for forecasting and alerts.

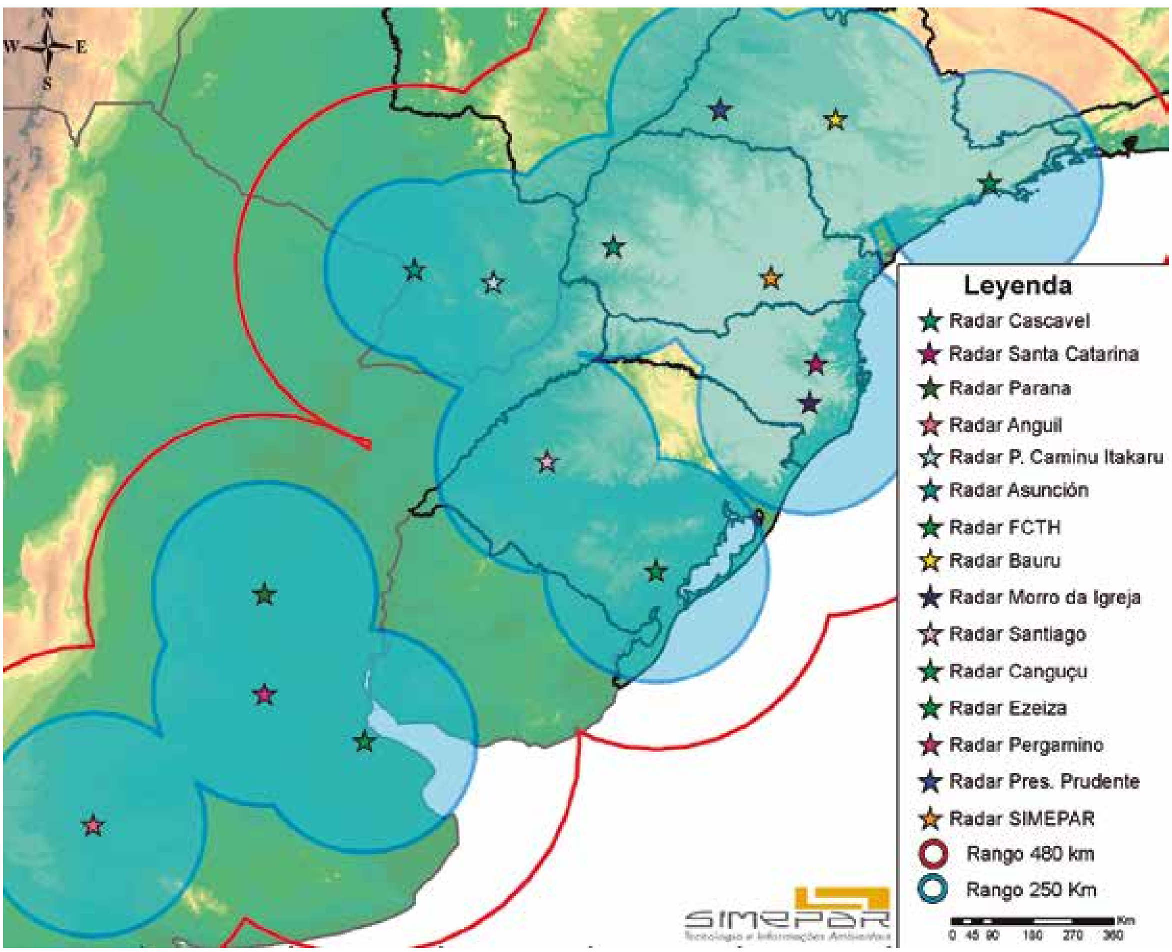
In the LPB there are several sources of information that update data and images every 30 minutes. The meteorological services of the region process information from GOES-13, which is available in real time. Various types of images are available throughout the day (infrared image, visible image, cloud cover, and water vapor), all of which provide useful information to define the weather situation and forecast. Products from other satellites, generally from polar orbit, are available with complementary information, such as precipitable water and instability indexes.

- ***WIGOS***

WIGOS (WMO Integrated Global Observing System) is an integrated proposal to improve and develop the WMO observing system. WIGOS will promote the organized evolution of current observational systems (GOS, GAW, WHYCOS) operated by its member countries into an integrated, intelligent, and coordinated observation system.

Figure 1.4.1.1

Meteorological Radar in the La Plata Basin



This will cover the growing observation requirements of WMO members in a sustainable manner, improving the coordination of the organization's observing systems with those of associated international organizations. WIGOS, supported by the WMO Information System (WIS), will be the foundation for providing reliable, real-time observations and products related to weather, climate, water, and the environment for all its members and programs. WIGOS will allow its members, in coordination with other national agencies, to respond better in the event of natural disasters, to improve the monitoring and forecasting services, and to adapt to climate change, especially in developing countries.

1.4.2 Hydro-climatic Warning and Prediction Systems

There are several sources of hydro-meteorological information available in the LPB. In addition, there are several institutions that perform the data processing in real time in order to generate information from the basic data and thus obtain a hydro-climatic sequence, prediction, or alert. In Argentina, among the institutions working on this topic is the National Weather Service (SMN), whose mandate is "to carry out and disseminate meteorological warnings in the face of meteorological situations that endanger the life or property of the inhabitants," and National Water Institute, a decentralized agency dependent on the Undersecretariat of Water Resources of the Nation. It is responsible for the development and operation of the Hydrological Information and Alert System of the La Plata Basin (SIyAH). The ALERT.AR program—funded by the Ministry of Defense's Secretary of Science, Technology, and Production—has been implemented since 2014 by the SMN, INTA, and the National Scientific and Technical Research Council (CONICET), with the purpose of generating meteorological forecasts capable of determining environmental conditions for the development of extreme events with a high impact on the population and its goods.

In Bolivia, the National Meteorology and Hydrology Service (SENAMHI) is the body that governs meteorological, hydrological, agrometeorological, and related activities at the national level, with international representation. As a science and technology institution, it provides specialized services to contribute to the sustainable development of the Bolivian State, meeting information requirements at the national and international levels, participating in global atmospheric surveillance and contributing to the Civil Defense disaster prevention. It is also important to mention the National Integrated Information System for Disaster Risk Management, carried out by the Vice Ministry for Civil Defense (VIDECI), which is supported by the National Disaster Early Warning System (SNATD).

In Brazil, the Center for Weather Forecasting and Climate Studies (CPTEC), provides *boxplot* graphs or diagrams as a product of climate monitoring of monthly and seasonal rainfall for 124 regions in Brazil. These products are generated using a historical series of 30 years of precipitation data on Brazil (1981 to 2010). Similarly, the National Institute of Meteorology (INMET), in its Internet portal, offers information on accumulated precipitation in recent days, presenting cumulative precipitation maps for the entirety of Brazil for recent specific periods, with daily updates. The National Water Agency (ANA) is the National System of Information on Hydraulic Resources (SNIRH) operator, where the Hydrological Monitoring System (telemetry) is available, among other sources of information.

In Paraguay, the National Directorate of Civil Aeronautics (DINAC), through the Department of Meteorology and Hydrology (DMH), is responsible for issuing meteorological warnings, particularly those caused by severe storms that generate risky situations due to intense rains, strong winds, and hail. Direct communication with the Secretary of National Emergencies (SEN) allows the activation of a national-level alert system. The DMH has a network of conventional and automatic meteorological stations, a meteorological satellite image capture system, and a meteorological radar; in addition, it has resumed radiosonde observations in Asunción by implementing the Leading Environmental Analysis and Display System (LEAS), which facilitates the display of data and images from automatic observing systems, radar, and satellites. The DMH has in its portal the daily behavior of the Paraguay River, comparing extreme situations of floods and droughts. The National Administration of Navigation and Ports (ANNP) makes hydrological observations, particularly of daily hydrometric height, in coordination with the Directorate of Hydrography and Navigation of the Paraguayan Navy, for which it has several measurement points on the Paraguayan section of the Paraguay River and in the border section.

In Uruguay, Uruguayan Institute of Meteorology (INUMET) produces monthly values of accumulated precipitation and their corresponding anomaly, using all the rain gauges that make up the National Pluviometric Network. Similarly, the National Institute of Agricultural Research (INIA) also performs pluviometric analysis for agricultural purposes, representing seasonal precipitation and its corresponding anomalies, using 75 INUMET meteorological stations and five of its own stations as a database. Uruguay has an Early Flood Warning System (SAT) in Durazno. This system is based on a hydrological-hydrodynamic model in an area of 8,750 km^2, using real-time precipitation data and precipitation and wind forecasts as input, as well as data on topography, soils, geology, and land use.

Chapter 2: Climate Variability and Change in the La Plata Basin

The hydro-climatic regime of the LPB is highly influenced by the South American Monsoon, a system of seasonal atmospheric circulation conditioned by the seasonal solar radiation that affects the tropical and subtropical parts of South America. One of its main characteristics is the well-defined annual cycle of precipitation in most of the Basin, with maximums in summer and minimums in winter. This seasonality is more accentuated in the sub-basins of Paraguay and of the Paraná Rivers, being somewhat attenuated in those of the Uruguay and of the La Plata River itself.

El Niño and La Niña events, associated with variations in the surface temperature of the Equatorial Pacific Ocean, has a significant effect on the climate of a large part of the La Plata Basin, especially on the inter to annual weather scale, affecting rainfall variability. Intense precipitation and overflows have been observed during the El Niño years, such as from 1982 to 1983 and from 1997 to 1998. In La Niña years, tendencies of rainfall deficit and drought have been observed. The relationship between precipitation and El Niño and La Niña events is a predictor of the rain systems for the forthcoming months, given that its evolution can be predicted months in advance.

During the southern spring and summer, the rains of southeastern South America are controlled by both the South Atlantic Convergence Zone (SACZ)—a band of intense convective activity that extends from the south of the Amazon to the southeast of Brazil and the Atlantic Ocean—and the South American Low to Level Jet (SALLJ). These systems produce important rains in the region. In the same way, between autumn and spring, the incursion of extratropical cyclones are responsible for much of the precipitation that occurs in the eastern part of the Basin and in the sub-basins of the Lower Paraná and the Uruguay and in the La Plata River itself, coinciding also with reduced precipitation in the sub-basins of the Paraguay.

The systematic increase in precipitation and overflow from the middle of the 70s is consistent with the intensity and frequency of SALLJ events, which is apparently corroborated by the observations that indicate more frequent extreme rain events in the La Plata Basin, which have increased in the last 30 years. This higher frequency and intensity of extreme precipitation events is also accompanied by a tendency for the delay in the beginning of the austral spring or an increase in the length of the dry season in the central and northern parts of the Basin.

The year 2015 was the warmest since the mid-nineteenth century, when temperature measurements became available. According to WMO data, the global mean surface temperature beat all previous records by a surprisingly high margin, 0.76 ± 0.1°C above the 1961-1990 average. In the LPB, a higher than average temperature was observed, between 0.5°C and 1.5°C.

2.1 Climate Change Scenarios in the La Plata Basin

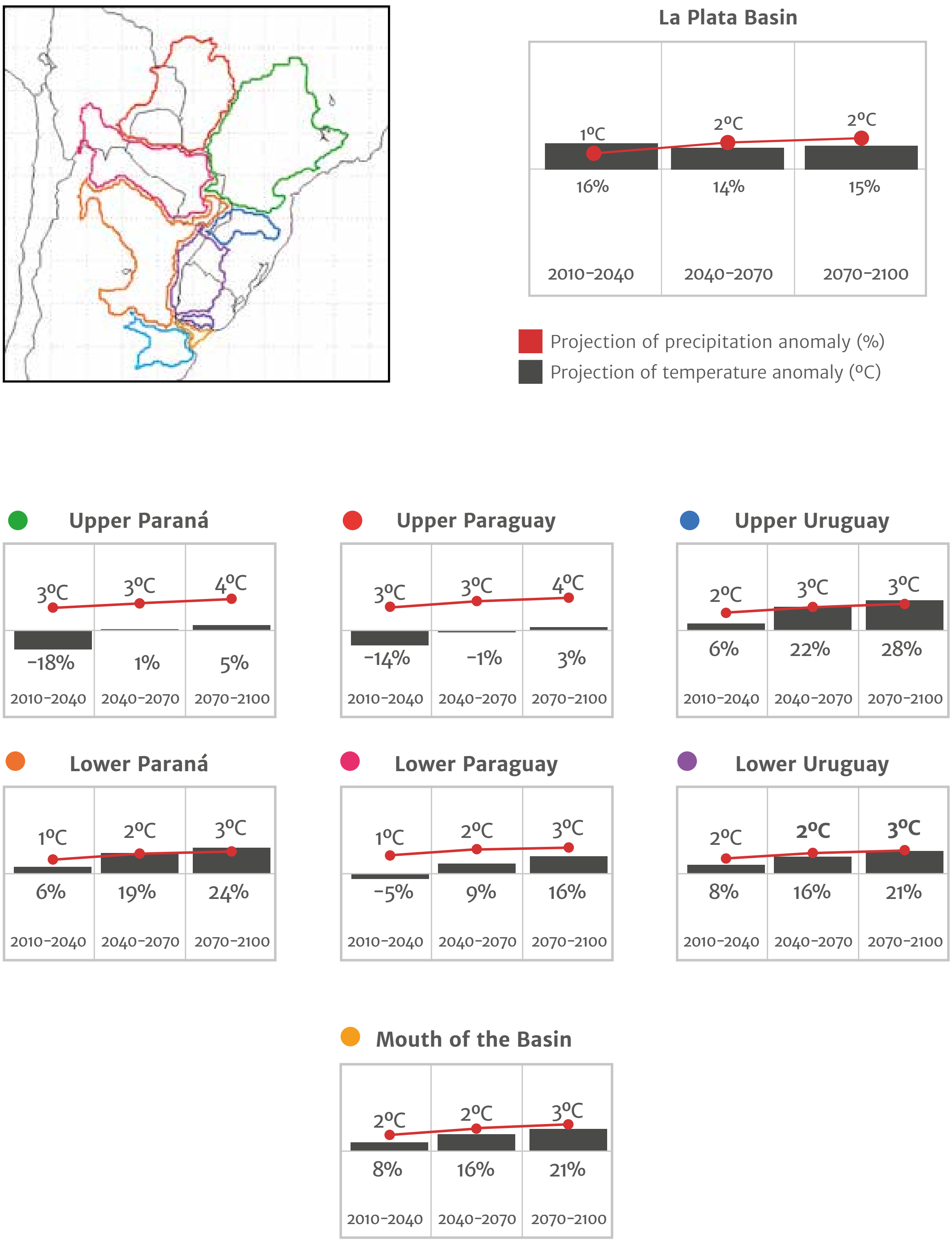
As part of the project's activities, simulations using the ETA regional climate model were carried out, for the RCP 4.5 scenario (moderate), for the period from 1960 to 2100, which reproduced a present climate using precipitation and air temperature field stations that could be considered acceptable compared to the data observed in the same period. The ETA climate model has allowed for the generation of regional results from the scenarios established by the IPCC, and for the translation of those results into other indicators, such as risk, water levels, soil moisture, and soil erodibility. While the conclusions are important and indicative of potential impacts, it is acknowledged that this approach has its limitations given the current uncertainty of global climate models Thus, for the management of future scenarios, it is advisable to employ a combination of models in order to then consider the joint results. However, despite the negative trend being more pronounced than other models in precipitation and positive temperature anomalies, the ETA model can be considered a valid guide for the analysis of future climatic scenarios. The results of the application of the ETA model were as follows:

- *Precipitation.* Seasonal precipitation in general was adequately reproduced, with a tendency to underestimate the summer precipitation in the SACZ area (upper Paraguay and upper Paraná), while in winter and spring the tendency is the overestimate the precipitation in the southeastern part of the Basin (upper Paraná and upper Uruguay). With respect to the temperature of the present climate, a steady reoccurrence can be observed, even though it underestimates the temperature in the summer and fall in the southeast (upper Uruguay) and in the winter in the central to western part of the Basin (lower Paraguay and lower Paraná), while the temperature in the SACZ zone is overestimated a bit (upper Paraguay and upper Paraná).

- *Climate.* With respect to future climates, the average result of the seasonal fields of precipitation and air temperature are presented for the periods 2011 to 2040, 2041 to 2070, and 2071 to 2100, which are compared with the present climate. Future precipitation, according to the model, presents differences or anomalies for different periods in relation to the reference period: 1961 to 1990. From 2011 to 2040 it is possible to observe a negative anomaly tendency with respect to precipitation in a large part of the La Plata Basin, principally in the summer and, to a lesser extent, in the fall and in the spring. This negative anomaly extends throughout the area known as the SACZ region, from the Atlantic coast of the southeastern region to the central western region. It is necessary to underscore the strong negative anomalies in summer in the upper Paraná sub-basin. The

Figure 2.1.1

Projections of the average annual precipitation anomaly (%) and the mean annual temperature anomaly (° C)



decrease in precipitation is also observed during the winter season (June, July, and August) in the southeastern part of Brazil, although with lesser magnitude. Meanwhile, an increase in precipitation is observed in the upper Uruguay sub-basin during the spring and fall and in areas towards the La Plata River.

- *Temperature.* The future climate temperature for the periods analyzed demonstrates a persistent warming tendency during the reference period throughout the Basin. During 2011 to 2040 the greatest anomalies can be observed in the upper Paraguay (Pantanal) sub-basin, especially in summer, when the anomalies reach up to 3.5°C. In the same region, extremes are also observed in fall and spring, with winter being the season that presents the most subtle anomalies, although with significant values of 2°C or more. During 2041 to 2070 global warming will continue to rise, demonstrating anomalies of between 2.5°C to 4.0°C in spring and summer, with more subtle increases in fall and winter, from 2.5°C to 3.0°C for all of the Basin, with the warmest zones continuing to be the Pantanal region in the upper Paraguay.

2.2 Results Analysis and Impact Predictions

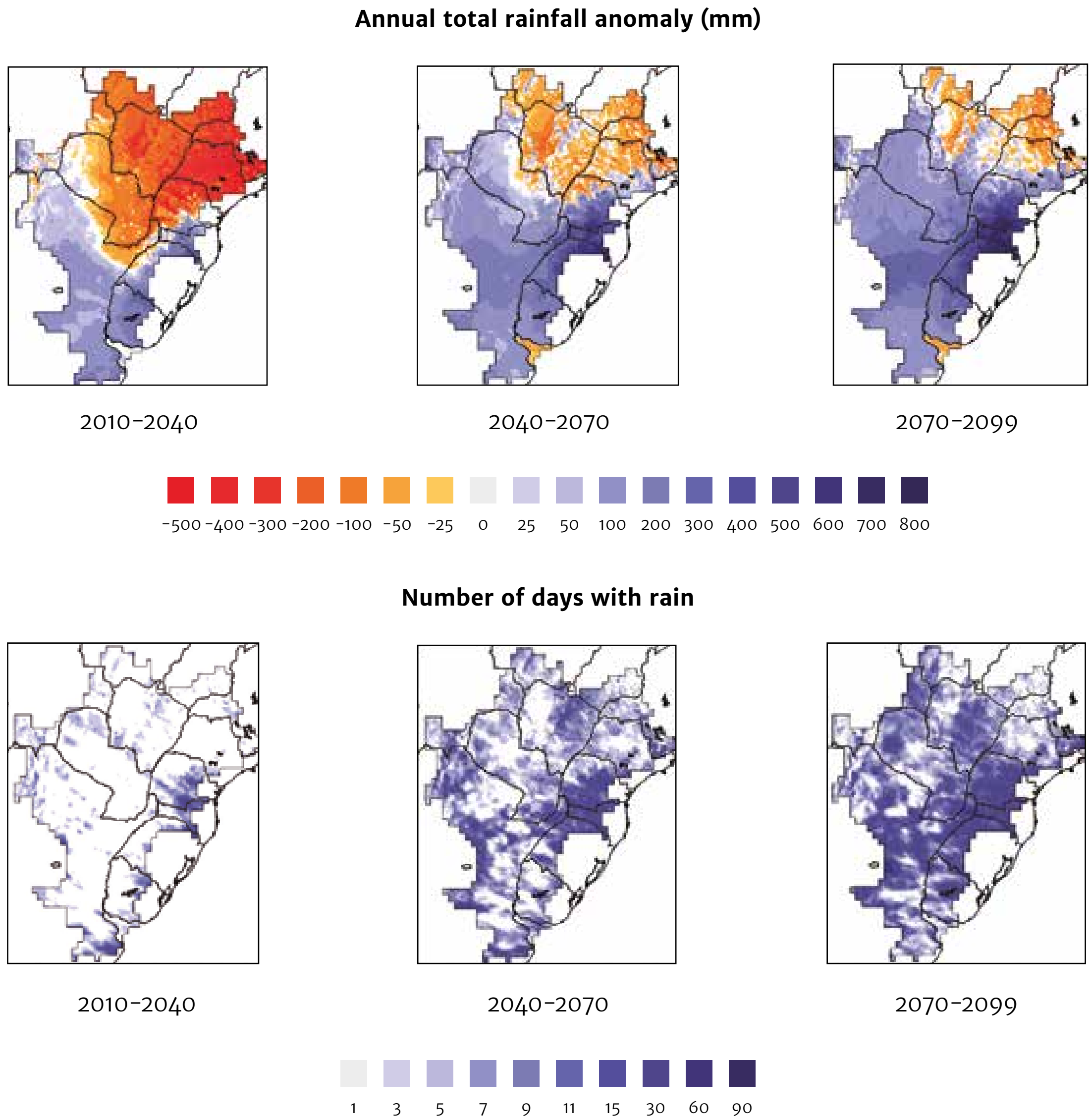
Other ETA results indicate that consecutive dry days will decrease during the twenty-first century, while consecutive wet days will increase during the same period, keeping consistent with the annual precipitation trend. Projections also indicate a greater tendency of intense rainfall, especially in the southeastern region of the Basin, which could influence the occurrence of extreme events. Regarding total annual precipitation, an increase throughout the century can be observed. While during the period from 2011 to 2040, the total annual rainfall is lower than what is currently observed in the northern part of the Basin, it subsequently tends to increase. In contrast, in the central and southern parts of the Basin, it tends to increase with respect to the present. The number of rainy days tends to increase throughout the century, suggesting greater activity of precipitation systems **(Figure 2.2.1)**.

When considering immediate scenarios in climatic terms, the period from 2011 to 2040 presents situations such as a decrease in precipitation in much of the Basin and a considerable increase in temperature. This scenario could affect water resources in the LPB. In a scenario with lower precipitation and higher temperatures, the regional hydrological balance could lead to declining average flows, facilitating the occurrence of extreme events, such as a greater possibility of droughts and forest fires.

The results of the studies carried out on climate change projections and their possible impact on the water level of the rivers of the LPB—for the periods 2011 to 2040, 2041 to 2070, and 2071 to 2100—indicate an increase in average and minimum water levels in the Uruguay and Iguazú rivers and an initial decrease in average water levels followed by a subsequent increase in the northern region of the Paraná basin—mostly in the basin of the Paranaíba River—and in the Upper Paraguay region. On the other hand, a reduction in minimum water levels is foreseen. The projections also indicate an increase in the average and minimum water levels in the Chaco region, represented by the Bermejo and Pilcomayo rivers, and an initial reduction of the average water level, followed by an increase with respect to the reference period in the Paraná River, in Itaipú. The same is true for minimum water levels. In the middle and

Figura 2.2.1

Annual total precipitation anomaly



ETA—CPTEC Model.

lower reaches of the Paraná River, it is expected that both average and lower water levels initially decrease, and then increase in the future **(Figure 2.2.2)**.

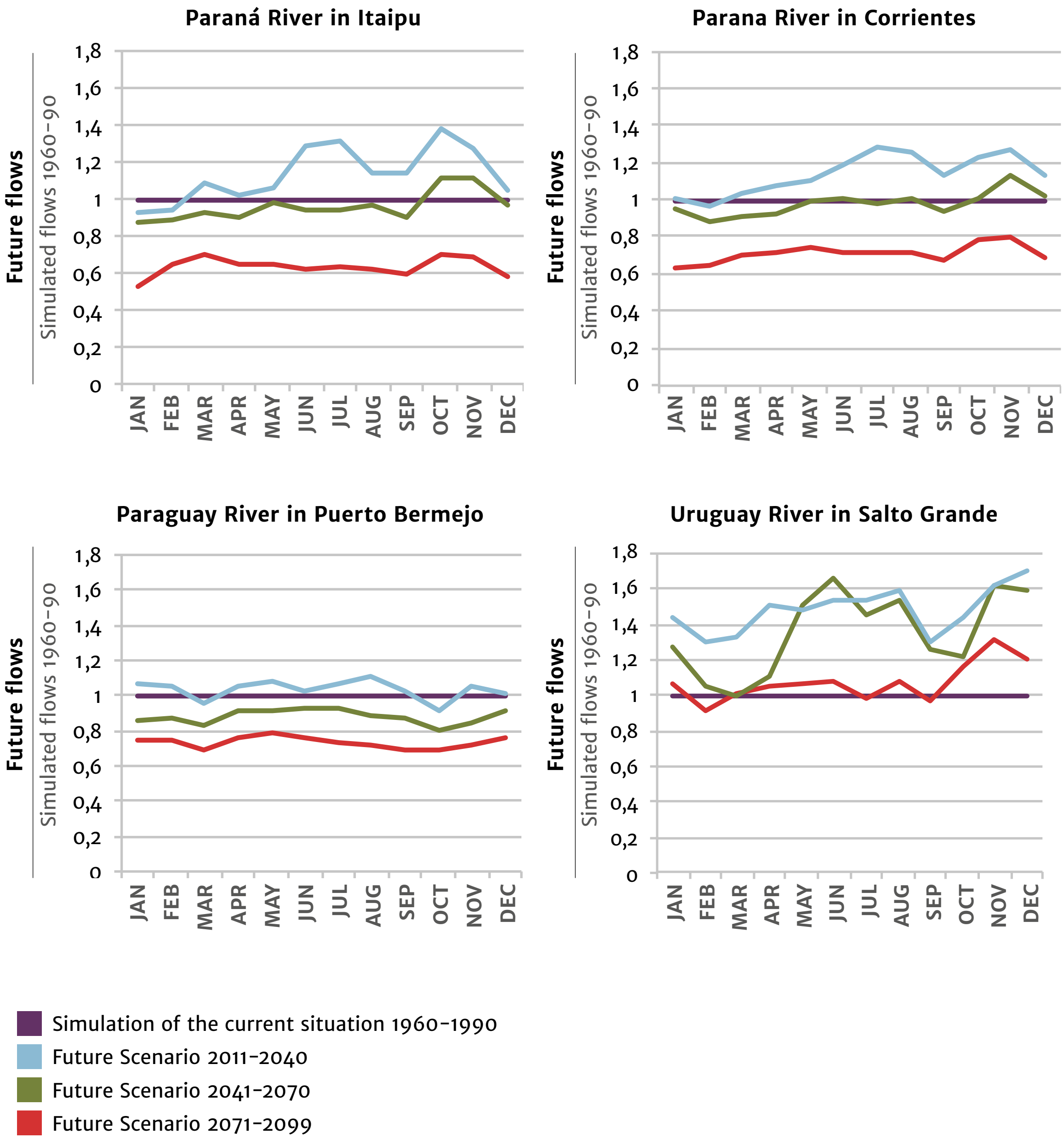
The main impact on urban development is observed in reduced water security, especially in those cities that are in the headwaters of the rivers and with very large populations; in addition, the reduction in water level rates aggravates the ability to dilute untreated effluents. With regard to rural development, the countries of the region are important players in the global community of agricultural *commodities*. In the scenario of reduced precipitation and water level in the upper basins, grain production is affected, mainly in the central-western region of Brazil, which is currently the region with the highest agricultural production. On the other hand, it improves the water availability for agricultural production in the lower basins of Argentina and Uruguay.

Also, the reduction of precipitation and water level in the upper basins directly affects hydroelectric generation, considering that 60 percent of its generation is concentrated in southeastern Brazil and, in turn, that a large part of the water levels that feed hydroelectric projects in the international stretches originate in the upper basins.

For navigation, which depends on water levels in the upper basins, considering the climate change scenarios presented, the impact may represent a significant increase in costs, mainly in the middle and upper reaches of the Paraguay River, in order to permit for navigation with adequate draft over time.

Figure 2.2.2

Relation between the simulated monthly average flows corresponding to three future scenarios and the present situation



Chapter 3: Critical transboundary issues

During the formulation stage of the Framework Program (2003 to 2005) a preliminary analysis was conducted on the principal environmental problems and the causes and challenges to overcome in the LPB. Through a broad participatory process, the state and behavior of water systems was characterized, summarizing the present and emerging critical transboundary issues (CTI), the associated causal chains, information gaps, and preliminary recommendations for their solution. The appendix presents a general outline of the causal chains of the topics addressed by the CTIs.

As presented in the Macro-Transboundary Diagnostic Analysis (Macro-TDA), the principal CTIs identified in the Basin were: i) Extreme hydrological events linked with climate variability and change; ii) Loss of water quality; iii) Sedimentation of waterways and bodies of water in the Basin; iv) Alteration and loss of biodiversity; v) Unsustainable use of fishery resources; vi) Unsustainable use of aquifers in critical areas; vii) Water use conflicts and the environmental impact of irrigated crops; viii) Lack of disaster contingency plans; and ix) unsafe water and the deterioration of environmental health. Navigational limitations and developing hydroelectric power were also identified as topics of particular importance, for being two socioeconomic sectors fundamental for regional integration.

The projects and studies developed during Phase 1 of the Project (2010 to 2016) allowed for the deepening of knowledge to more precisely characterize the CTIs, obtaining an integrated vision of the state of the transboundary water system and the development of strategies for the integrated management of water resources (**Table 3.1**). The activities were carried out with the active involvement of specialists and authorities from various government institutions and academia related to water resource management, environment, and climate in each country.

An important aspect of this stage was the development of more detailed climate projections in order to identify the potential impact of climate change on different socioeconomic sectors (agriculture, energy, health, water resources, etc.), providing input for the preparation of the updated version of the Transboundary Diagnostic Analysis (TDA), and guiding the management recommendations for each of the CTIs analyzed, as a technical-scientific foundation for the formulation of the Strategic Action Program (SAP). The chapter summarizes the results obtained for each one of the CTIs identified.

Table 3.1

Main Results of Phase 1 of the Framework Program (2010-2016)

Working Group (WG) - Principal Results

Subcomponent: Strengthening cooperative capacity for integrated water resource management
1. Legal and Institutional Framework
• Survey of national legislation and international treaties and conventions • Institutional strengthening • Publication of an institutional and legal framework for the integrated management of water resources in the La Plata Basin
2. Decision-Making Support System
• Base Map of the La Plata Basin • Installed hardware infrastructure and system communications • Main software and applications for query and reporting • Human resources for system administration • Publication of the Decision-making Support System for the La Plata Basin. Database and thematic mapping
3. Public Participation, Communication, and Education
• Implementation of the Priority Project Cultivating Good Water in the 3 Binationals of the Basin • Execution of 4 Demonstrative Pilot Projects with civil society involvement • Implementation of the Public Participation Fund, with 12 sub-projects • Dissemination of project information: website • Publication of the document “Public Participation Fund Projects. Replication of the Cultivating Good Water Program.
Subcomponent: Integrated Water Resource Management
4. Integrated Hydraulic Balance
• Diagnosis of water balance information in the La Plata Basin: inventory of cartographic, hydro-meteorological, and climatological information and information on uses and demands in the Basin, integrated in a common format • Surface water balance calculated for the entire Basin at the national level • Implementation of integrated hydrological model in the La Plata Basin • Integrated water balance calculated for the Cuareim/Quaraí Basin • Publication of the document “Water Balance in the La Plata Plate Basin. Availability and uses, considering future scenarios. Management models.”

Working Group (WG) - Principal Results

5. Monitoring and Evaluation of Water Quality and Quantity

- Compilation of background and foundational information.
- Elaboration of a methodological guide which establishes the stations, the set of parameters, and the protocol for sampling and analysis
- Campaigns to monitor water quality and quantity
- Analysis of point and diffuse pollution sources
- Publication of water quality and quantity in the La Plata Basin

6. Integrated Groundwater Management

- Groundwater diagnostic in the La Plata Basin
- Characterization of the YTTAS: integrated hydro-geological diagnosis, the elaboration of geological and hydrogeological maps, and a socio-productive analysis of the study area
- Characterization of the aquifers of the La Plata Basin
- Guidelines for the joint management of groundwater in the La Plata Basin
- Hydrogeological characterization of the Cuareim/Quarai River Basin
- Publication of "Groundwater in the La Plata Basin"

7. Management of Aquatic Ecosystems

- Inventory of fish, environments, and protected areas
- Inventory of exotic aquatic species, main impacts, and recommendations for their control
- Inventory of wetland regions in the La Plata Basin, with identification of priority areas for protection
- Diagnosis of aquatic ecosystems and management guidelines for the conservation and management of aquatic biodiversity
- Guidelines for a biodiversity management strategy for the La Plata Basin
- Corridor proposal for the system of ecological corridors for the La Plata Basin
- Geographical information system (GIS) to support biodiversity management: georeferenced database
- Publication of the documents "Aquatic ecosystems of the La Plata Basin" and "Inventory of wetland regions of the La Plata Basin"

8. Land Degradation

- Reports with national background on land degradation and desertification, information integration throughout the LPB
- Identification of degraded areas and projects on soil conservation and desertification
- Diagnosis of the conservation status of the Selva Misionera Paranaense (SMP) and proposals for a management strategy
- Maps of land types, current use, and land cover in the LPB
- Map of risk of water erosion
- Identification of good practices of land use and management
- Diagnosis of land degradation in the LPB, including scenarios of climate variability and change
- Publication of the document "Land degradation in the La Plata Basin and Selva Misionera Paranaense"

Working Group (WG) - Principal Results
9. Opportunities for Sustainable Development
• Diagnostic on clean technologies and opportunities for development in the LPB • Diagnostic on ecotourism and opportunities for development in the LPB • Diagnostic on hydroelectricity • Diagnostic on navigation in the LPB • Publication of the documents "Hydroelectricity and Navigation in the La Plata Basin" and "Clean Technologies and Ecotourism in the La Plata Basin"
Demonstrative Pilot Projects: 10. Biodiversity, 11. Confluence, 12. Cuareim/Quaraí, 13. Pilcomayo
• DPP Biodiversity: Inventory of fish diversity; Identification of Strategic Areas for conservation and vulnerable zones; Identification of alien species and collection of data on fisheries biology • DPP Confluence: Basic information for generating forecasts and contingency plans; Hydrological warning system for the LPB; Operational system to warn against pollutant spills; strengthening local measurement systems; training and dissemination • DPP Cuareim/Quaraí: Technical evaluation on soil management in the Basin; Proposal and implementation of a binational water quality monitoring program; Proposal for water resources management; Implementation of a flood warning system for the cities of Artigas and Quarai; Establishment of formal coordination mechanisms between the Basin Committee and the Federal State; Strengthening the binational Cuareim/Quaraí River Joint Commission; Creation of the Cuareim River Basin Commission at the national level (Uruguay); Quantification of aggregate extraction in the Cuareim River; Characterization of the groundwater and elaboration of integrated water balance in the Basin. • DPP Pilcomayo: Follow-up and support for the management and control of the environmental liabilities of the mining districts of the Cotagaita river basin; actions to control and reduce soil erosion and clogging of rivers; contributions to the LPB strategic plan • Publication of the four documents with each of the DPP experiences.
Subcomponent: Hydro-climatic Models
14. Hydro-climatic Models and Adaptation Scenarios
• Implementation of the WMO's WIGOS program in the Basin • National hydro-climatic background reports • Georeferenced inventory of monitoring stations • Flood frequency, impact, and vulnerability maps • Estimates of drought conditions • Modeling of climate change scenarios using the ETA regional climate model (INPE) • Reports with workshop results • Transfer and training of technical representatives from the 5 countries • Hydrological modeling of the LPB from the MGB hydrological model • Hydrological modeling of the LPB incorporating climate change scenarios • Publication of the document "Hydroclimatology in the La Plata Basin"
Subcomponent: Elaboration of the TDA and SAP
All 14 WG Participated
• Updated TDA for the La Plata Basin • SAP for the La Plata Basin • Publication of both documents in Spanish, Portugese, and English • Proposals for SAP implementation

3.1 Extreme Hydrological Events

3.1.1 Flooding

Floods are the greatest natural threat in the LPB. They are caused by three main factors: the natural increase of river flows in rainy seasons, disorganized urban sprawl that occupies flood plains, and the increase in groundwater levels. Since 1970, floods have been occurring more frequently, on average every four years. The greater frequency is associated with the El Niño phenomenon and the impact of land use on the upper basins.

Among the principal affected areas are the large flood plains of the Paraguay River, which have slow-occurring runoff; the banks of the Paraná River and its tributaries, such as the Iguazú River, frequently flooding important cities like Resistencia, Corrientes, Rosario, and Santa Fe; and the Uruguay River, mainly in São Borja, Itaquí, and Uruguaiana in the lower part of the Basin shared by Argentina and Uruguay, downstream of the Salto Grande dam.

Although this problem is associated, above all, with natural causes (mainly the increase in rainfall since 1970), there are anthropogenic causes such as inadequate territorial planning, with large flood plains occupied by humans or agricultural activities, and the construction of infrastructure works, such as roads which obstruct surface runoff and increase infiltration as a consequence of increased irrigated area. In recent years, natural and anthropogenic activities have caused an increase in groundwater levels in the Pampas region of Argentina, leading to underground infrastructure damages in urban areas and an increased risk of contamination, as well as flooding in large rural areas means for agricultural and livestock activity.

During the current stage of the project, vulnerability maps, with their occurrence and impact in the sub-basins, including a regional analysis of the results were created. The study allowed for the identification of urban and rural critical areas and the main watercourses with high, medium, and low vulnerability to floods. Of the watercourses analyzed, 41 percent had high vulnerability to flooding (significant damage), 35 percent had medium vulnerability (reasonable damage), and 24 percent had low vulnerability (localized damage). In particular, the subject of urban flooding was analyzed, preliminarily identifying the populations with greater potential of problems in the face of floods. The analysis showed a total of 92 cities with more than 50,000 inhabitants and 226 populations between 10,000 and 50,000 inhabitants with a high probability of having problems with river floods.

- ***Principal Socioeconomic Impacts***

While no systematic studies have been implemented in the Basin to assess losses or damages due to flooding, there are historic records that help to establish the magnitude of the problem. During the El Niño event of 1982 to 83, for example, the estimated losses in the La Plata Basin were more than a billion dollars. In Argentina, the direct and intangible damages of the floods between 1987 and 1998 were estimated at 2,640 million dollars, with more than 235,000 people evacuated. Similarly, in the period from 1991 to 1992, flooding created a loss of 513 million dollars, more than 3 million hectares flooded, and 122,000 people evacuated.

Recent studies carried out in Paraguay estimated that the baseline cost of a flood in an intermediate city is in the neighborhood of 5 million dollars. This value was estimated considering, among other variables, losses in GDP due to hours of work stoppage, loss of workers' income per hour of work stoppage, temporary shelters, provision of emergency facilities, reconstruction of average housing, reconstruction of social housing, rehabilitation of waterways and waterworks, and operations to return victims to their homes.

- ***Influence of Climate Variability and Change***

In general terms, there is an increase in rainfall mainly in the south and southwestern areas of the LPB (although there is a decrease in the northern area), an increase in the frequency of intense rains, an increase in river flows, and an increase in dry periods. All these factors indicate a current trend towards an increase in riparian flooding in the LPB. In terms of the analysis of possible future scenarios, according to the available precipitation studies (FP, 2016c), the following conclusions can be drawn:

- For the period 2011 to 2040, there is an increase of up to 1 mm/day in the southern area and a decrease of up to 3 mm/day in the northern part of the Basin.

- For the period 2041 to 2070, there is an increase of up to 1 mm/day in the south, southwest, and western zones, while in the north and northeast there is a decrease of up to 1 mm/day.

- In the period 2071 to 2099, the increase continues for the southern, western, and northern areas and there is a decrease in the eastern zone for the December-January-February quarter. Subsequently, this signals a moderate or neutral increase for the rest of the months of the year.

If the current trend continues, the southern and southwestern part of the Basin could have greater river flooding problems, while in the northwest zone, even with less precipitation, this problem will depend on whether the seasonal distribution is homogeneous or if, on the contrary, the current trend continues, where the rains accumulate in fewer days.

Floods on the Paraguay River.

Figure 3.1.1.1

Flood Occurrence in the La Plata Basin

Occurrence of floods:

- High: return periods of less than 5 years
- Medium: return periods between 5 and 10 years
- Low: return periods greater than 10 years

Figure 3.1.1.2

Flooding Impact in the La Plata Basin

Impact of flooding:

- High
- Medium
- Low

High impact: high risk of damage to humans lives, significant damage to essential services, facilities and public infraestructure and residential areas.

Average impact: reasonable damage to essential services, public and residential infraestructure and facilities.

Low impact: localized damage.

3.1.2 Droughts

In much of its territory, the Basin does not present significant water deficiencies for current uses. However, some of the largest urban centers, low levels of water are commonly found in sources used for human consumption. This is because some of these cities are located in the headwaters of the tributaries of the main rivers, such as Sao Paulo and Curitiba, which limits the availability of sources. Although there are historical records of severe droughts, there has been a general reduction in the risk of drought and an increase in precipitation, which has favored changes in land use (from farming systems to agricultural production systems) and increased pressure on natural resources.

In the Gran Chaco region (shared by Argentina, Bolivia, Brazil, and Paraguay) the semi-arid zone is subject to erosive processes and loss of fertility resulting from over-ranching and unsustainable agriculture. This situation is aggravated towards the west, where the arid Chaco region presents the most extreme conditions of aridity, observing a process of desertification.

The activities developed during the execution of the project allowed for the analysis of the basin's vulnerability against drought events. The study was developed through a spatio-temporal characterization of the periods with water deficit at sub-basin level, with an annual temporal scale, using monthly rainfall series from 46 rainfall stations. Dry years were identified for the complete series of data (period from 1861 to 2014 in some stations, more than 17 with series of more than 99 years) and the average recurrence of those periods. The results of the studies showed the following:

- The mean time between dry years for the totality of the La Plata Basin was six years, varying, according to the

Drought in the western region of the Chaco.

sub-basin analyzed, between five and nine years. In order to evaluate a possible change in current climate trends over the complete historical series, the dry periods for the period from 1961 to 2014 were identified. The mean time between dry years for the whole LPB was nine years, varying according to the sub-basin analyzed between six and sixteen years. It was observed that in those areas where the mean time of recurrence of dry years is high, variation is minimal in the two analyzed periods, whereas in areas where the average time between dry years is low, in the reduced series, time between droughts increases considerably.

- Regarding the spatial-temporal distribution of droughts, it was observed that, for periods with a good spatial representation of the rainfall network, the area with water deficit varies between 5 and 20 percent of the total area of the Basin, with some years with a higher percentage of affectation, for example, the year 1962 with 55 percent, the years 1968 and 1988 with 33 percent, and the year 2008 with 48 percent. Analyzing the situation by sub-basin, it was observed that there is significant variability among them, reaching values of 70 to 80 percent of surface area in a dry year, although in those same years the situation differs in the other sub-basins.

- ***Environmental, social, and economic impacts***

There is a general consensus on the existence of significant adverse economic consequences due to the occurrence of droughts, and these consequences are reflected on a national scale, as they affect important sectors of the economies of LPB countries, such as agriculture and livestock production, agribusiness, hydropower generation, and navigation, among others. However, it is a complex task to quantify the effects of drought economically, taking into account all its direct and indirect implications. In the framework of the Project's activities, the incidence of drought was analyzed by relating the occurrence of a dry year to the variation in the GDP growth of the sub-basin affected by drought.

Although the GDP growth value in each of the sub-basins depends on the economies of the countries that make them up, as well as on many other factors that are independent of the drought situation, it is also a constant in most regions that the economic sectors related to the availability of water resource have a large influence on the GDP. On average, the dry years identified have meant an average GDP decrease of 5 percent (between 3 and 7 percent).

- ***Influence of Climate Variability and Change***

Among the main results of the characterization of water deficit periods in the sub-basins, based on the calculation of the SPEI index for each of them, the following stand out:

- *Upper Paraguay and upper Paraná:* There is an increase in dry periods, both in their duration and in their magnitude and average intensity. The same applies to the spatial coverage of dry periods. In the period from 2007 to 2040, the worst situation occurred, gradually improving but not reaching the levels of the control period (1961 to 2005).

- *Lower Paraguay:* Dry periods increase considerably in duration, magnitude, and spatial coverage for the period from

2007 to 2040, but without reaching the levels of the upper Paraguay and upper Paraná basins. From the period from 2041 to 2070 the situation improves, although the situation of the control period is not reached. The spatial coverage of drought also begins to decline, although it remains above the levels of the control period.

- *Lower Paraná:* In the control scenario, the basin presents a normal to slightly humid climate, with brief dry periods of low intensity. In future scenarios, the climate gradually becomes more humid over time, decreasing the dry periods and their magnitude, intensity, and spatial coverage. Therefore, future scenarios would present greater water resources than the control scenario.

- *Upper Uruguay:* The climate in the period from 1961 to 2005 alternates between dry and wet periods. In the period from 2007 to 2040, there are fewer dry periods, although with longer duration and intensity. In the 2041 to 2070 scenario, the humid climate predominates, decreasing the number of dry periods, their duration, intensity, and coverage.

- *Lower Uruguay:* The signal clearly indicates an increase in water resources as the most distant scenarios are analyzed over time. Dry periods decrease in quantity, duration, intensity, and spatial coverage.

- *La Plata River:* The period from 1961 to 2005 was characterized by the alternation of dry and wet periods. In the future scenario from 2007 to 2040, there is a strong decrease in dry periods, their duration, and magnitude, as well as their spatial coverage. In the rest of the scenarios, although with a predominance of normal to humid climates, short dry periods are observed. In all cases, dry periods are fewer than those observed in the control scenario.

- ***Causal Analysis and Primary Recommendations***

Among the primary causes of extreme hydrological events are: Lack of urban and territorial planning, poor coordination of information on extreme events, lack of regional disaster prevention policies, and lack of education and awareness processes. In light of this, it is recommended to consolidate, expand, and improve coordination between the various systems of monitoring, information, climate prediction, and early warning; Improve the urban and territorial planning to increase resilience and reduce vulnerability to extreme events; Promote the development of regional policies and the strengthening of the legal framework for the prevention and management of these events; and Develop and exchange experiences on research, awareness-building, and environmental education programs related to extreme events, among other things.

3.2 Loss of Water Quality

The main threats to water quality are point-source pollution—a consequence of sewage and industrial effluent discharge and, in some specific areas, mining and oil production—and diffuse pollution, resulting from agricultural and livestock activity, in addition to the municipal solid waste that is discharged by drainage networks to the main river courses.

Throughout the LPB as a whole, it can be observed in general terms that diffuse organic contamination—mainly as a consequence of agricultural/livestock activities—

predominates over that of point sources. However, they have parity in the case of the Paraná sub-basin, and the predominance is inverted in the La Plata River sub-basin. This can be explained by the presence in these sub-basins of a large metropolis, like São Paulo and Buenos Aires, respectively. The impact generated by organic matter is more relevant in the case of point sources in low flow courses, typical of the headwaters of the basin, in contrast with the large rivers, which are characterized by their high capacity of self-purification.

With regard to pollution as a result of aquatic activities, one of the main problems is biological contamination by invasive species, of which the golden mussel stands out. There is also a growing recurrence of harmful algal blooms by cyanobacteria—for example, in the waters of the Uruguay River, the Uruguayan border of the La Plata River, and the Santa Lucia River (Uruguay) sub-basin—as a result of nutrient contributions from agricultural activity.

In terms of heavy metals, the contributions are mainly a consequence of industrial and mining activity. For example, contamination due to the presence of heavy metals in the Pilcomayo and Bermejo rivers has as its origin in the strong mining activity in the headwaters of their respective basins in Bolivian territory.

Given the large land area of the LPB and the various anthropogenic activities and their degree of development, each sub-basin presents its own particularities in terms of loss or threat to water quality, which are summarized herewith:

- *Paraná River:* The Paraná River is characterized by its great power of dilution and capacity for self-purification. However, degradation or loss of water quality is observed in the riparian areas of urban-industrial conglomerates and in the rivers and streams of the sub-basin, such as in the areas of São Paulo, Brasilia, and Curitiba, with great demand for water and the corresponding increase in the load of contaminant discharges. It is also observed that industrial effluents from industries linked to agricultural/ranching activities, such as livestock, sugar cane, and pig and chicken farms represent important organic matter contamination contributions, with the consequent decrease of dissolved oxygen levels in water bodies.

  In the lower Paraná basin, pollution problems are observed, mainly in large urban conglomerates, such as the cities of Rosario and Santa Fe, and areas with industrial development, such as the city of Esperanza, which is characterized by the presence of tanneries that pour their effluents into the northern part of the Salado river basin, a tributary of the Paraná.

- *Paraguay River:* Particular attention should be given to mining activity in the upper basin of the Paraguay River in Bolivia and Brazil. Discharges of water used in extraction and processing, as well as the erosion and dissolution of mining waste, contaminate rivers and groundwater. The information on aquifer impact is still preliminary and the information relating to surface water pollution as a result of acid drainage from open-pit mining is not entirely accurate. In the Brazilian section of this high basin, water resources are also contaminated as a result of mining activities, mainly in the state of Mato Grosso, and also from pesticides used in annual crops in the Planalto region. Downstream, in Paraguay, the highest contaminant load comes from agricultural activity (crops and pastures) and, mainly, from domestic and industrial effluent discharges in areas close to large urban centers, such as Concepción, Asunción, and Pillar. A high concentration of phenols was observed—highly toxic compounds for aquatic species that do not biodegrade—indicating pollution likely coming from industries such as timber in the Paraguay River, in Humaitá, and in one of its tributaries, the Apa River.

In the Bermejo River, one of the main tributaries of the Paraguay River, there is a certain degree of pollution caused by oil discharge, originating in the oil wells that discharge the water used in oil exploitation—which has high salinity, high temperature, and traces of hydrocarbons—into different tributaries of the basin.

In the Pilcomayo River, which has a predominance of detritus fish species, high levels of heavy metals have been detected. At Mision La Paz (province of Salta), high concentrations of lead, arsenic, copper, mercury, zinc, and silver were found.

- *Uruguay River:* In the upper basin of the Uruguay River, the largest sources of industrial pollution are found in the tributaries, the Peixe and Canoas rivers, which receive high pollution loads of point source and diffuse origin due to the industrial activity in the state of Santa Catarina. Effluents from the paper, tannery, and food industries from the cities of Cacador and Videira (the Peixe River basin) and Lages (the Canoas River basin) represent an important source of contamination by heavy metals and other substances, as well as organic matter. These loads have increased due to the growth in production, the outsourcing of industrial production, and the difficulty in treating small loads, which leads to the production of diffuse loads for the basin. Most urban-industrial effluents are discharged into river systems with little or no prior treatment, which generates inadequate environmental conditions in most of the urban rivers that drain from these cities. In this sub-basin there is an increase in the occurrence of noxious algae blooms (cyanobacteria) resulting from eutrophication processes associated with increases in nutrient spillage. In some cases these blooms may pose a threat to drinking water sources, since conventional treatments do not remove cyanotoxins. These events of harmful algal blooms also move to the Uruguayan banks of the La Plata River.

- *La Plata River:* More than 97 percent of the freshwater inflow to the La Plata River comes from the Paraná and Uruguay rivers, with the rest corresponding to numerous rivers and streams that dump their waters into the coastal strip. Three sources of pollution have been identified as responsible for the pollution in the La Plata River coastal strip: sewage effluent discharge, the dumping of industrial effluents, and urban solid waste discharge. The first two are declining due to the extension of the sewage network and to greater control of industrial effluents. The presence of solid urban waste in various urban and suburban streams is a growing problem, mainly due to an increase in waste generation and a low acceptance rate into the waste collection system, in addition to the use of watercourses as a container for waste not recycled and discarded by the collectors, which are dragged, especially when it rains, through the drainage network to the surface watercourses that discharge their waters in the coastal zone of the La Plata River.

In the case of Uruguay, the most affected are urban watercourses, the Carrasco, Miguelete, Pantanoso, Colorado, and Las Piedras streams, and many of their tributaries, as well as the Montevideo Bay and the Santa Lucia River sub-basin, which is the source of potable water for the city of Montevideo. In both countries, the rivers and streams mentioned have nearly permanent low levels of oxygen (levels of hypoxia or anoxia). These low levels of oxygen generate situations of anaerobiosis, with the consequent emanation of unpleasant odors and environmentally degraded areas.

- ***Causal Analysis and Primary Recommendations***

Regarding water quality loss, the following are the principal detected causes: inadequate wastewater treatment, lack of training for environmental managers, lack of development policies that encourage the use of clean technologies and the minimization of waste, and deficiency in compliance with existing regulations. The main recommendations for mitigation are: Harmonize regulations and develop consensual criteria for water quality assessment and monitoring, seek sources of funding for the construction and operation of domestic and industrial wastewater treatment plants, promote the implementation of sustainable agricultural practices and the rational use of agrochemicals, implement best practices for environmental quality monitoring and management in mining projects, strengthen agencies responsible for water quality management, develop joint programs for monitoring water quality and quantity among countries, and develop training programs for environmental managers, among others.

3.3 Sedimentation of Water Bodies and Courses

The greatest sediment production is located in the Andean section of the La Plata Basin, particularly in the high basins of the Bermejo and Pilcomayo rivers. Particularly notorious is the Bermejo River, which has an average annual discharge of 446 m³/s and 100 million tons of suspended sediment per year into the Paraguay River. The sediments of this river are the primary cause of the need for water clarification for consumption in cities all the way to the La Plata River, and is the origin of the transverse sedimentation of canals in the Parana River Valley and of the navigable canals and port accesses in the La Plata River. The Pilcomayo River has an average annual flow of 203 m³/s and an annual sediment contribution of similar magnitude to the Bermejo, but does not have enough energy to transport its solid load to the Paraguay River.

The mean annual concentration of sediments for the LPB as a whole is 150 mg/l, which while moderate for a river in a tropical zone, is a decisive parameter for water purification of rivers and for sedimentation in navigation channels with very low speeds. The mean annual concentration of 500 mg/l has been recorded in the Pantanal river tributaries, corresponding to an average erosion rate of 146 t/ km²/year in watersheds with an average area of 17,000 km². In the southwestern region of Brazil near the border with Argentina (covering the middle and lower reaches of the left bank tributaries of the Paraná River and a substantial part of the Uruguay River basin) the mean annual concentration is in the range of 100 mg/l and the specific production of sediments is of the order of 95 t/ km²/year.

At the sub-basin level, topics related to sediment production and transport as summarized as follows:

- *Upper Paraguay:* The Parapetí River begins in the eastern range of the sub-Andean Sierras and forms an alluvial fan of several dozens of square kilometers in Bolivia and Paraguay. Under the current dynamics, in the Parapí riverbed one can observe fluvial sedimentation processes, which occur due to the change in slope of the river course. In the rainy season the river carries sedimentary material by dragging and suspension. The coarser materials are deposited near the exit of the sub-Andean mountain range and the thinner materials are deposited as they travel along the plain, until arriving in the Izozog swamps, where very fine material accumulates.

- *Lower Paraguay:* The sediment production of the upper Pilcomayo River Basin is somewhat greater than that of the Bermejo River, but this load is deposited in the swamps of its alluvial cone in the Chaco plain and consequently does not reach the Paraguay-Paraná River. The total sedimentation of the channel to levels higher than the floodplain is a morphological problem that affects the management of the basin. Consequently, the river flows over the plateau forming new swamps annually.

  The solid contribution of the Bermejo River to the Paraná River constitutes about 75 percent of the total sediment of this river, a percentage that increases if you consider recent decades, due to the execution of dams in Brazil and the respective retention of sediments. The contribution of limes and clays constitutes 90 percent of the fine sediment transported by the Paraná River, which sediments predominantly in the La Plata River. Management measures are identified in the Upper Bermejo basin that substantially affect the amount of sediments generated for the whole basin. The most sediment-producing areas of the Upper Bermejo basin are not significantly affected by current anthropogenic actions, but specific problems of sediment production in the basin could be resolved through structural and non-structural measures.

  La Plata River: The area with the greatest fluviomorphological activity is the upper La Plata River, adjacent to the Delta, where the annual amount of silt and clays dredged in the navigation channels is equivalent to 23 percent of the total contribution of the Bermejo River.

- ***Influence of Climate Variability and Change***

Changes in temperature and precipitation will manifest in variations in sediment production and transport rates in the Bermejo and Pilcomayo river basins. There is a tendency to maintain current rates for the next 30 years, and a decrease for the period from 2041 to 2070 in both basins, which is of greater importance in the Pilcomayo River basin. In the distant future, there is a slight tendency to increase in the case of the Bermejo river basin, but there is not a clear trend in the Pilcomayo river basin. The increase in predicted sediment yield implies an increased risk of morphological changes in the Lower Bermejo river bed, an increase in water clarification costs in potable water plants throughout the river route to the La Plata River, and an increase in the dredging volumes in transverse channels of the Paraná River, the La Plata River, and in the ports and respective accesses.

- ***Causal Analysis and Primary Recommendations***

The principal causes of this issue have been identified as improper use and handling of soil (farming expansion, use of marginal soils, elimination of natural pastures, overgrazing); the lack of incentives, expansion policies, and training to implement sustainable agricultural techniques; and technical and economic weakness of state agencies. For this, it is recommended to promote the development and harmonization of standards for the protection and natural resource use; to implement agro-ecological zoning and land use plans; to strengthen institutional capacity for land use management; to implement soil recovery and erosion control programs in priority areas; and to develop training and expansion management programs in management techniques and soil conservation.

3.4 Alteration and Loss of Biodiversity

The LPB is a region of extraordinary ecological value. Its wide climatic and geological variety, coupled with the great availability of water in much of its territory has allowed for a great diversity of ecosystems and species. However, there is great concern about the threat to ecosystem integrity as a result of the advancement of human activities.

The joint work of the five countries during project implementation allowed for them to characterize the alteration of habitats and the fragmentation and loss of connectivity, which can be aggravated by the effects of climate change in critical or more vulnerable areas. The loss of integrity (goods and services) due to environmental risk, with impacts on biodiversity throughout the LPB, mainly in the Pantanal and in the Selva Misionera Paranaense (SMP) and a low percentage of protected areas was also identified, putting at risk the environmental goods and services provided by these ecosystems. Dams were identified as important factors, affecting some flood plains and disrupting migratory corridors.

There is also evidence of the presence of exotic species distributed throughout the Basin, particularly the bivalve mollusk of the genus *Corbicula* and the golden mussel (*Limnoperna fortunei*), with proven impacts on native wildlife, the ecosystem, infrastructure works (such as water outlets), and other human activities.

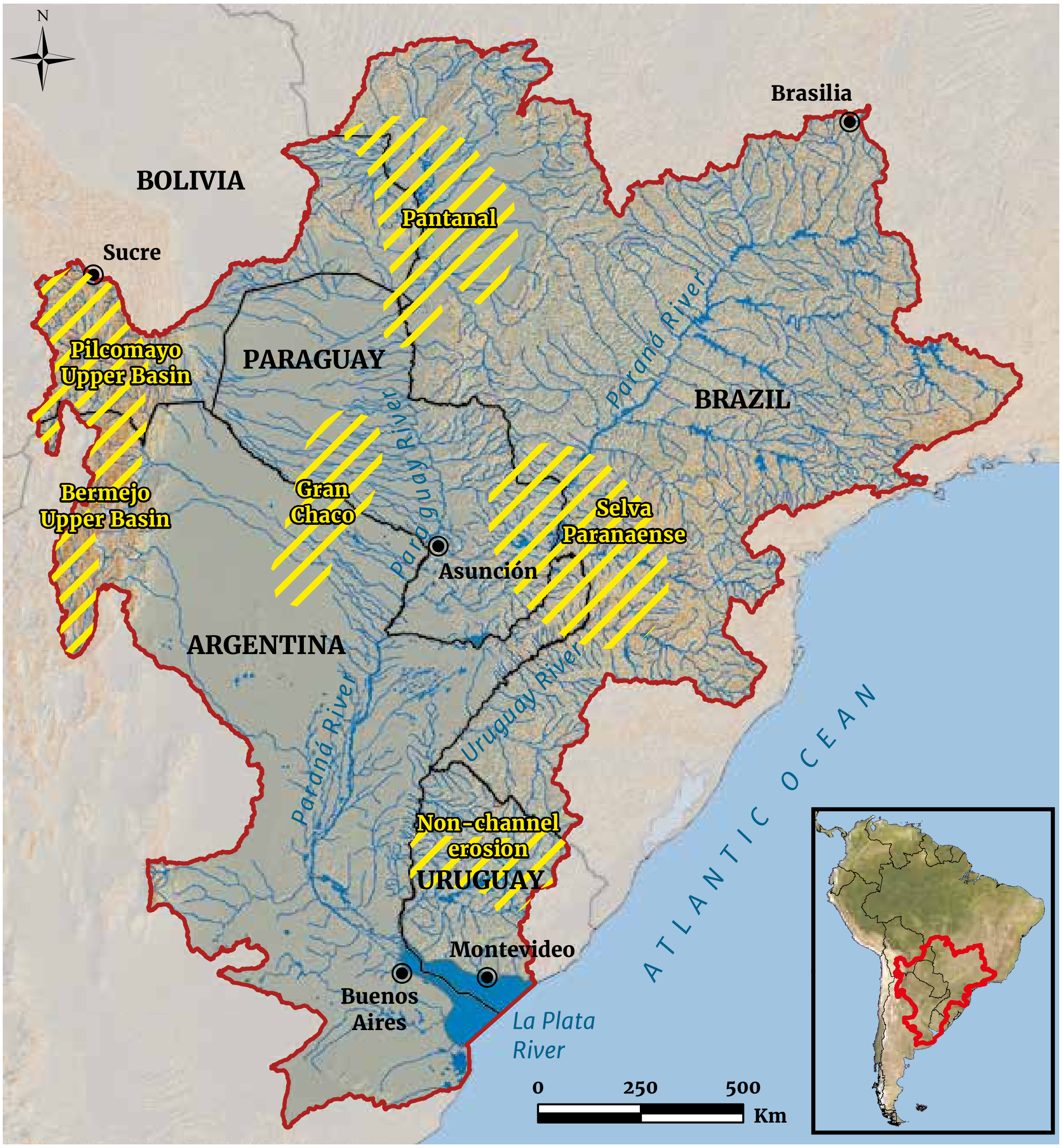
At the sub-basin level, the analysis is the following:

- *Upper Paraguay:* The Pantanal is located in this sub-basin, one of the most transcendent wetlands for the Basin's aquatic biodiversity. This sub-basin has suffered a considerable loss of terrestrial ecosystems (40 percent) and presents an environmental risk of loss of integrity. Sixty-one protected areas covering 12.6 percent of its area have been created. There are six Ramsar sites (46,500 km²), two MAB Biosphere Reserves (326,492km²), and 19 important bird areas (IBA). It is the least populated sub-basin, with 2.4 million people.

- *Lower Paraguay:* This sub-basin has suffered a 15 percent loss of terrestrial ecosystems. Three important water reservoirs have been planned in the sources of the Bermejo River. It is one of the least-populated sub-basins (2.8 million inhabitants). Sixty-six protected areas have been set up covering 7.4 percent of its area, representing a low level of protection since it does not meet the 10 percent target set by the CBD by 2010. The designation of nine Ram-

Figure 3.3.1

Areas with higher criticality associated with land degradation



sar sites (11,384 km²), six Biosphere Reserves (21,097 km²), and 94 important bird areas (IBA) is a clear indication of the high international priority received by this sub-basin.

- *Upper Paraná:* This sub-basin has suffered a very high loss of terrestrial ecosystems (75 percent). There are no Ramsar sites, which indicates the absence of major wetlands of international relevance. The upper Paraná and its tributaries have undergone major modifications to control flooding and hydroelectric power generation (43 large reservoirs), which affect the respective floodplains. It is the most populated sub-basin, with 61.8 million inhabitants, with a high population density (6.9 inhabitants/km²) and six important cities, including the capital of Brazil, Brasilia. There are a large number of protected areas (313), but they cover only 7.7 percent of the sub-basin area. The Biosphere Reserve (MAB-Unesco), Mbaracayú Forest (2,800 km²), is partly included within this sub-basin. There are 32 IBA within its borders.

- *Lower Paraná:* There are several important wetlands, such as the Ramsar Lagoons and Iberá Estuary, the Chaco Wetlands, Jaaukanigás, Otamendi Reserve, and the lower Paraná floodplain, Paraná Delta (Argentina) in this sub-basin. It has suffered a considerable loss of terrestrial ecosystems (40 percent) and presents environmental risk due to loss of integrity. Three reservoirs associated with dams have been built, one in the Juramento River (Cabra Corral, Salta, Argentina) and two in Paraná: the Yacyretá and Itaipú dams. Other works that impact the ecosystem are the Rosario-Victoria road connection, the real estate expansion over wetlands, and their loss to the construction of hills for the use of agriculture and cattle breeding. The population amounts to 9.5 million (1.6 inhabitants/km²), with seven major cities. Eighty-two protected areas covering only 5.6 percent of the area have been created, a level of protection well below the CBD's 10 percent target for 2010. The designation of five Ramsar sites (10,950 km²), two Biosphere reserves (10,619 km²), and 78 IBAs show that it is a high international priority.

- *Upper Uruguay:* There are no noteworthy wetlands. This sub-basin has suffered a considerable loss of terrestrial ecosystems (60 percent). Three large reservoirs associated with dams with hydroelectric power plants have been built on the Uruguay River (Machadinho, Itá, and Passo Fundo) and there are plans for the construction of three new ones, which will increase the respective alteration of the fluvial environments. It is a sub-basin with a relatively small population, with 1.7 million inhabitants and without any large cities. Twenty-nine protected areas have been created covering only 4.4 percent of the sub-basin area, a low level of protection with regard to the 10 percent target imposed by the CBD. While there are important wetlands, such as the Moconá Falls, there are no Ramsar sites. There is a Biosphere Reserve, Yabotí (2,366 km²), and 12 IBAs have been identified.

- *Lower Uruguay:* The most important wetlands are: Uruguay River plains and islands, Farrapos Estuary Ramsar site, Villa Soriano, and Palmar de Yatay Ramsar Site. The sub-basin has suffered a significant loss of terrestrial ecosystems (60 percent). There are four large reservoirs associated with dams with hydroelectric power stations, one on the Uruguay River (Salto Grande) and three on the Negro River (Palmar, Rincón del Bonete, and Baygorria), with their respective alterations of river environments. It is a sub-basin with an intermediate population level, with 3.8 million inhabitants and a population density of 1.6 people/km²), with three important cities. Thirty-nine protected areas covering only 1.8 percent of its area have been created, well below the CBD’s 10 percent target for 2010. Three Ramsar sites (849 km²), a Biosphere Reserve (997 km²), and 20 IBAs have been identified.

- *La Plata River:* The important wetlands are Samborombón Bay and the Santa Lucía swamps. This sub-basin has suffered a considerable loss of terrestrial ecosystems (35 percent), concentrated in the coastal strip of the La Plata River, mainly in the metropolitan areas associated with the cities of Buenos Aires and Montevideo. It is the second most populated sub-basin, with 24.9 million inhabitants, five major cities, including the capitals of Argentina and Uruguay—Buenos Aires and Montevideo, respectively. Eleven protected areas covering only 0.8 percent of the sub-basin area have been created, the lowest of the entire LPB and well below the CBD's 10 percent target for 2010 and even further away from the 2011 to 2020 Aichi target of 17 percent. Two Ramsar sites (Costanera Ecological Reserve and Samborombón Bay, 4,883 km²) and two MAB Biosphere Reserves (1,289 km²) have been designated on the Argentine banks, and nine IBAs have been identified.

- ***Selva Misionera Paranaense (SMP)***

The topography of the SMP comprises relatively flat areas with deep soils near the Paraná and other main rivers, with altitudes between 150 and 250 masl, to a relatively flat plateau with altitudes between 550 and 800 masl. The areas that are between the main rivers and plateau, with altitudes between 300 and 600 masl, have relatively steep slopes and are very exposed to soil erosion when forest cover is removed.

More than 3,000 species of vascular plants, numerous mammals, a rich diversity of amphibians, reptiles, invertebrates, and marsupials have been registered in the SMP, as well as more than 550 species of birds, with a large concentration of endemic species. The predominant vegetation is the semi-deciduous subtropical forest. Variations in the local environment and soil type allow for the existence of different plant communities, gallery forests, bamboo forests, palmetto forests *(Euterpe edulis)*, and Paraná pine forests *(Araucaria angustifolia).* Most of the forests have been exploited to obtain wood; some secondary forests are recovering from deforestation. Thus, forest fragments are composed of primary and secondary forests at different stages of succession.

These processes of land degradation in the SMP have been addressed by different countries through different action and response strategies. Conservation measures for SMP sections focus mainly on the implementation of a network of conservation areas.

- ***Influence of Climate Variability and Change***

Loss or alteration of habitats and fragmentation and loss of connectivity may be aggravated by the effects of climate change in critical areas or those more vulnerable to rising water levels.

Figure 3.4.1

Ecological corridor strategy on a large spatial scale in La Plata Basin

Ecological Corridors Strategy

- Great rivers (Main corridor)
- Affluents (secondary corridors)
- Protected areas

- ***Causal Analysis and Primary Recommendations***

The main causes identified for this CTI were the replacement of natural ecosystems with productive activities; the lack of incentives for the care and conservation of natural systems; the lack of protocol for the control of invasive species; and the lack of social awareness around the value of water resources and biodiversity. Given these causes, it is recommended to establish cooperation mechanisms between countries regarding biodiversity; to develop ecological corridors in the rivers and coasts and other forms of conservation that contemplate social participation; to promote the development of transboundary protected areas and the adoption of regional minimum standards for biodiversity conservation.

3.5 Unsustainable Use of Fishery Resources

In the LPB, 40 percent (367) of fish species have socio-economic relevance as a resource for commercial, artisanal, subsistence, recreational, and aquaculture fisheries. The number of relevant species presents an east-west gradient, suggesting that the use and valuation of the native fauna is more relevant in the sub-basins of the Paraguay River (upper and lower) and the lower Paraná, which also have a high fishing pressure. About 53 percent (480) of fish species are considered to be endemic in any of the seven sub-basins, indicating that the conservation of fish biodiversity requires differentiated efforts. Endemism is highest in the upper Paraná, it is intermediate in the sub-basins on the western edges of the Basin, and lowest in the lower Uruguay and the La Plata River.

Thirteen species of exotic fish were registered in the La Plata Basin, several of them with invasive capacity. The most widespread exotic species are: Asian carp *(Cyprinus carpio)* (present in five sub-basins), herbivorous carp *(Ctenopharyngodon idella),* and bighead carp *(Hypophthalmichthys nobilis),* registered in four of the seven sub-basins. Also important are tilapia *(Tilapia rendalli),* Nile tilapia *(Oreochromis niloticus),* rainbow trout *(Oncorhynchus mykiss),* and African catfish *(Clarias gariepinus).* The greatest diversity of exotic species was recorded in the sub-basins of the Paraná River (eight species in the upper Paraná, seven species in the lower) and La Plata River (eight species). In the upper Uruguay there is no record of exotic species, while there are intermediate levels in the remaining sub-basins.

In general terms, the main problems associated with fishery resources are related to the retraction of fish stocks as a result of the high fishing pressure already observed in some areas and the high risk of an increase in invasive alien species (IAS), due to their escape from their centers of cultivation. The low level of protection and the loss of terrestrial habitats impact fish biodiversity. The sub-basins that require the most attention are: Upper Parana, which has nine species of threatened fish and a high degree of invasion of exotic species, with high development of exotic fish culture; the Lower Paraná, where there are 13 threatened fish species and a high degree of invasion (with seven species) of invasive exotic fish; the Lower Uruguay, which registers six species of threatened fish and five species of exotic fish; and the La Plata River, which presents considerable fish diversity, with five threatened species. The degree of invasion is considered high, with eight species of invasive exotic fish, the highest risk being herbivorous carp and Asian carp.

- ***Influence of Climate Variability and Change***

High vulnerability to climate change is anticipated for riparian habitats in the major fishing communities.

- ***Causal Analysis and Primary Recommendations***

For the unsustainable use of fishery resources, the main causes appear to be overexploitation of species for commercial interests; lack of technical consistency and design and implementation of fisheries policy; the lack of harmonious and integrated policy for the protection of aquatic life in the whole Basin; and unsustainable practices and difficulties in accepting new technologies. For recommendations, it is especially suggested to promote integrated policies, standards, and criteria for the protection and sustainable use of fishery resources at the basin level; to strengthen tools and management and control mechanisms; to conduct vulnerability studies on priority riparian habitats; and to implement awareness and training programs on sustainable production techniques.

3.6 Unsustainable Use of Aquifers in Critical Areas

The La Plata Basin has shown an increase in the use of subterranean water resources due to urban and rural population development and the sharp increase in agricultural and industrial activities in the Basin. The lack of knowledge about the vulnerability of recharge areas and the deficiencies in well inventories, as well as their monitoring and exploitation, are factors that contribute to the unsustainable use of this resource.

The work carried out during the execution of the Framework Program has allowed for advancements in the characterization of transboundary aquifers, including the Yrendá-Toba-Tarijeño (YTTAS), the Serra Geral, the Baurú-Caiuá-Acaray, the Pantanal, and the Agua Dulce. In particular, the work carried out on the YTTAS, one of the most important transboundary freshwater reservoirs in the region and one of the most significant on the South American continent, stands out. A geological map has been prepared and studies carried out that allow for the creation of national hydrogeological maps. A hydrogeological map covering the whole Basin was created, at a scale of 1:2,500,000, which allows for the identification, among other things, of groundwater salinity distribution and the density of information on available wells.

In terms of well density, the Lower Paraná sub-basin has the lowest density in the Basin, with only 1.5 wells/10 km², corresponding to the Mesopotamian area of Argentina. The La Plata River sub-basin, after the confluence of the Paraná and Uruguay rivers, and also with low population density and good surface water availability, has a density of 1.8 wells/10 km². The area with the highest level of groundwater exploitation today is the upper Uruguay sub-basin, where a density of 70 wells/10 km² is observed.

In regard to natural vulnerability, low vulnerability is observed for the Pantanal and the Andean region, low to medium for the area comprising the Paraná sedimentary basin, and high for the YTTAS region and a portion of the Gran Chaco.

- ***Influence of Climate Variability and Change***

The climatic variations modeled for a period of almost 80 years would be insignificant from the point of view of groundwater, since geological time periods are very broad. However, in some locations where recharge is affected by precipitation (more restricted aquifers such as Raigon), variation may affect this recharge.

- ***Causal Analysis and Primary Recommendations***

In terms of unsustainable use of aquifers in critical areas, the major causes are the existence of pollutants from agriculture and domiciliary and industrial waste; lack of management over the use of groundwater; lack of transboundary institutional coordination for shared control and management; and the limited social participation. The main recommendations to improve these conditions include developing tools for integrated and participatory management; performing vulnerability studies to identify high-risk areas at the regional and local levels; developing regional data banks; and encouraging greater social participation.

3.7 Water Use Conflict and the Environmental Impact of Irrigated Crops

The permanent and sustainable growth of irrigated areas in the Basin is the main reason for current and potential conflicts in water use. As a reference, the irrigated area went from 1.85 million hectares (considering the territories in Argentina, Brazil, Paraguay, and Uruguay) in the '60s to 4 million hectares currently. The growth was particularly accelerated in the last three decades due to increasingly technically advanced commercial production and the persistent occurrence of droughts, together with the need to ensure economic performance and survival of agricultural enterprises and producers. The expansion of irrigation and the growing conflict shows the lack of overall vision and capacity to generate participatory processes amongst the actors involved, demonstrating the need to promote integrated water resource management (IWRM) as a mechanism to facilitate equitable and sustainable solutions.

The work carried out during the execution of the Project allowed for the deepening of knowledge regarding water availability, defining the surface water balance in each country, as well as the integrated water balance (superficial-groundwater) in the pilot basins. An assessment of water uses and demands at the national level (population, agriculture, forestry, livestock, industrial, mining) was also carried out, and then integrated at Basin level. The main results show a significant concentration of water use for rice irrigation in the area near the Cuareim/Quaraí and Ibicuy rivers, on the Brazilian and Uruguayan banks, respectively, and in the basin that contributes to the Uruguay River on the Argentine bank. Considering that irrigation will in the future consolidate its dominant position as the main water consumer in all the countries of the Basin, it should be a priority to increase and regulate the supply of water and increase its efficiency, optimizing the relation between kg of product per m^3 of irrigation water consumed, in order to transform growth into development.

- ***Influence of Climate Variability and Change***

Rice flooding uses a high volume of water, which can create conflicts with the water supply and the environmental maintenance of the channels. In the event of a drought, this problem would be very serious if private reservoirs built by the rural owners accumulated all available water.

- ***Causal Analysis and Primary Recommendations***

The main causes identified for water use conflicts and the environmental impact of irrigated crops are weak or deficient information available on shared water resources (inventory of availability and use); the lack of joint management bodies for shared water resources; asymmetries in juridical-institutional structures for integrated management of shared resources; and the ignorance of social actors as to resource value and limited availability. As for the recommendations, the main ones are to promote agreements and develop universal legal frameworks for water use management; to strengthen management capacity and institutional coordination within competent bodies the five countries; to generate information and facilitate public access to the data of interest for supply and demand management; and to establish communication, dissemination, and awareness-building strategies around management.

3.8 Lack of Disaster Contingency Plans

The rivers of the Basin and their riparian areas are subject to the risk of disasters due to extreme natural events and human error that can cause accidents of various kinds, such as toxic spills and the breakdown of infrastructure works. Accidents and disasters recorded in the Basin demonstrate the lack of prevention strategies and, above all, accident contingency plans. Countries confront them with isolated measures, many times spontaneous and insufficient and subject to a plurality of jurisdictions.

As part of the project's activities, a detailed diagnostic of hydro-meteorological monitoring and alert systems nationally (in each of the five countries of the Basin) and regionally, as the basis for strengthening contingency plans in the event of disaster. Progress is being made in coordinating the five countries in the hydro-meteorological network.

There are hydrological and hydraulic studies associated with the hypothetical breakages of the principal dams of the Uruguay and Paraná rivers in Argentina, carried out by Dams Safety Regulatory Agency (ORSEP), which inspects dam safety studies and, more specifically, the development of so-called Emergency Action Plans (EAPs). In Brazil, under the Law 12334/2010, the National Policy on Dam Safety was established, creating the National Dam Safety System.

There is still a need to establish common agreements to facilitate the exchange of data and information and the establishment of homogeneous criteria (defining maximum probable rises, probable breakage scenarios, etc.) to allow for more detailed safety studies (fundamentally for the analysis of domino effects in waterfall dams) and facilitate the development of coordinated or joint plans and actions. The exchange of information and experiences can be used for the benefit of the entire basin. The contingency plans before riparian and pluvial flooding across the Matanza-Riachuelo river basin (2,470 km^2), Buenos Aires, Argentina, together with other similar ones which have been implemented in the province of Santa Fe, Argentina, are activities which can be used as a reference for similar situations and contexts in other areas of the region.

- ***Causal Analysis and Primary Recommendations***

The major causes of the lack of disaster contingency plans have been identi-

Table 3.7.1

Demand for Water in the La Plata Basin

a) Integration of data by country

	Demand in hm³/year						
Country	**Population**	**Agricultural**	**Livestock**	**Industrial**	**Mining**	**Total**	**%**
Argentina	4,787	7,304	1,066	2,138	124	**15,419**	**31.5**
Bolivia	125					**125**	**0.0**
Brazil	6,250	14,128	1,911	6,771		**29,060**	**59.3**
Paraguay	443	552	484	17		**1,496**	**3.1**
Uruguay	397	2,011	342	132	47	**2,929**	**6.0**
Total	**12,002**	**23,995**	**3,803**	**9,058**	**171**	**49,029**	
%	**24.5**	**48.9**	**7.8**	**18.4**	**0.0**		**100.0**

b) Integration of data by water systems

	Demand in hm³/year						
Sub-basin	**Population**	**Agricultura**	**Livestock**	**Industrial**	**Mining**	**Total**	**%**
Paraná	8,119	15,067	2,269	7,726	68	**33,250**	**68.0**
Paraguay	625	1,831	527	156	7	**3,146**	**6.4**
Uruguay	588	6,598	594	427	20	**8,227**	**16.8**
La Plata River	2,545	499	413	742	76	**4,275**	**8.7**
Total	**11,877**	**23,995**	**3,803**	**9,051**	**171**	**48,897**	
%	**24.3**	**49.1**	**7.8**	**18.5**	**0.5**		**100.0**

Source: PM, 2016j.

fied as the risks associated with the operation of dams; the lack of updates to dam safety criteria taking the impacts of climate change into consideration; the absence of national and transnational regulations governing dam safety and lack of awareness about the risks for populations located downstream of such works, as well as the operating companies themselves. Therefore, the main recommendations are: to establish common standards and safety criteria, taking into account the impact of climate variability and change; to develop and adopt national regulations and transnational safety agreements and emergency operation plans; to develop or update contingency plans and programs in the event of broken dams; and to develop citizen awareness measures on prevention risk reduction.

3.9 Unsafe Water and Deteriorating Environmental Health

Episodes of waterborne diseases, such as diarrhea, cholera, malaria, and dengue, are common in certain regions, particularly where there are households without access to safe drinking water or sanitation. Diarrhea is by far the largest water-related epidemic disease that mainly affects children, and in particular those from households without access to improved sources of drinking water or sanitation. Other diseases of lesser occurrence are leptospirosis, leishmaniasis, and yellow fever.

In recent years there have been a number of blue-green algae blooms or toxigenic cyanobacteria that have successfully colonized aquatic ecosystems, with potential risks to human health, which currently are found dispersed in inland water bodies (rivers, lakes, reservoirs) and marine environments, either as single-cell or multicell organisms (colonial or filamentous). These belong to the oldest organisms on the planet and have characteristics that are common to other bacteria and eukaryotic algae, which gives them unique qualities in terms of their physiology, tolerance to extreme conditions, and adaptive flexibility. These blooms, which generally occur in low-depth bodies of water with low water circulation, are also associated with high temperatures, pH changes, prolonged water retention times, and low turbulence.

Its natural development has been modified by human action, mainly by the excessive contribution of nutrients, especially nitrogen and phosphates, from sewage discharges and the increasing use of fertilizers. This phenomenon can also be aggravated by climate variability and change, as the increase in the temperatures of water bodies favors the development of cyanobacteria masses—called algae blooms—as a competitively successful group in comparison with other phytoplankton. As they grow disproportionately, depending on the genus and species concerned, these organisms produce cyanotoxins, which, when present in ambient water, can affect the health of the population, of domestic and wild animals, and of livestock.

As for schistosomiasis, a parasitic disease originating in Africa, it was discovered in South America at the beginning of the 20th century in Brazil, which is now an endemic country. It has spread mainly in the populations along the Atlantic coast of that country, reaching the state of Rio Grande do Sul. The most efficient preventive measure is the control of people who come from endemic areas for different reasons (work, tourism, etc.). Another serious problem is the presence of arsenic. Water is contaminated by contact with the layers of rocks with a high content of this carcinogenic mineral. Arsenic is also used in some industrial processes and can be filtered into water bodies if not treated with care.

- ***Causal Analysis and Primary Recommendations***

The principal causes of this unhealthy water and the determination of environmental health have been identified as the lack of information on waterborne diseases; inefficient control over industrial rollovers and application of agrochemicals in agriculture; the asymmetry of the legal and technical criteria and for water resource and public health management; and resistance to making changes in habits. As recommendations, it emphasizes strengthening research and the generation and dissemination of data on waterborne disease; promoting policies and programs for treating municipal solid waste, industrial waste, and management of agrochemicals; strengthening the capacity of local managers and the institutional articulation and coordination of organizations and institutions in the water and sanitation sectors in each country; and encouraging education and citizen awareness programs on environmental hygiene and health.

3.10 Navigational Limitations

Navigation is one of the fundamental socioeconomic sectors for integrating the Basin by providing connections between production centers, storage, and ports from which products are exported to rest of the world. Currently navigation is mainly dedicated to transporting products, primarily agricultural products, between the different regions of the Basin. Whether it is the most economical means of transport depends on the connections with other factors—the impulse to develop ports, investment in the maintenance roads and ports, and agreements among countries. Integrated assessment of all elements within the country institutions associated with economic potential it is the great challenge for the expansion and modernization of navigation in the Basin.

The characteristics and primary limitations for navigation on the most important rivers are:

- *Paraguay River.* Presents characteristics of a plain river, subject to erosion and sedimentation, so that morphological changes occur in the bed that in the course of time modify the navigation channel. Variable water levels on the river, subject to the precipitation system in its basin, determine the coming hydraulic cycle on the Paraguay: low waters (from November to February), high waters (from May to August), and medium waters (from March to April and September to October). In the low-water periods, there are generalized difficulties in navigation and, more specifically, the appearance of critical steps. The Paraguay River does not have artificial regulation of its flow, so the dynamic process of the river necessitates permanent monitoring of the effective depths of the navigation channel in order to determine the critical steps and, through dredging, to facilitate the navigation of boats of up to 10 feet throughout the year. The section that presents the greatest difficulties for navigation is that which lies between the mouths of the Apa and Pilcomayo rivers, due to the existence of a rock bed. Poor drainage, poor channel signaling, and lack of satellite navigation charts make navigation difficult.

- *Paraná River.* River is a plain river that changes its course. This mobile bed feature, which is very susceptible to tides, results in obvious changes in the position of the navigation channel and in the setting of critical steps. It is a river that receives sediments, especially from the Bermejo River, which causes silting in some areas. At the same time, however, the river flows generating a process of self-dredging, which means dredging is not required in those places. The stretch from Santa Fe over the Paraná River, to Asuncion, over the Paraguay River is one of the most beneficial since, for the most part, it is navigable throughout the year at eleven feet of draft. The Apipé rapids used to exist in the Posadas-Corrientes section, but they disappeared with the construction of the Yacyretá dam, whose sluice and reservoir now allow navigation without any draft problems until the confluence of the Paraná River with the Iguazú.

- *Uruguay River.* This river, commercially navigable only in a stretch of approximately 200 km from its outflow, has historically offered navigational conditions inferior to those prevailing in the Paraná River. In addition, it has not been systematically maintained. The Uruguay River Administrative Commission (CARU), a binational organization responsible for the planning and control of activities carried out in the section of shared jurisdiction between Argentina and Uruguay, has carried out a study that resulted in the drainage project necessary to make it possible to sail with drafts up to 7.0m to the Argentine port of Concepción del Uruguay (km 187) and up to 5.17m to the Uruguayan port of Paysandú (km 207). The governments of both countries have committed the necessary financial contributions for the execution of the projected works, and have begun to take pre-dredging (bathymetry) and effective dredging actions in some parts of the lower section of the river.

- *Tieté River.* Currently has an inland transportation waterway in Brazil. In 2014, this waterway suffered an interruption due to a long period of drought, which also led to conflicts with other water uses, such as urban water supply, irrigation, and hydroelectricity.

- *Paraguay-Paraná Waterway.* This waterway is 3,442 km long from Nueva Palmira, on the left bank of the Uruguay River in Uruguay, to Puerto Cáceres, at the north end on the Paraguay River. In 2004, it hit the mark of 13 million tons of goods transported, a value that is growing rapidly each year. The busiest segment of traffic is between Puerto Caceres and Corumbá. The Paraguay River between Puerto Caceres and its confluence with the Cuiabá River presents a sinuous, wide, and shallow bed, which makes it difficult to navigate ships that require a certain draft.

- *Tietê–Paraná Waterway.* The Tietê River runs through a highly industrialized region of Brazil, which accounts for 35 percent of Brazil's GDP. There are multiple uses of energy and navigation in this system. There are currently eight locks and nine dams with hydroelectric power plants. This waterway runs from the Tietê (which crosses the city of São Paulo) to the Itaipú dam, which does not yet have a lock, impeding transit in the Paraná River downstream.

- *Uruguay Waterway.* The Uruguay River is navigable in its lower section, shared by Uruguay and Argentina, downstream from the Salto Grande dam. Upstream from Salto Grande, the river is navigable from Salto to São Borja, although traf-

Figure 3.10.1

La Plata Basin Waterways

fic is scarce. In 2002, the Administrative Commission of the Uruguay River (CARU) promoted the completion of full studies on the navigation of this river.

- ***Influence of Climate Variability and Change***

Recalling the period of very low flows in the upper basin of the Paraguay River between 1960 and 1973 and its effect on the shipping costs and on increased environmental impacts, it is important to verify the potential effects in the future, taking climate change into consideration. The reduction in levels, as in the period mentioned, would increase navigation costs by about 300 percent due to the need to increase the number of vessels for the same tonnage.

- ***Causal Analysis and Primary Recommendations***

For navegational limitations, the main causes are considered to be lack or inadequacy of infrastructure to overcome natural critical points, weak joint institutional management, asymmetries and weaknessess in country regulations, and a preference for terrestrial transportation. Given this, it is recommended to fundamentally harmonize regional policies for river transport; to adapt the legal and institutional framework for inland navigation; to develop cross-border plans for maintenance and dredging of navigable waterways; and to promote an integrated transportation system.

3.11 Limited Development of Hydroelectric Potential

Hydroelectric generation is another core activity for socioeconomic integration in the Basin, as it is the main form of energy in at least three of the basin countries--Brazil, Paraguay, and Uruguay— and it is also important for Argentina. The hydroelectric potential throughout the Basin is estimated at around 93.000 MW, of which 66 percent is already being exploited, with more than 150 hydroelectric power plants already in operation, 72 of which at levels above 10 MW (**Figure 3.11.1**). About 20 percent of the hydroelectric energy in the Basin countries is generated in the transboundary stretches. A significant part of the hydroelectric potential is concentrated in the Paraná and Uruguay rivers, due to their geological and hydrological characteristics.

The work completed during the execution of the Project allowed for the updating of the state of knowledge about hydroelectricity, with a broad vision focused on the deepening of the integration of existing and future systems. The analysis shows that Argentina has the highest untapped potential (2,650 MW), equivalent to 66 percent of its total potential in the Basin (4,000 MW). Brazil has the largest hydroelectric potential, with around 74,000 MW (80 percent of the Basin's potential), of which about 67 percent is being exploited. Paraguay accounts for approximately 14 percent of the hydroelectric potential of the Basin, of which 67 percent (around 9,000 MW) is already being exploited. Uruguay has almost all of its hydroelectric potential in operation, which constitutes approximately 1.5 percent of the Basin total (1,515 MW).

Interaction through electrical interconnections is associated with the use of transmission lines connecting the electrical systems of two or more nations. The great advantage of electrical interconnection is the possibility of transmitting electrical energy from one country to another, taking advantage of the differences and complementarities of electrical systems, consumption habits, seasonality, and temperature variations. In addition, the possi-

Figure 3.11.1

Hydroelectric Power Plants with more than 100 MW of power

bility of being compensated for structural problems in a particular country also exists. The integration of the hydroelectric sector is currently carried out through binational hydroelectric plants, among which Itaipú stands out.

Depending on the distance to the load centers and the size of the inventoried potential, the construction of new hydroelectric plants may not be economically viable if the market is much smaller than the power of the plant. However, electrical integration allows large-scale companies located in countries with more protected internal markets to be economically viable by meeting the demand for integrated electrical energy from several countries in a much more reliable way, compensating for any electric disparities or shortcomings with surplus energy from other countries. In this sense, the electrical integration between the countries creates greater reliability of the energy systems to cope with adverse meteorological conditions, technical problems, and consumption peaks. On the other hand, since electrical systems must be designed not only to meet the average demand, but above all to be able to face consumption peaks, the possibility of compensating and complementing the facilities of several regions is a better use of the investments made.

- ***Influence of Climate Variability and Change***

The LPB has a privileged position with respect to the availability of water resources in much of its territory. However, climate variability and change can affect the production of hydroelectric power. The operation of the power plants depends on the annual or multi-annual rainfall cycle and, consequently, on the associated river flow. Phenomena such as El Niño and La Niña and variations in water surface temperature in the Tropical and Southern Atlantic can lead to climatic anomalies.

It will be necessary to continue the studies in order to have a clear vision of the impacts of climate change on the water resources of the Basin and, consequently, to reduce the uncertainty, which constitutes an obstacle to operational planning and the management of hydroelectric plants.

- ***Causal Analysis and Primary Recommendations***

For the topic of hydroelectric potential, a causal chain analysis was not performed. However, some important recommendations are: to create energy integration agreements between Basin countries; to integrate hydro-meteorological monitoring of hydraulic exploitation networks with other information systems; and to take actions to use the regional interconnected communications system to improve the transmission of regional information for early-warning hydrological systems.

3.12 Summary of the Main Problems Detected by Sub-basin

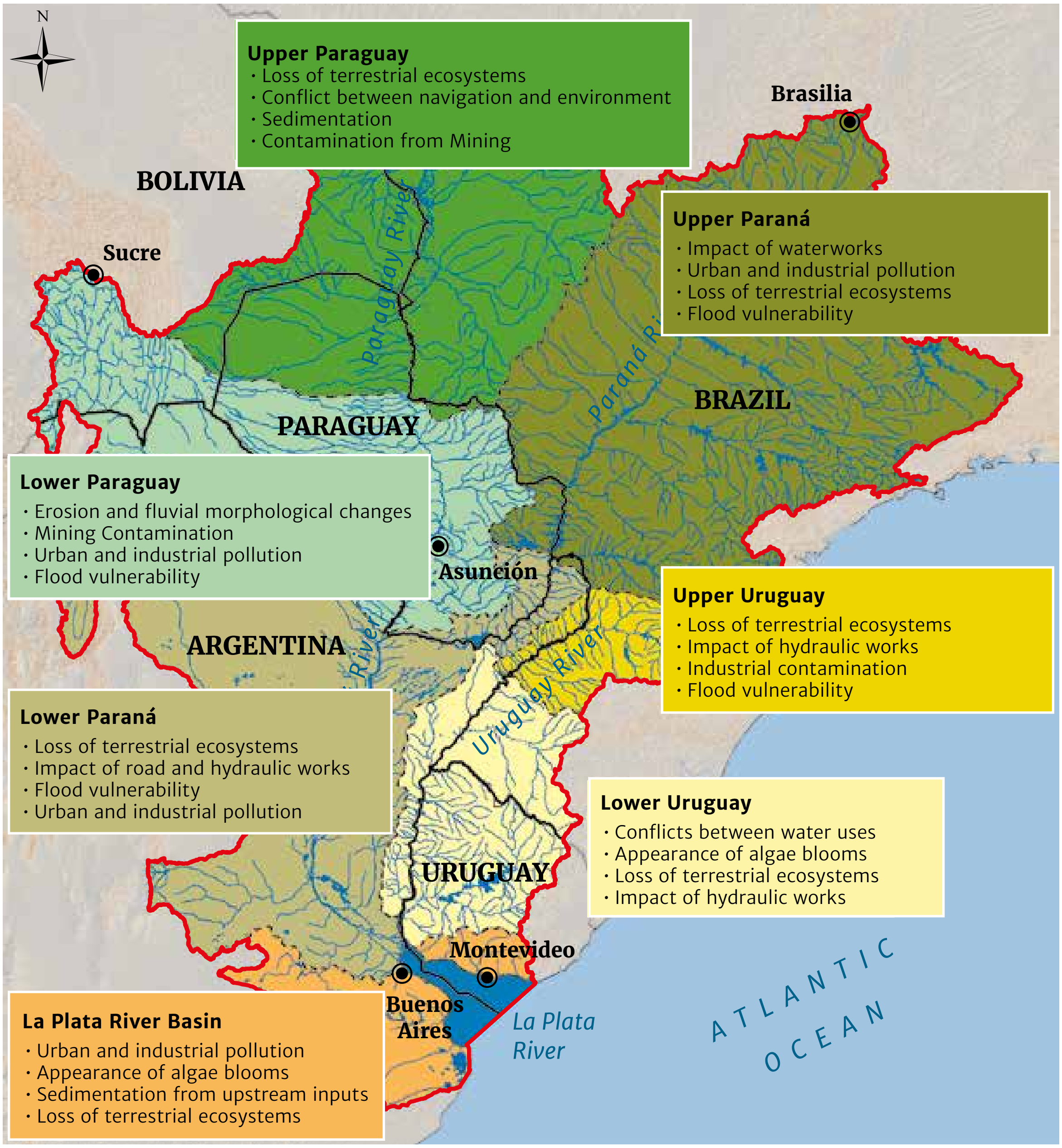
This section summarizes the main problems detected in each sub-basin for most of the Critical Transboundary Issues discussed above, in order to highlight and provide a basis for linking them **(Figure 3.12.1).**

Upper Paraguay

The Pantanal is located in this sub-basin, one of the most transcendent wetlands for the Basin's aquatic biodiversity. This sub-basin has suffered a considerable loss of terrestrial ecosystems (40 percent) and presents an environmental risk

Figure 3.12.1

Characteristic problems of each sub-basin



of loss of integrity. Sixty-one protected areas covering 12.6 percent of its area have been created. There are six Ramsar sites (46,500 km²), two MAB Biosphere Reserves (326,492 km²), and 19 important bird areas (IBA). It is the least populated sub-basin, with 2.4 million people.

In terms of navigation, it boasts the tract of the Paraguay-Paraná Waterway with the greatest difficulty of traffic, between Puerto Caceres and Corumbá. Between Puerto Caceres and the confluence with the Cuiabá River, the bed is sinuous, wide, and shallow, which makes it difficult to navigate boats that require a certain draft. In order to expand the waterway's transport capacity, works have been planned to increase it, a project that may involve a significant environmental impact requiring careful technical evaluation.

With respect to sediment production and transport, the Parapetí River requires more attention, as sedimentation processes can be observed in its channels that occur due to the change of slope of the river course. In the rainy season, the river carries sedimentation by drag and suspension. The coarser materials are deposited near the exit of the sub-Andean mountain range and the thinner materials are deposited as they travel along the plain, until arriving in the Izozog swamps, where very fine material accumulates.

Based on the analysis of 4,579 km of the upper section of Paraguay River, it was estimated that 65 percent of the course has a high vulnerability to floods, 25 percent a medium vulnerability, and 10 percent low vulnerability. As for the number of populations likely to have problems with riverine floods, three were identified with more than 50,000 inhabitants and 15 between 10,000 and 50,000 inhabitants.

In terms of droughts, the characterization of future periods of water deficit shows an increase in dry periods, in terms of duration, magnitude, and average intensity, as well as spatial coverage.

In relation to pollution, the mining activity in Bolivia and Brazil stands out. There are tin deposits in the form of cassiterite and acid drainage as a result of this activity and its environmental liabilities. On the other hand, in the Brazilian sector, water resources are contaminated by pesticides used in annual crops in the Planalto region.

Lower Paraguay

This sub-basin is characterized by sediment production, which is somewhat greater in the upper basin of the Pilcomayo River than in the Bermejo River basin. However, the load on the Pilcomayo River is deposited in the swamps of its alluvial cone in the Chaco plain, and it consequently does not reach the Paraguay River. The total sedimentation of the channel to levels higher than the floodplain is a morphological problem that affects watershed management. As a consequence, the Pilcomayo River floods overflow over the plain, forming new swamps annually. For its part, it should be noted that the contribution of silt and clays from the Bermejo River constitutes 90 percent of the fine sediment transported by the Paraná River.

As far as pollutant loads are concerned, the majority come from agricultural activity (crops and pastures) and, mainly, discharges of domestic and industrial effluents in areas close to large urban centers such as Concepción, Asunción—the capital of Paraguay—and Pilar. Likewise, there is a high concentration of phenols—indicating probable contamination from industries, including timber—in the course of the Paraguay River and one of its tributaries, the Apa River. There is also a heavy metal presence in the Pilcomayo and Bermejo rivers, originating from the mining activity in the headwaters of their respective basins on Bolivian territory.

It is one of the least populated sub-basins, with 2.8 million inhabitants, also including the constitutional capital of Bolivia, Sucre. It has suffered a 15 percent loss of terrestrial ecosystems. Three important reservoirs have been planned in the sources of the Bermejo River, and 66 protected areas have been created covering 7.4 percent of its area. There are nine Ramsar sites (11,384 km²), six Biosphere reserves (21,097 km²) and 94 IBA.

On the other hand, based on the analysis of 17,417 km of the lower section of the Paraguay River, it was estimated that 38 percent of the course has a high vulnerability to flooding, 41 percent an average vulnerability, and 21 percent low vulnerability. As for the number of populations likely to have problems with river floods, nine were identified with more than 50,000 inhabitants and 17 between 10,000 and 50,000 inhabitants.

In terms of droughts, the characterization of future periods of water deficit shows an increase in dry periods—both in duration, magnitude, and spatial coverage—but without reaching the levels of the upper Paraguay and upper Paraná sub-basins.

Upper Paraná

This is the most populated sub-basin, with 61.8 million inhabitants and six major cities, including Brasilia, the capital of Brazil. Upper Paraná and its tributaries have undergone major modifications for flood control and hydropower generation (43 large reservoirs and eight dams with locks). The Tietê-Paraná Waterway encompasses the Tietê River, which runs through a highly industrialized region of Brazil, and the Paraná River to the Itaipú dam, which still does not have a sluice.

In terms of contamination, degradation or loss of water quality is observed in riparian areas of the urban-industrial conglomerates and in the rivers and streams of the sub-basin, for example, in the areas of São Paulo, Brasilia, and Curitiba, with great demand for water and a corresponding increase in the load of contaminants discharged. It is also observed that the industrial effluents of industries linked to agricultural activities represent important contributions of contamination by organic matter, with a consequent decrease in dissolved oxygen levels in water bodies.

This sub-basin has suffered a very high loss of terrestrial ecosystems (75 percent). There are no Ramsar sites, which indicates the absence of large wetlands of international relevance. There are a large number of protected areas (313), although they cover only 7.7 percent of its area. The Mbaracayú Forest Biosphere Reserve (2,800 km²) is part of this sub-basin. There are 32 IBAs within its limits. Nine species of threatened fish inhabit this sub-basin, and there is a high degree of invasion of exotic species. The cultivation of exotic fish is highly developed.

In terms of floods, 11,939 km of the high Paraná River stretch were analyzed, with 23 percent of the course considered to have high vulnerability to floods, 40 percent average vulnerability, and 37 percent low vulnerability. With regard to the number of populations likely to have problems with river floods, 39 were identified with more than 50,000 inhabitants and 66 between 10,000 and 50,000 inhabitants.

In terms of droughts, the characterization of future periods of water deficit shows an increase in dry periods, in terms of duration, magnitude, and average intensity, as well as spatial coverage.

Lower Paraná

There are several important wetlands, such as the Ramsar Lagoons and Iberá Estuary, the Chaco Wetlands, Jaaukanigás, Otamendi Reserve, and the lower Paraná floodplain, Paraná Delta (Argentina) in this sub-basin. It has suffered a considerable loss of terrestrial ecosystems (40 percent) and presents environmental risk due to loss of integrity. There are 82 protected areas covering only 5.6 percent of the total area. There are five Ramsar sites (10,950 km²), two Biosphere Reserves (10,619 km²), and 78 IBAs. Thirteen species of threatened fish inhabit this sub-basin, and there is a high degree of invasion with seven species of exotic fish. The cultivation of exotic fish is highly developed.

The population amounts to 9.5 million inhabitants, with seven major cities. Three dam reservoirs have been built with power plants producing more than 100 MW, one in the Juramento River and two in the Paraná. Other works that impact the ecosystem are the Rosario-Victoria road connection, the real estate expansion over wetlands, and their loss to the construction of hills for the use of agriculture and cattle breeding.

In terms of floods, from the analysis of 12,946 km of the lower section of the Paraná River, it emerged that 73 percent of the course presents a high vulnerability to floods, 24 percent an average vulnerability, and 3 percent low vulnerability. As to the number of populations likely to have problems with riverine flooding, 22 were identified with more than 50,000 inhabitants and 77 between 10,000 and 50,000 inhabitants.

Regarding droughts, the characterization of future periods of water deficit shows that the climate becomes gradually more humid for the most distant scenarios in time, decreasing dry periods and their magnitude, average intensity, and spatial coverage.

In terms of pollution, problems are observed mainly in large urban conglomerates such as the cities of Rosario and Santa Fe and areas with industrial development, such as the city of Esperanza, with tanneries that pour their effluents into the Salado River, an affluent of the Paraná.

Upper Uruguay

This is the least populated sub-basin, with 1.7 million inhabitants, with no large cities. It has suffered a significant loss of terrestrial ecosystems (60 percent). Three large reservoirs associated with dams with hydroelectric power plants have been built on the Uruguay River, and there are plans for the construction of three new ones. Twenty-nine protected areas have been created, covering only 4.4 percent of its area. Although there are important wetlands, such as the Moconá Falls, there are no Ramsar sites. There is a Biosphere Reserve, Yabotí (2,366 km²), and 12 IBAs have been identified.

As for industrial pollution, the largest sources are found in the tributaries, the Peixe and Canoas rivers, which receive high pollution loads of both point source and diffuse origin, coming from the paper and food industries and tanneries of, respectively, the cities of Cacador and Videira.

Regarding flooding, 4,454 km of the upper stretch of the Uruguay River were analyzed, estimating that 55 percent of the course has a high vulnerability to floods, 19 percent has average vulnerability, and 26 percent low vulnerability. As for the number of populations likely to have problems with river floods, four were identified with more than 50,000 inhabitants and 18 between 10,000 and 50,000 inhabitants.

In terms of droughts, the characterization of future periods of water deficit shows fewer dry periods, although with longer duration and intensity. Later, the humid climate predominates, decreasing the number of dry periods, their duration, intensity, and coverage.

Lower Uruguay

From Garabí to its mouth in the La Plata River. This is a sub-basin with an intermediate population level, with 3.8 million inhabitants and three important cities. It presents some conflicts over the alternative use of water between rice irrigation, the supply of cities, and the conservation of ecological flows in rivers. In terms of contamination, there is a reoccurrence of harmful cyanobacteria algae blooms as a consequence of nutrient inputs from agricultural activity.

The Planicie wetlands and islands of the Uruguay River, the Farrapos Estuary Ramsar Site, Villa Soriano, and the Palmar de Yatay Ramsar Site stand out. The sub-basin has suffered a significant loss of terrestrial ecosystems (60 percent). There are four large reservoirs associated with dams with hydroelectric power stations, one on the Uruguay River and three on the Negro River. Thirty-nine protected areas have been created, covering only 1.8 percent of its area. There are three Ramsar sites (849 km²) and a Biosphere Reserve (997 km²), and 20 IBAs. Six species of threatened fish and five species of exotic fish have been recorded.

In terms of floods, the analysis of 13,334 km of the lower section of the Uruguay River shows that 27 percent of the course has a high vulnerability to floods, 39 percent an average vulnerability, and 34 percent a low vulnerability. For its part, seven populations were identified with more than 50,000 inhabitants, and 18 between 10.000 and 50.000 inhabitants, which have the probability of facing problems with riverine floods.

In terms of droughts, the characterization of future periods of water deficit shows an increase in water resources in the more distant future scenarios. Dry periods decrease in quantity, duration, and intensity, as well as in spatial coverage.

The Uruguay River is navigable in its lower section, shared by Uruguay and Argentina, downstream of the Salto Grande dam. Upstream from Salto Grande, it is navigable from Salto to São Borja, although traffic is scarce.

La Plata River Sub-basin

The second most populated sub-basin, with 24.9 million inhabitants, and five major cities, including Buenos Aires and Montevideo, the capitals of Argentina and Uruguay, respectively.

The largest pollution of urban-industrial origin in Argentina comes from the cities of Buenos Aires and its suburban area, and from La Plata and Gran La Plata, the sub-basins of the Matanza-Riachuelo and Reconquista rivers, as well as numerous streams and channels. In the case of Uruguay, the urban courses are the most affected, the Carrasco, Miguelete, Pantanoso, Colorado and Las Piedras streams and many of their tributaries, as well as the Bay of Montevideo and the Santa Lucía River sub-basin. Likewise, there is a recurrent occurrence of harmful cyanobacteria algae blooms on the Uruguayan banks of the La Plata River and in its sub-basin, as a result of nutrient inputs from agricultural/livestock activities.

The fine sediments of the Bermejo River, transported by the Paraná River, settle predominantly in the upper section of the La Plata River, contiguous to the Paraná Delta, the area with the greatest fluviomorphological activity.

Based on the analysis of 3,150 km in the La Plata River sub-basin, it was estimated that 6 percent of the courses have a high vulnerability to floods, 45 percent an average vulnerability, and 49 percent low vulnerability. As for the number of populations likely to have problems with riverine floods, eight were identified with more than 50,000 inhabitants and 15 between 10,000 and 50,000 inhabitants.

In the case of droughts, the characterization of future periods of water deficit shows a strong decrease of the dry periods, their duration and magnitude, as well as their spatial coverage.

In this sub-basin, the Samborombón Bay and Santa Lucía swamps stand out as important wetlands. The sub-basin has suffered a considerable loss of terrestrial ecosystems (35 percent), concentrated in the coastal strip of the La Plata River. Eleven protected areas have been created, covering only 0.8 percent of its total area. There are two Ramsar sites (4,883 km²) and two Biosphere Reserves (1,289 km²) in the Argentine section, and nine IBAs have been identified. There is a considerable wealth of fish fauna, registering five threatened species. The degree of invasion is high, with eight recorded species of exotic fish.

Chapter 4: Conceptual foundation of the Strategic Action Program

Through the process of updating the TDA and the recommendations provided for each CTI analyzed, a vision and objected for the SAP of the La Plata Basin was created, as well as goals associated with each CTI. The process involved the consolidation and prioritization of recommendations based on causal analysis, defining objectives to achieve qualitative goals for each CTI, and identifying the main corresponding actions, defining in general terms the position, structure, and content of the SAP **(See Table 4.1.1)**.

Visión:

The countries of the La Plata Basin, strengthened by the shared management of water resources, achieve sustainable development and the welfare of their inhabitants, overcoming Critical Transboundary Issues and in consideration of the effects of climate variability and change.

SAP Objective:

To promote the management of shared water resources, cooperation and regional integration, while seeking to achieve sustainable development in the La Plata Basin countries and the welfare of their inhabitants.

4.1 Consolidation of Recommendations and Definition of the SAP Structure

Recommendations for each of the goals, both in terms of objectives and actions, were initially grouped according to the nature of the proposed intervention –consolidating the politico-institutional, socio-cultural, and economic-managerial aspects associated with different goals, added together with gaps in information– and subsequently integrated into six Strategic Areas **(Figure 5.1)**, according to the following approach:

- Strategic Area I. *Information Management.* Incorporates actions related to searching, identifying, integrating, processing, and disseminating the information needed to support decision-making in integrated water resource management in the context of climate variability and change, including early detection systems and hydro-environmental monitoring.

- Strategic Area II. *Planning, Management, and Sustainable Use of Water Resources.* Includes planning and management actions aimed at strengthening prevention and CTI control mechanisms, seeking to take advantage of potential water resources to improve the quality of life of the population within the framework of climate variability and change, and also seeking to strengthen the objective to integrate the Basin countries through actions related to the development and sustainability of potential water energy and river transport.

- Strategic Area III. *Environmental Protection/Rehabilitation.* Lays out a vision for correcting environmental liabilities and maintaining still-preserved areas of environmental interest; for cross-border environmental protection in the La Plata Basin through joint actions between the countries, both for the protection of still-preserved or relatively well preserved environments and for the recovery and rehabilitation of environments impacted by human action and aggravated by climate variability and change.

- Strategic Area IV. *Education, Communication, and Public Participation.* Incorporates education, training, communication, and public participation in the Basin to improve social capacity to address/solve the CTIs and to seize participatory development opportunities in the La Plata Basin.

- Strategic Area V. *Research and Technological Development.* Actions aimed at strengthening technical and scientific development on issues of interest to resolving the CTIs and development opportunities in the La Plata Basin.

- Strategic Area VI. *Institutional Strengthening.* Includes proposals aimed at promoting/strengthening the institutional and legal order necessary to address the CTIs and facilitate SAP implementation. Includes strengthening the CIC and participating national agencies acting on water resources and related areas, as well as harmonizing legal standards in developing common or compatible protocols for implementing the strategic actions and SAP activities.

Strategic Area I precedes the others, as it adds together all of the information necessary for analysis and decision-making. The nucleus of the SAP is made up of Strategic Areas II and III. The first is more oriented toward the future, organizing water management in the context of sustainable development. The perspective of the second is to preventatively remedy environmental liabilities and to prevent further environmental degradation, depending on the use and management of water and land resources, within the framework of climate variability and change.

Strategic Areas IV and V are transverse areas. The first aims to deepen ties with society and public participation, creating communication and education actions focused on capacitation in priority areas for the development of the La Plata Basin. The second, aiming to uncover information on the processes involved, reducing information gaps and developing new technologies in the interest of solving the CTIs.

Finally, the Strategic Area VI aims to support all SAP activities through the development and strengthening of the institutional frameworks necessary for the implementation of the Program.

Table 4.1.1

Objectives and management recommendations for the CTIs

Critical Transboundary Issue/ Associated Goals	Objectives/Recommendations
Goal 1. **Less impact and vulnerability to extreme hydrological events**	• To promote the development of policies and the strengthening of legal frameworks for the prevention and management of extreme events. • To strengthen hydro-meteorological monitoring and prediction systems. • To promote institutional cooperation and coordination throughout the Basin. • To improve urban and regional planning to increase resilience and reduce vulnerability to extreme events. • To strengthen national and local agencies in managing extreme events. • To develop research, awareness-building, and environmental education programs.
Goal 2. **Reduce pollution levels and maintain water quality in a sustainable way**	• To harmonize and consolidate standards and measuring and control instruments. • To promote solid waste management and domestic wastewater treatment. • To reduce nutrient inputs and agricultural and industrial pollutants to water bodies. • To strengthen institutional capacities and collective monitoring at the Basin level. • To develop training and citizen participation programs.
Goal 3. **Reverse processes of land degradation; less sedimentation of water bodies and waterways**	• To promote the development and harmonization of natural resource use and protection standards. • To strengthen institutional capacities for land use management. • To implement land remediation and erosion control programs in priority areas. • To develop training and extension programs in land use and management.
Goal 4. **Utilize aquifers sustainably, while meeting development needs**	• To promote the development of a policy and regulatory framework for sustainable aquifer use. • To strengthen management capacity and institutional coordination. • To promote research and exchange of information. • To implement education and awareness programs.

Critical Transboundary Issue/ Associated Goals	Objectives/Recommendations
Goal 5. **Rational and sustainable use of fishery resources**	• To promote compatible protocol and criteria for the protection and sustainable use of fishery resources at the basin level. • To strengthen tools and mechanisms for management and control. • To develop actions to prevent and reverse the reduction of fishable stock. • To implement awareness and training programs in sustainable production techniques.
Goal 6. **Greater connectivity and integrity of river and coastal ecosystems, reducing environmental risks and impacts on aquatic biodiversity**	• To strengthen and harmonize regional legal frameworks for the protection of aquatic biodiversity. • To strengthen the management capacities of competent organizations. • To develop river and coastal ecological corridors and other forms of participatory conservation. • To integrate information, research, and monitoring systems at the Basin level. • To implement awareness-building and training programs.
Goal 7. **An increase and regulation of water supply and improved irrigation efficiency, reducing tensions and the potential impacts of irrigated crops**	• To promote agreements and the development of common legal frameworks for managing water use and audit systems. • To develop measures to increase water capture and storage, and to improve irrigation efficiency. • To strengthen the management capacities and institutional coordination of competent organizations. • To generate information and facilitate public access to data of interest for supply and demand management.
Goal 8. **Potential disaster impacts are reduced due to dam operation**	• To promote the development of common standards and criteria for dam safety, considering the impact of climate variability and change. • To promote the exchange of information and experiences on security of public works and dam operations. • To develop/update contingency plans and programs. • To develop public awareness-building measures concerning prevention and risk mitigation.

Objectives and management recommendations for the CTIs (continue)

Critical Transboundary Issue/ Associated Goals	Objectives/Recommendations
Goal 9. **Environmental sanitation in cities reduces water contamination and the incidence of disease**	• To promote policies and programs for solid and industrial waste treatment and agrochemical management. • To strengthen the capacity of local managers and institutional coordination. • To strengthen research and the generation and dissemination of data on waterborne diseases. • To implement citizen education and awareness programs on environmental hygiene and health.
Goal 10. **River navigation is enhanced as a transportation and a regional integration tool**	• To promote policy development and to strengthen standards for river transport. • To promote structural improvements for maintenance and port operations. • To strengthen institutional capacities for planning and joint management.
Goal 11. **Energy integration increases the reliability of systems**	• To strengthen institutional coordination and exchange of information and experiences with hydropower. • To promote multiple uses of shared reservoirs and the use of bonuses in integrated water resource management. • To articulate hydro meteorological monitoring systems in energy planning.
Goal 12. **Greater resilience and adaptive capacity reduces risks and impacts related to climate variability and change**	• To promote the incorporation of climate change measures in policies, strategies, and development plans.

Chapter 5: Strategic Action Program for the La Plata Basin (SAP)

The Strategic Action Program (SAP) for the La Plata Basin has a planning horizon of 20 years, and includes six (6) Strategic Areas, 13 components, and 28 strategic actions (**Table 5.1**). The combination of these strategic actions and the 130 activities that comprise them constitutes the intervention response and management recommendations aimed at resolving or mitigating the impacts of the main Critical Transboundary Issues affecting the Basin (based on the analysis of the identified causes) and to promote their sustainable development.

Although the environmental, social, and economic impacts of each of these actions can be differentiated, all priority actions are considered insofar as they are intended to solve issues of particular importance for an area or region or to advance the solution of critical problems in the Basin in general.

The Strategic Areas of the SAP are related to the Sustainable Development Goals, which constitute the global agenda for the next few years, because they revolve around actions that strengthen development at the global, national, local, and individual levels, enhancing improvements in thematic areas such as food security, drinking water, energy, urban infrastructure, consumption, and sustainable production, among other things.

Figure 5.1 relates each of the SAP Strategic Areas to the seven Sustainable Development Goals which the SAP implementation will impact.

Table 5.1

SAP Structure

Strategic Area/ component	Strategic actions
STRATEGIC AREA I: INFORMATION MANAGEMENT -- DSS for IWRM in the La Plata Basin	
I.1 Networks and Information Systems	I.1.1 Expansion and consolidation of monitoring networks I.1.2 Expansion and integration of information systems
I.2 Hydro-environmental Monitoring and Hydrological Warning	I.2.1 Design and implementation of a hydro-environmental monitoring system in the La Plata Basin I.2.2 Consolidation of the hydrological alert system for La Plata Basin
STRATEGIC AREA II: PLANNING, MANAGEMENT, AND SUSTAINABLE USE OF WATER RESOURCES	
II.1 Integrated Water Resource Management and Adaptive Measures	II.1.1 Integrated management of surface water and groundwater in critical areas II.1.2 Land use planning and restructuring in priority vulnerable areas II.1.3 Water supply management program II.1.4 Risk management and adaptive measures program
II.2 Sustainable Productive Development	II.2.1 Promote farming systems resilient to climate variability and change II.2.2 Sustainable fishery and aquaculture programs II.2.3 Ecotourism program II.2.4 Clean technology program
II.3 Water Resource Use in the Context of Regional Integration	II.3.1 Enhance river navigation as a mode of transportation and regional integration II.3.2 Coordinating hydroelectric systems in the context of climate variability and change
STRATEGIC AREA III: ENVIRONMENTAL PROTECTION/ REHABILITATION	
III.1 Ecosystem Management	III.1.1. Conservation and expansion of protected areas and sustainable management of riparian and wetland ecosystems III.1.2 Management of aquatic and other associated ecosystems
III.2 Sustainable Land Management	III.2.1 Land recovery and erosion control III.2.2 Local conservation and sustainable land management
III.3 Environmental Sanitation	III.3.1 Reduction of pollution sources III.3.2 Urban sanitation and health

Strategic Area/ component	Strategic actions
STRATEGIC AREA IV: EDUCATION, COMMUNICATION, AND PUBLIC PARTICIPATION	
IV.1 Environmental Education	IV.1.1. Environmental education program IV.1.2 Training and rural outreach program
IV.2. Communication and Public Participation	IV.2.1 Social communication and public participation program to promote awareness and social participation
STRATEGIC AREA V: RESEACH AND TECHNOLOGICAL DEVELOPMENT	
V.1 Research and Technological Development	V.1.1 Support research development, technological development, and innovation associated with the CTIs
STRATEGIC AREA VI: INSTITUTIONAL STRENGTHENING	
VI.1 Institutional Framework	VI.1.1 Strengthening of CIC as an organization for coordination and institutional linking for the purpose of SAP implementation VI.1.2 Strengthening national agencies in the SAP implementation stage
VI.2 Legal Framework	VI.2.1 Harmonization of national legal frameworks for transboundary water resource management, including agreements between countries VI.2.2 Developing common technical guidelines and protocols for actions aimed at enabling the management of shared hydraulic resources

Figure 5.1

SAP Strategic Areas related to the fulfillment of the Sustainable Development Goals

STRATEGIC AREA I. Information Management – Support system for decision-making in the field of integrated water resource management of La Plata Basin

Strategic Area I seeks to establish a common baseline for the coordination, processing, integration, and access to information relative to the diverse aspects of the Basin, such as supporting decision-making related to the integrated management of hydraulic resources, in the context of climate variability and change.

The actions included under this Strategic Area seek to advance and strengthen the efforts made during the implementation of the Framework Program (2011-2016). During this period, the basis of a decision-making support system was established through the integration of a free-access online information platform containing information relative to hydraulic resources and the environment generated by the supervisory institutions of the countries and other regional and supra regional authorities.

The existing system comprises nodes located in the five countries that form the Basin and the CIC, the coordinating body of all of the actions realized by countries under the framework of the La Plata Basin Treaty. This platform will allow access to georeferenced information through a map viewer and access to historic registries of hydro-meteorological variables. It features a base map of the La Plata Basin, as well as information on groundwater and ecosystems, among other things Additionally, it provides a virtual space through which to integrate information generated by other projects previously developed in the region through initiatives such as WIGOS and WMO.

In the future, it seeks to expand the hydro-meteorological information base, to incorporate a catalog of legislation and policy guidelines on shared management of hydraulic resources, and to facilitate the tasks of processing and operations analysis, either through hydro-environmental monitoring or a hydrological alert system. The development of DSS-Plata will be accompanied by institutional strengthening of the bodies responsible for generating and managing information in accordance with international standards, as outlined in Strategic Area VI.

Component I.1:
Networks and Information Systems

This component is associated with the planning process and seeks as its objective to expand, consolidate, and integrate necessary information to strengthen knowledge of hydro-meteorological and hydro-environmental phenomena, taking into consideration the networks and systems already developed within the five countries.

It includes actions for the expansion and connection of meteorological radar networks at the Basin level, in order to improve the regional meteorological alert systems and the development of geostationary satellites suitable for hydro-meteorological applications. The strategic actions considered are:

- *Strategic Action I.1.1 – Expansion and consolidation of monitoring networks.* This strategic action aims to promote the expansion and consolidation of observation networks, including hydrological, climatological, hydro-meteorological, water quality, sediment transport, and aquifer-level observation stations, among others. This information is an initial link for the information systems as well as the monitoring and alert systems of the La Plata Basin's IWRM.

- *Strategic Action I.1.2 - Expansion and integration of information systems.* This strategic action is aimed at promoting the expansion and integration of digital mapping and library databases regarding studies, macro- and micro-regional and territorial plans, and water resource plans. This information, together with the data collected in I.1.1, is the initial link for the monitoring and alert system of La Plata Basin's IWRM.

Component I.2: Hydro-environmental monitoring and hydrological warning

This component is the operating part of La Plata Basin's decision-making support system (DSS-Plata) and seeks to design and implement the LPB's hydro-environmental monitoring system, as well as to consolidate the critical hydro-meteorological event alert system. This operating part of DSS-Plata will be based on the previously existing analog systems in the countries and tasked with organizing, integrating, and consolidating information in the territorial projections in critical transboundary basins. The strategic actions are:

- *Strategic Action I.2.1 - Design and implementation of a hydro-environmental monitoring system in the La Plata Basin.* Hydro-environmental monitoring aims to be a tool that provides information for decision-making regarding pollution risks and the risk of disruption of ecosystems, among other things, with the goal of promoting the implementation of control and mitigation measures for ecological and environmental risk. Both the strategic actions of the networks (I.1.1) and the information systems (I.1.2) will be the integration links between the data generated at the national and transboundary levels, which later will be utilized for hydro-environmental monitoring, where national bodies will have a space for common action.

- *Strategic Action I.2.2 - Consolidation of the hydrological alert system for the La Plata Basin.* The critical hydro-meteorological event alert system will offer information to support decision-making regarding floods, droughts, navigation, hydroelectricity, and livestock farming, through agrometeorological diagnostics that will influence the development of activities associated with food security.

STRATEGIC AREA II. Planning, Management, and Sustainable Use of Water Resources

This Strategic Area aims to develop and strengthen diverse topics that coincide with the integrated planning and management of the Basin's water resources, seeking to strengthen prevention and control mechanisms for the primary environmental degradation phenomena, reducing vulnerability and increasing resilience to extreme events, particularly floods and droughts. This Strategic Area also includes actions aimed at improving the quality of life of the population through sustainable development and maximization of available hydraulic resources in the Basin in a way that balances economic and social interests and the social demands of a healthy and functioning environment in ecosystemic terms. The concept of food security will be given particular emphasis within the context of climate variability and change, particularly in zones that are more vulnerable and of high social impact, seeking to promote the development of sustainable and resilient productive systems, incorporating soil, water, and ecosystem protection practices, improving efficiency and risk development and other uses of water. Additionally, it will provide follow-up concerning the integration of La Plata Basin countries, through actions related to the basin's development, sustainable energy potential, and river transport, in the context of environmental challenges caused by climate variability and change. The Strategic Area includes the following components and actions:

Component II.1: Integrated water resource management and adaptive measures

This component comprises actions aimed at reducing ecosystem vulnerability through the management of hydraulic resources, as a central component of the overall management of the development of the Basin. The potential impacts of climate variability and change on the availability of water resources, as well as its effects on the well-being of the population and region's economies are identified within this component. Proposals will be developed to improve access to water resources for: productive development and the needs of the populations in areas of water stress; enhanced planning systems; integrated and sustainable use of surface and groundwater resources in critical vulnerable areas of water stress; and development and realization of contingency plans and programs to reduce the potential impact of disasters. The proposed strategic actions are:

- *Strategic Action II.1.1 – Integrated management of Surface and groundwater resources in critical areas.* Carries out actions that seek to improve the optimization of hydraulic resources within ecosystems and critical zones, with the goal of increasing and improving access to hydraulic resources for productive development and to meet population needs. It will promote, in particular, the sustainable use of aquifers to meet development needs, seeking to expand and standardize water provision and its efficient use, with the objective of reducing potential impact in areas under water stress.

- *Strategic Action II.1.2 – Land use planning and restructuring in priority vulnerable priority areas.* This strategic action seeks to improve urban and territorial planning, promoting territorial restructuring as a primary instrument for determining land use and economic activities reliant on natural resources. It promotes improved resilience and reduced vulnerability to extreme events, particularly floods and droughts. The actions will be carried out at the local level as normative instruments for territorial occupation, aiming to reduce the impacts of climate vulnerability and change on major populated areas. At the regional level, the agro-ecological zoning of priority areas (micro basins or sub-basins) will be promoted, strengthening the technical and legal capacities of the local governments for the planning and management of the resources according to the capacities for use.

- *Strategic Action II.1.3 – Water supply management program.* Includes actions aimed at guaranteeing water supply for human and productive activities, so as to be able to cope with periods of low flows and droughts or any imbalance between supply and demand resulting in restrictions on water consumption and, consequently, on economic and regional development. Similarly, it includes activities to ensure that water quality standards clearly defined for specific uses are met, either in normal situations or especially facing the occurrence of accidental contaminant spills.

- *Strategic Action II.1.4 – Risk management and adaptive measures program.* This strategic action aims to develop strategies for integral risk management, acting in distinct areas related to natural disasters: (i) disaster prevention, through better preparedness of civil society and responsible institutions; (ii) mitigating the effects of disasters, reducing vulnerability and mitigating potential damage to life and property; and (iii) risk prevention (long-term), acting on its causes. Identification and analysis of both threats and vulnerabilities are considered, developing activities in concatenated and integrated phases of prevention, mitigation, preparedness, response and rehabilitation. The proposed activities complement those of component I.2 *Hydro-environmental monitoring and hydrological warning,* as well as the activities of IV.3 *Communication and public participation,* particularly in reference to the development of actions aimed at raising risk awareness, involving authorities, achieving community participation, and reducing economic and social loss.

Component II.2: Sustainable Productive Development

This component aims to improve income and the quality of life of small producers and communities, particularly those located in vulnerable areas, revaluing the environmental function of ecosystems and the multiple potential uses of water resources available in the Basin. To this end, actions will be carried out aimed at implementing sustainable production practices and soil, water, and ecosystem protection to promote the advancement of fishing and aquaculture, ecotourism, and the use of clean technologies. In developing these actions, the main focus will be on food security, taking into account the effects of climate variability and change. This component includes the following strategic actions:

- *Strategic Action II.2.1 – Promote farming systems resilient to climate variability and change.* This action addresses the concept of resilience in production systems, seeking not only to develop robust food systems in the face of climatic disturbances, but also to ensure adaption, response, and recovery capacity, helping to reduce potential impacts. The activities includes fostering local capacity to improve plans and actions related to food security at the local/community level; agroecological zoning of the principal productive areas; development and implementation of adaptation measures in pilot areas, including sustainable agricultural practices, use of resistant varieties, and/or crops adapted to new climatic conditions, and the adoption of sustainable irrigation techniques, among others.

- *Strategic Action II.2.2 – Fishing and Aquaculture Program.* This strategic action seeks to promote the rational and sustainable use of fishery resources working at different levels to develop and promote integrated policy, norms, and compatible criteria at the basin level, operating in particularly critical and vulnerable zones, with actions oriented towards strengthening local capacities to develop control and management tools and mechanisms, and to implement actions to prevent and reverse the reduction of fishable stocks. Also, in coordination with the Strategic Area *Capacity building and social participation*, it will develop and implement awareness and capacity-building programs in sustainable fishery techniques and aquaculture development.

- *Strategic Action II.2.3 – Ecotourism program.* This strategic action seeks to promote ecotourism as a means by which to improve income generation for local communities, and as strategy for protection of ecosystems and the management of protected areas. In accordance with what has been identified by the TDA, particular attention will be given to the sub-basin of the lower Uruguay, which is composed of a series of islands and coastal wetlands, and which merits special attention in terms of management. Due to its natural and cultural wealth, this zone represents important potential for ecotourism and nautical tourism, and therefore is a high conservation priority.

- *Strategic Action II.2.4 – Clean technology program.* The activities under this strategic action seek to promote policies and programs that stimulate the use of clean technology and minimize waste, improving income and the quality of life for small-scale producers and communities implementing sustainable production practices.

Component II.3: Water Resource Use in the Context of Regional Integration

Recognizing the importance of the energy and navigation sectors for the socioeconomic development of the countries of the Basin, this component aims to identify in a precise manner the potential impacts of climate variability and change, proposing adaptation measures to reduce or mitigate its principal effects. The strategic actions and activities proposed under this component are:

- *Strategic Action II.3.1 - Enhance river navigation as a mode of transportation and regional integration.* The activities under this strategic action seek to promote navigation development in the La Plata Basin, overcoming the primary obstacles currently impeding transboundary river navigation, taking into consideration the potential impacts of climate variability and change.

- *Strategic Action II.3.2 - Defining hydroelectric systems in the context of climate variability and change.* The activities in this strategic action seek to reduce the vulnerability of the energy sector, considering the uncertainty of current climate models in terms of predicting future precipitation levels and the effects on energy generation.

STRATEGIC AREA III. Environmental Protection/Rehabilitation

This Strategic Area seeks to strengthen ecosystem conservation mechanisms and the prevention and control of environmental degradation processes affecting the La Plata Basin within the framework of climate variability and change. These actions are aimed at land recovery and conservation, erosion reduction, and eradication or reduction of pollution sources in order to mitigate negative effects on human health and promote the implementation of measures that contribute to urban sanitation. This Strategic Area is organized into three components.

Component III.1: Ecosystem Management

This component comprises actions geared toward contributing to the sustainable management of biodiversity to guarantee its conservation. The proposed strategic actions are:

- *Strategic Action III.1.1 - Conservation and expansion of protected areas and sustainable management of wetlands.* This strategic action seeks to establish agreements and guidelines for joint action in conserving transboundary protected areas and wetlands; to promote conservation and restoration of riparian ecosystems through the creation and consolidation of ecological, river, and coastal corridors; the consolidation of transboundary protected areas, giving priority to the conservation and sustainable use of biodiversity and the protection of endangered species, habitats, and vulnerable ecosystems.

- *Strategic Action III.1.2 – Management of aquatic ecosystems.* Involves updating species inventories; the management and conservation areas important for the reproduction, raising, and feeding of (mainly) fish; and developing measures to control invasive, exotic, and non-native aquatic species.

Componente III.2: Sustainable Land Management

This component comprises actions for erosion and sedimentation control in defined critical areas, and the implementation of best practices in soil and water management and conservation for diffuse erosion control. The proposed strategic actions are:

- *Strategic Action III.2.1 - Land recovery and erosion control.* Focuses on all activities designed to address erosion-sedimentation problems in important support basins (typically rivers). While it is good to include and tend to all forms of erosion, is of special interest to treat erosion not caused by the anthropogenic causes (channel edge erosion, mass landslides, large-sized gullies), which can be mitigated (or accelerated) by anthropogenic actions. Activities include developing proposals to manage the buffer zones, and the design and implementation of land recovery and erosion control in critical areas, particularly in the Upper Basin of the Bermejo River, from the Pilcomayo in the Pantanal region, the Paraná hydrographic region, the outskirts of Buenos Aires and Sao Paulo, and the areas around Paraná River reservoirs, among others.

- *Strategic Action III.2.2 - Local conservation and sustainable land management.* Focuses particularly on the mitigation of diffuse erosion effected by changes in land use and coverage on a local scale, typically in agricultural/livestock establishments. Policies and training programs will be developed to promote best practices in land and water management and conservation in the design and management of agricultural production systems. It also includes the development and implementation of predictive tools (models) validated at the local level, to guide decision-making.

Componente III.3: Enviro mental Sanitation

This component refers to the problems caused by pollutants associated with agricultural, industrial, and mining activities and the deficiency or lack of basic sanitation (collection and treatment of domestic and industrial sewage, urban drainage, and solid waste). Through this component, reduction and recuperation targets will be established and agreed upon by the countries for control and mitigation. It presents two clearly defined strategic actions: one addressing the reduction of pollutant sources and the other urban sanitation and health. The proposed strategic actions proposed for this component are the following:

- *Strategic Action III.3.1 – Reduction of pollution sources.* This strategic action aims to reduce the principal pollution sources in the Basin, addressing the lack of control over organic, chemical, and solid waste caused by industrial, mining, livestock, and agriculture activity. It includes activities designed to reduce the impact of agrochemical use (fertilizers, herbicides, insecticides, and fungicides), as integral elements to agricultural production technologies and nutrient reduction, particularly phosphorus, the cause of cyanobacteria blooms. The activities also include the development and implementation of a joint solid waste and agrochemical management program.

- *Strategic Action III.3.2 – Urban sanitation and health.* Proposes that drinking water be stored in critical urban areas, considering climate change adaptation measures and alternatives for the protection of urban aquifers and the treatment of urban effluents. It also includes the establishment of health plans associated with the treatment and mitigation of waterborne illness.

STRATEGIC AREA IV. Education, Communication, and Public Participation

This area is transverse to all of the Strategic Areas, involving components and strategic actions aimed at educating, training, building awareness, disseminating information, reporting, and facilitating improved social participation (efficient and effective) in solving problems of interest in the La Plata Basin.

Component IV.1: Education

- *Strategic Action IV.1.1 - Environmental education and training program.* Proposes to develop and implement an education and citizen awareness program on sustainable development issues in the context of climate variability and change. The program in each country based on minimum content protocol established for the LPB region, will focus on socio-environmental issues such as sanitation, sustainable use of aquifers, risk prevention and mitigation, sustainable fishing and tourism, among other things. It will promote the use of pedagogical criteria adapted to the social and topical context of each country.

Component IV.2: Training

- *Strategic Action IV.2.1 - Training and rural outreach program.* Includes programs for training, outreach, and awareness in water resource management practices, ensuring IWRM and land conservation. The activities will focus on topics related to native fish framing and sustainable fishing techniques, agricultural techniques, forestry, and sustainable mining, and mining the local knowledge and traditional practices of each country. Training programs will initially be carried out in priority areas of the Basin affected by land and water degradation problems caused by agricultural and mining activities. The activities will also comprise developing outreach programs on these topics, and the development and dissemination of sustainable technologies to increase the availability and efficient use of surface and underground water irrigation.

Componente IV.3: Communication

- *Strategic Action IV.3.1 - Social communication and public participation program to promote awareness and social participation.* Proposes to carry out an awareness, communication, and public dissemination program adapted to the different national, regional, and social realities in order to promote water resource management and addressing the different CTIs. The Communication Program is expected to inform and involve society in the environmental situation of the LPB and in particular on the effects of climate variability and change.

STRATEGIC AREA V. Research and Technological Development

This Strategic Area meets the demand presented by the TDA concerning the development of research and technology to be applied to solving the Critical Transboundary Issues. It aims to promote the reallocation of resources based on necessary technological developments to promote the sustainable management of water resources.

Component V.1: Research and Technological Development

- *Strategic Action V.1.1. – Support research development, technological development, and innovation.* Includes developing research and technologies to be applied to solving critical transboundary issues covering several critical transboundary issues, which address various knowledge areas and problems: the vulnerability of coastal habitats, erosion, generation and transport of sediment, the ratio of groundwater to surface water (integrated water balance), ecological flow, integrated and participatory watershed management, technologies to increase the availability and efficient use of water for irrigation and environmental sanitation and health.

STRATEGIC AREA VI. Institutional Strengthening

Strategic Area VI includes proposals for institutional and legal adjustments deemed necessary to facilitate SAP implementation. From the institutional point of view, Strategic Area VI comprises i) strengthening the Intergovernmental Coordinating Committee of the Countries of the La Plata Basin; ii) strengthening participating national bodies' action on water resources and related areas; and iii) bringing them together, the adaptation of the relationship and procedures governing the interaction of the various participating institutions. From a legal point of view, this area is interested in the harmonization of legal standards and setting common or compatible standards and protocols in the five countries for the purpose of greater uniformity of the fundamental principles which may facilitate the realization of the Framework Program's objectives and the SAP's strategic actions and activities.

Component VI.1: Institutional Framework

Includes proposals for institutional and legal adjustments necessary to facilitate the implementation of the SAP. From the institutional perspective, it includes actions for strengthening the Intergovernmental Committee of the Countries of the La Plata Basin (CIC) and of the national organisms acting on water resources and in related areas, as well as the adequacy of the interrelation and procedures that regulate their interactions. From a legal perspective, harmonization of legal norms and the establishment of common or compatible standards and protocols in the five countries will be sought, with a goal of achieving greater homogeneity in the fundamental principles, which may facilitate the achievement of the objectives of the Framework Program and the strategic actions and activities of the SAP. The strategic actions are:

- *Strategic Action VI.1.1. - Strengthening the CIC as an organization for coordination and institutional linking for the purpose of SAP implementation.* Proposes actions aimed at strengthening the CIC, expanding its powers, and enhancing its technical and administrative resources, as well as adapting the instances of binational and regional coordination.

- *Strategic Action VI.1.2. - Strengthening national agencies involved in the binational or regional coordination of the SAP implementation stage.* Includes strengthening the various national bodies with responsibilities in the management of shared water resources, addressing the weaknesses and institutional requirements for managing agencies competent in relation to the Critical Transboundary Issues within the framework of climate variability and change. Strengthening actions for national agencies will focus on covering needs in relation to the implementation of the SAP and the incremental costs required to support regional action.

Component VI.2: Legal Framework

Considers the adaptation and harmonization of national legal frameworks related to the joint management of shared water resources in La Plata Basin.

- *Strategic Action VI.2.1. - Harmonization of national legal frameworks for transboundary water resource management, including agreements between countries.* Contains actions aimed at promoting agreements between countries as well as adaptations of national legislation to enable a uniform legal framework.

- *Strategic Action VI.2.2. - Developing common technical guidelines and protocols for actions aimed at enabling the management of shared hydraulic resources.* Refers to establishing common or compatible regulations, protocol, and standards in order to facilitate the implementation of SAP actions.

Chapter 6: Final considerations and foundations for implementing the SAP

The Strategic Action Program (SAP) was designed as an instrument for coordinating policies for water resource management and related environmental issues, in the context of present challenges as well as future problems related to climate variability and change in the La Plata Basin. The SAP has a long-term vision and considers the Critical Transboundary Issues identified to be barriers to overcome in order to promote sustainable development. This La Plata Basin SAP has a planning horizon of 20 years, it includes six (6) Strategic Areas, 13 components, and 28 strategic actions. The set of strategic actions and the 130 activities that make them up constitute the intervention response and management recommendations to solve or mitigate the impacts of the major Critical Transboundary Issues that affect the Basin (based on the analysis of the causes identified) and to promote sustainable development.

For SAP implementation, a programmatic approach is suggested. With this approach, Strategic Areas or specific components may be simultaneously developed and executed, dealing with particular issues (hydro meteorological monitoring and alert, water supply, ecosystem management, reduction of pollution sources, etc.). The timing and implementation schedule of these actions within the framework of the program as a whole will depend on obtaining the funding needed for implementation. In the short term, the priority is to seek funding for the implementation of selected projects in each of the Strategic Areas, addressing the most important aspects identified to solve critical issues in the Basin, catalyzing the production of new sources of funding that invigorate the implementation of the other SAP actions.

The SAP strategic actions include various territorial areas, covering in some cases the entire Basin and in other cases specific areas located in certain sub-basins, including both individual states and provinces, such as regions that spread across several countries. And the scope of the intervention will be different as well, as will the diverse agencies and institutions in charge of executing the actions. The multiplicity of actors involved in the implementation of actions—each with their own timetables, priorities, interests, and mechanisms—raises the need to establish an organizational framework to facilitate the articulation, functionality, and sustainability of the program. In this regard, a priority action is the development of an institutional framework and the harmonization of legal frameworks as essential tools for coordinating the program's strategic actions, taking into account the regional nature of its objectives and encouraging the participation of the different local actors appointed nationally through representatives from each country and at the regional level under the CIC.

Appendix: Critical Transboundary Issues Causal Chains

1 Extreme hydrological events

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Deforestation and loss of plant cover	Poor coordination of extreme data information	Lack of coordination between countries for the implementation of common management	Lack of education and awareness processes
Inadequate monitoring systems, hydro-meteorological prediction, and insufficient investigation of extreme events	Insufficient economic resources	Lack of enforcement mechanisms for existing regulations	Historical trend toward occupying flood areas
Lack of definition of areas of risk	Lack of operational capacity for the management and dissemination of territorial planning plans associated with extreme events	Lack of legal framework for managing transboundary water resources	Lack of environmental awareness
Lack of urban and territorial planning	Lack of regional economic criteria for handling extreme events	Lack of regional disaster prevention policies	Lack of culture of searching for collective solutions
Changes in land use	Lack of sustainable management of the Basin	Insufficient technical institutional capacity in localities	

2 Loss of water quality

Technical Causes

- Inadequate use of agrochemicals in agriculture and agribusiness
- Inadequate wastewater treatment (domestic and industrial)
- Discharge of heavy metals as a product of the mining activity (Pilcomayo)
- Inadequate management of hazardous substances
- Nutrient contribution to water bodies
- Inadequate disposal of solid waste in flood valleys
- Inadequate waste management in cross-border transport

Economic-managerial causes

- Insufficient monitoring and control
- Lack of investment in sewage treatment plants and industrial effluents, and poor maintenance of existing treatment plants
- Insufficient resources for adequate water quality management
- Lack of resources for mitigation of mining pollution (Pilcomayo)
- Inadequate management of agricultural activity
- Lack of quantification and valuation of environmental liabilities
- Mining activity without environmental adaptation
- Lack of non-structural measures for erosion control
- Lack of economic valuation of water as a strategic natural resource.
- Lack of training of environmental managers

Political-Institutional Causes

- Lack of vision and integrated management policy in the Basin
- Heterogeneity of water quality standards and regulations
- Lack of development policies that encourage the use of clean technologies and minimization of waste (e.g. mining in the Pilcomayo basin)
- Different degrees of development of regulations on water quality management and deficiencies in their application
- Different degrees of water quality consideration in state policies
- Difficulties in integrating environmental and water resources agencies

Cultural causes

- Poverty and its effect on capacity for sustainable management of water resources
- Deficiency in compliance with existing regulations
- Deficiency in water education
- Lack of awareness about the valuation of environmental goods and services

3 Sedimentation of Water Bodies and Courses

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Improper use and management of soils (expanding agricultural activity, use of marginal soils, removal of natural pastures, deforestation, overgrazing)	Weakness in the management and administration of organisms	Technical-economic weakness in state agencies	Limited political and citizen awareness
Excessive expansion of the agricultural frontier	Inadequate implementation and insufficient economic resources for monitoring, control, and mitigation	Insufficient institutional coordination, deficient application and inadequate regional harmonization of natural resource protection and use standards	"Chaqueos" or burns
Soil compaction (basins of the Bermejo and Pilcomayo rivers)	Lack of implementation and complementation of land use plans, mainly at the basin level	Institutional decisions based on short-term profitability and not on land use suitability	Excessive profit for owners (producers). Short-term vision in leases
Deforestation of coastal native forest (upper Uruguay basin)	Extensive livestock and principally soy monoculture	Bureaucracy and centralism	Perception of inexhaustibility of natural resources
Inadequate infrastructure construction and maintenance	Lack of incentives, extension and training to apply sustainable agricultural techniques		
Erosion generated by mining activity (basin of the Pilcomayo and Bermejo rivers)	Institutional weakness to ensure compliance with environmental legislation		
Erosion of coasts due to fluctuation from large dam operation (Salto Grande, Uruguay River)			

Technical Causes

- Widespread causes
- Localized causes

4 Alteration and loss of biodiversity

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Entry of invasive species (golden mussel, among others) and displacement of native species	Lack of financial and material resources for studies and monitoring	Control deficiencies and lack of adequate institutional decisions	Lack of social awareness about the value of water resources and biodiversity
Loss of ecological flows for the maintenance of wetlands	Lack of strategic planning for biodiversity conservation	Technical-economic weakness of state agencies	Irrational exploitation of fishing resources
Loss of physical chemical quality of water	Lack of integration of the concept of biodiversity protection into integrated watershed management	Lack of protocol for invasive species control	Lack of willingness in civil society to seek collective solutions
Alteration of peak flows	Shortcomings in the coordination of research programs	Lack of training programs, awareness-building, and human resource training	
Interruption of the migratory flow of fish	Lack of incentives for the care and conservation of natural systems	Little presence of biodiversity on the political agenda	
Replacement of natural ecosystems by productive activities	Absence of regional environmental assessments	Deficiencies and heterogeneity of country regulations	
Alteration in water dynamics due to infrastructure works			
Illegal hunting, fishing, and extraction of flora			
Illegal trafficking in animals and plants (contraband)			

5 Unsustainable use of fishery resources

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Overexploitation of target species	Lack of technical and political coherence in the design and implementation of fishery policies	Lack of harmonized and integrated policies for the protection of aquatic life at the basin level	Unsustainable techniques and difficulties in accepting new technologies
Interruption of species migration from fisheries by civil works in general	Lack of fishery statistics and environmental and biological monitoring	Asymmetry of the norms and criteria for natural resource use	Increased poverty that increases fishing pressure
Disturbance and habitat loss due to alterations in the hydraulic regime	Insufficient incentive for native species production	Lack of economic management tools	Little awareness of the importance of complying with and adhering to fishery regulations
Contamination	Increased fishing pressure due to prices set by the external market and overexploitation	Non-compliance with current legislation and poor controls	
Inadequate management of tanks (nets and ditches) in aquaculture	Inadequate design or absence of impact mitigation systems	Lack of participatory management	
	Increased fishing pressure due to the loss of economic profitability for fishermen		

6 Unsustainable use of aquifers in critical areas

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Insufficient knowledge of the vulnerability of the system (risk and recharge areas)	Deficiency of groundwater use management	Insufficient regulations and regulatory framework for the construction and use of drilling perforations	Insufficient culture, social awareness, and training on groundwater use
Identification of contaminating foci from agricultural uses and residential and industrial discharges	Deficiency of environmental management tools	Insufficient integration of land, water, and environmental legislation in each country and among countries	Insufficient economic-environmental valuation by society
Deficiency of monitoring the exploitation of the aquifer, supply and demand		Insufficient cross-border institutional coordination for shared control and management	Insufficient integrated water resource vision
Deficiency of complete and effective monitoring systems		Insufficient exchange of information	Insufficient social participation
Deficiency in aquifer inventories, studies, and research			
Deficiency in the construction of the perforations, with risk of contamination			

7 Conflicts Over Water Use and Environmental Impact of Irrigated Crops

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Scarce or poor information available on shared water resources (inventory of use and availability)	Lack of integration and asymmetric application of water, land, and environmental legislation	Asymmetries in the control and management of resource uses	Lack of social awareness and training on water use
Lack of knowledge of water demands for different uses	Lack of joint management of shared water resources	Asymmetries in public policy	Lack of knowledge amongst stakeholders on the value of water resources and their limited availability
Lack of hydrological studies of the basin	Little research on optimization of water resource use	Asymmetries in legal-institutional structures for integrated resource management	Lack of user knowledge on regulations for water use
Asymmetries in the granting of rights of use			Lack of a culture to seek collective solutions and shared management
Construction of hydraulic works for exploitation without the proper approval of the authority			
Unsustainable agricultural practices			

8 Lack of disaster contingency plans

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Risk of breakage due to under-dimensioning of discharge organs, pipping effects, etc., and less importantly, due to operating errors	Lack of contingency plans for the potentially affected river section	Lack of transnational contingency plans	Lack of knowledge about the risks to the populations located downstream of the dams and to the dam operators themselves
	Lack of common standards for emergency operation and dam safety	Lack of national and transnational regulations regulating dam safety	
	Failure to review the safety criteria of dams, considering the incidence of climate change	Lack of communication and coordination between countries to provide information on dams existing upstream of possibly affected countries	

9 Unsafe Water and Deterioration of Environmental Health

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Inadequate disposal of solid waste	Inefficiency in the control of industrial discharges and agrochemicals	Lack of harmonized and integrated policies for surveying public health problems related to water	Resistance to changing habits
Untreated sewage discharge	Lack of an integrated water information system	Lack of coordination between governments (local and central) and social, technical, and economic actors on water pollution	
Inappropriate destination of pesticide containers	Lack of local management capacity for sanitation and health	Asymmetry in legal and technical criteria for water resource management and public health	
Lack of water treatment for water supply	Lack of data banks for local health		
Inadequate urban drainage			
Lack of information on water-borne diseases			

10 Navigational Limitations

Technical Causes	Economic-managerial causes	Political-Institutional Causes	Cultural causes
Lack or insufficiency of infrastructure to overcome natural critical points	Inadequate joint institutional management	Asymmetries and weaknesses in country regulations	Lack of planning culture
Lack of waterway maintenance	Lack of agreement for the joint financing of works	Lack of transport policy	Preference for ground transportation
Lack of navigation locks	Lack of resources to maintain navigability	Lack of instrumentation of international treaties and conventions	
Insufficient infrastructure for access to ports and navigational operation	Lack of multimodal transport planning		
	Lack of information on socio-environmental impacts to civil society		

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ANA	National Water Agency (*Agência Nacional de Águas / Agencia Nacional de Aguas de Brasil*)
ANNP	National Administration of Navigation and Ports (*Administración Nacional de Navegación y Puertos de Paraguay*)
CBD	Convention on Biological Diversity (*Convenio sobre Diversidad Biológica, CDB*)
CC	Climate Change (*Cambio Climático*)
CEMADEN	National Center for Natural Disaster Monitoring and Alert (*Centro Nacional de Monitoramento e Alertas de Desastres Naturais / Centro Nacional de Monitoreo y Alerta de Desastres Naturales de Brasil*)
CGW	Cultivating Good Water (*Cultivando Agua Boa / Cultivando Agua Buena, CAB*)
CIC	Intergovernmental Coordinating Committee of the Countries of La Plata Basin (*Comité Intergubernamental Coordinador de los Países de la Cuenca del Plata*)
CIH	Intergovernmental Committee of the Paraguay-Parana Waterway (*Comité Intergubernamental de la Hidrovía Paraguay-Paraná*)
CNRH	National Water Resources Council (*Conselho Nacional de Recursos Hídricos / Consejo Nacional de Recursos Hídricos de Brasil*)
COFEMA	Federal Environment Council (*Consejo Federal de Medio Ambiente, de Argentina*)
COHIFE	Federal Water Council (*Consejo Hídrico Federal, de Argentina*)
CPRM	Brazilian Geological Service (*Serviço Geológico do Brasil / Servicio Geológico de Brasil*)
CPTEC	Center for Weather Forecasting and Climate Studies (*Centro de Previsão de Tempo e Estudos Climáticos / Centro de Predicción del Tiempo y Estudios Climáticos de Brasil*)
CRA	Brazilian-Paraguayan Joint Commission for the Sustainable Development and Integrated Management of the Apa River Basin (*Comisión Mixta Brasileño-Paraguaya para el Desarrollo Sustentable y la Gestión Integrada de la Cuenca del Río Apa*)
CTI	Critical Transboundary Issue
DGEEC	General Directorate of Statistics, Surveys, and Censuses (*Dirección General de Estadísticas, Encuestas y Censos de Paraguay*)
DGRNR	General Directorate of Renewable Natural Resources (*Dirección General de Recursos Naturales Renovables de Uruguay*)
DINAGUA	National Directorate of Water (*Dirección Nacional de Aguas de Uruguay*)
DINAMA	National Environment Directorate (*Dirección Nacional de Medio Ambiente de Uruguay*)
DINARA	National Directorate of Aquatic Resources of Uruguay (*Dirección Nacional de Recursos Acuáticos de Uruguay*)
DMH	Direction of Meteorology and Hydrology (*Dirección de Meteorología e Hidrología de Paraguay*)
DSS	Decision-making Support System (*Sistema Soporte para la Toma de Decisiones, SSTD*)
EBY	Yacyretá Binational Entity (*Entidad Binacional Yacyretá, Argentina-Paraguay*)
ECLAC	Economic Commission for Latin America and the Caribbean (*Comisión Económica*

	para América Latina y el Caribe, CEPAL)
EIA	Environmental Impact Assessment (*Evaluación de Impacto Ambiental*)
ENSO	El Niño Southern Oscillation (*El Niño-Oscilación del Sur- ENOS*)
FONPLATA	La Plata Basin Financial Development Fund (F*ondo Financiero para el Desarrollo de la Cuenca del Plata*)
FP	Framework Program for the Sustainable Management of La Plata Basin's Water Resources, with respect to the effects of climate variability and change (*Programa Marco para la Gestión Sostenible de los Recursos Hídricos en la Cuenca del Plata, en relación con los efectos de la variabilidad y el cambio climático, PM*)
FPPP	Fund for Promoting Public Participation (*Fondo para la Participación Pública, FPP*)
FREPLATA	Environmental Protection of the La Plata River and its Maritime Front (*Proyecto de Protección Ambiental del Río de la Plata y su Frente Marítimo, Argentina-Uruguay*)
GAS	Guaraní Aquifer System (*Sistema Acuífero Guaraní*)
GEF	Global Environment Facility (*Fondo para el Medio Ambiente Mundial, FMAM*)
GHG	Greenhouse gases (*Gases de Efecto Invernadero, GEI*)
HDI	Human Development Index
IAS	Invasive alien species (*Especies exóticas invasoras, EEI*)
IB	Binational Itaipú (*Itaipú Binacional, Brasil-Paraguay*)
IBA	Important Bird and Biodiversity Area / *Área Importante para la Conservación de las Aves*
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis / Instituto Brasileño de Medio Ambiente y Recursos Naturales Renovables*)
IBGE	Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística / Instituto Brasileño de Geografía y Estadística de Brasil*)
INDEC	National Institute of Statistics and Censuses (*Instituto Nacional de Estadística y Censos de Argentina*)
INE	National Institute of Statistics (*Instituto Nacional de Estadística de Bolivia*)
INE	National Institute of Statistics (*Instituto Nacional de Estadística de Uruguay*)
INMET	National Institute of Meteorology (*Instituto Nacional de Meteorologia / Instituto Nacional de Meteorología de Brasil*)
INPE	National Spacial Research Institute (*Instituto Nacional de Pesquisas Espaciais / Instituto Nacional de Investigaciones Espaciales de Brasil*)
INUMET	Uruguayan Institute of Meteorology (*Instituto Uruguayo de Meteorología*)
IPCC	Intergovernmental Panel on Climate Change / *Panel Intergubernamental de Cambio Climático*
IWB	Integrated Water Balance (*Balance Hídrico Integrado, BIH*)
IWRM	Integrated Water Resource Management (*Gestión Integrada de los Recursos Hídricos, GIRH*)
LPB	La Plata Basin (*Cuenca de la Plata- CdP*)
MAB	Man and the Biosphere Programme / *Programa El Hombre y la Biósfera - Reservas de la Biósfera de Unesco*

MAyDS	Ministry of Environment and Sustainable Development (*Ministerio de Ambiente y Desarrollo Sustentable de Argentina*)
MCTI	Ministry of Science, Technology, and Innovation (*Ministério da Ciência, Tecnologia e Inovação do Brasil / Ministerio de Ciencia, Tecnología e Innovación de Brasil*)
MDRT	Ministry of Rural and Land Development (*Ministerio de Desarrollo Rural y Tierras de Bolivia*)
MMA	Ministry of Environment (*Ministério do Meio Ambiente do Brasil / Ministerio de Medio Ambiente de Brasil*)
MMAyA	Ministry of Environment and Water (*Ministerio de Medio Ambiente y Agua de Bolivia*)
MPA	Ministry of Fisheries and Aquaculture (*Ministério da Pesca e Aquicultura do Brasil / Ministerio de Pesca y Acuicultura de Brasil*)
MR	Meteorological radar (*Radares meteorológicos, RM*)
MTOP	Ministry of Transportation and Public Works (*Ministerio de Transporte y Obras Públicas de Uruguay*)
MVOTMA	Ministry of Housing, Land Use, and Environment (*Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente de Uruguay*)
NOAA	National Oceanic and Atmospheric Administration
NWI	National Water Institute (*Instituto Nacional del Agua de Argentina- INA*)
OAS	Organization of American States (*Organización de los Estados Americanos, OEA*)
ORSEP	Dam Safety Regulatory Agency (*Organismo Regulador de Seguridad de Presas de Argentina*)
PCU	Project Coordination Unit (*Unidad de Coordinación de Proyecto*)
PMAE	Framework Program for Strategic Actions for the Sustainable Development of Water Resources in the La Plata Basin (*Programa Marco de Acciones Estratégicas para la Gestión Sostenible de los Recursos Hídricos de la Cuenca del Plata*)
PNAS	National Groundwater Program (*Programa Nacional de Águas Subterrâneas / Programa Nacional de Aguas Subterráneas de Brasil*)
PNFRH	National Water Resources Plan (*Plan Nacional Federal de Recursos Hídricos de Argentina*)
PNPDEC	National Policy of Civil Defense and Protection (*Política Nacional de Proteção e Defesa Civil /Política Nacional de Protección y Defensa Civil de Brasil*)
PNUMA	United Nations Environment Program (*Programa de las Naciones Unidas para el Medio Ambiente*)
SAP	Strategic Action Program (*Programa de Acciones Estratégicas, PAE*)
SEAM	Secretary of the Environment (*Secretaría del Ambiente de Paraguay*)
SEGEMAR	Argentine Geological Mining Service (*Servicio Geológico Minero Argentino*)
SENAMHI	National Meteorology and Hydrology Service (*Servicio Nacional de Meteorología e Hidrología de Bolivia*)
SERGEOMIN	Geological and Mining Service (*Servicio Nacional Geológico de Minas de Bolivia*)
SHN	Naval Hydrography Service (*Servicio de Hidrografía Naval de Argentina*)
SINAE	National Emergency System (*Sistema Nacional de Emergencias de Uruguay*)

SINARAME	National System of Meteorological Radar (*Sistema Nacional de Radares Meteorológicos de Argentina*)
SIyAH	Hydrological Information and Alert System of the La Plata Basin (*Sistema de Información y Alerta Hidrológico de la Cuenca del Plata, Instituto Nacional del Agua, Argentina*)
SMHN	National Weather and Hydrologival Service (*Servicio Meteorológico e Hidrológico Nacional de Bolivia*)
SMN	National Weather Service (Argentina) (*Servicio Meteorologico Nacional- SMN*) (cited in the text with the Spanish acronym)
SNHN	National Naval Hydrography Service (*Servicio Nacional de Hidrografía Naval de Bolivia*)
SNIRH	National System of Information on Hydraulic Resources (*Sistema Nacional de Informações sobre Recursos Hídricos/Sistema Nacional de Informaciones sobre los Recursos Hídricos de Brasil*)
SRHU	Secretary of Urban Environment and Water Resources (Secretaria de Recursos Hídricos e Ambiente Urbano / *Secretaría de Recursos Hídricos y Ambiente Urbano de Brasil*)
SSRH	Under-secretariat of Water Resources (*Subsecretaria de Recursos Hídricos de la Nación de Argentina*)
TCP	La Plata Basin Treaty (*Tratado de la Cuenca del Plata*)
TDA	Transboundary Diagnostic Analysis
UN	United Nations (*Organización de las Naciones Unidas, ONU*)
UNEP	United Nations Environment Programme / *Programa de las Naciones Unidas para el Medio Ambiente – PNUMA* (cited in the text with the Spanish acronym)
Unesco	United Nations Educational, Scientific and Cultural Organization (*Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura*)
UNFCCC	United Nations Framework Convention on Climate Change (*Convención Marco de las Naciones Unidas sobre el Cambio Climático, CMNUCC*)
WIGOS WMO	Integrated Global Observing System / *Sistema Integrado de Observación Global de la Organización Meteorológica Mundial*
WMO	World Meteorological Organization (*Organización Meteorológica Mundial – OMM*)
WTO	World Tourism Organization (*Organización Mundial de Turismo, OMT*)
YTTAS	Yrendá-Toba-Tarijeño Aquifer System (*Sistema Acuífero Yrendá Toba Tarijeño - SAYTTT*)

Institutional References

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Argentina	Bolivia	Brazil	Paraguay	Uruguay
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Miguel A. Giraut (2011-2016)	Mayra Montero Castillo (2011-2016)	Julio Thadeu Silva Kettelhut (2011-1016)	David Fariña (2014-2016) Sofia Vera (2013-2014) Daniel Gonzalez (2013) Silvia Spinzi (2012) Daniel Garcia (2011-2012)	Silvana Alcoz (2011-2016)

National Coordinator Assistants

Argentina	Bolivia	Brazil	Paraguay	Uruguay
Susana Minatti (2011-2016)		Aureliano Cesar (2011-2016)	Julieta Gauto (2011-2016)	Ana Laura Martino (2011-2016)

National Units of the Framework Program

Thematic Groups of the Framework Program

Argentina*	Bolivia	Brazil	Paraguay	Uruguay
Legal and Institutional Framework				
Ministerio de Relaciones Exteriores y Culto (Mónica Troadello, Natalio Marcelo Jamer)	Ministerio de Relaciones Exteriores (Juan Carlos Alurralde, Pablo Guzmán Lougier, Mayra Montero Castillo)	Ministerio de Relaciones Exteriores (Eugenia Barthelmess, Joa Luiz Pereira Pinto); Ministerio do Medio Ambiente/ Secretaría de Recursos Hídricos y Ambiente Urbano (Julio Thadeu Silva Kettelhut)	Ministerio de Relaciones Exteriores (Didier Olmedo, Luis Fernando Avalos, Blas Felip)	Ministerio de Relaciones Exteriores (Juan Antonio Remedi)
Decision-making Support System				
Subsecretaría de Recursos Hídricos de la Nación (Federico Scuka, Carla Lupano)	Ministerio de Medio Ambiente y Agua (Lizet Sullcata)	Agencia Nacional de Aguas (Sergio Barbosa)	Secretaría del Ambiente (Julián Cáceres); Facultad de Ingeniería de la Universidad Nacional de Asunción (Federico Ferreira, Nestor Cabral)	Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente (Virginia Fernández); Instituto Uruguayo Meteorología (INUMET) (Víctor Marabotto); Comisión Técnica Mixta de Salto Grande (CTM-SG) (Ignacio Corrales)
Public Participation, Communication and Education				
Secretaría de Ambiente y Desarrollo Sustentable de la Nación (Silvia Freiler, Daniela García)	Ministerio de Relaciones Exteriores (María del Sagrario Urgel Aguilar, Consuelo Ponce) Ministerio de Educación	Ministerio de Medio Ambiente/ Secretaría de Recursos Hídricos y Ambiente Urbano (Franklin de Paula Júnior)	Universidad Nacional de Pilar (Ernilda Vera); Secretaría de la Información y Comunicación (César Palacios); Secretaría del Ambiente (Maria Coronel)	MVOTMA (Luján Jara); Ana Laura Martino; Ministerio de Educación y Cultura (Laura Barcia); Secretaría Comunicación Presidencia (Carolina Echavarría)
Integrated Hydraulic Balance				
Instituto Nacional del Agua/Centro Regional Litoral (Carlos Paoli)	Servicio Nacional de Meteorología e Hidrología (Luis Noriega)	Instituto de Investigaciones Hidráulicas (André Silveira, Walter Collischonn)	Secretaria del Ambiente (Andrés Wehrle); Universidad Nacional de Asunción (Juan Pablo Nogués); Itaipú Binacional (Pedro Domaniczky)	Universidad de la República (UDELAR) (Luis Silveira, Christian Chreties, Magdalena Crisci, Jimena Alonso); UDELAR-Regional Norte (Pablo Gamazo); CTM-SG (Nicolás Failache); MVOTMA (Rodolfo Chao)

*Consejo Hídrico Federal Argentina (2011- 2016).
Dirección de Hidráulica de Entre Ríos (Oscar Duarte). Instituto Correntino del Agua y del Ambiente (Mario Rujana).

Thematic Groups of the Framework Program

Argentina	Bolivia	Brazil	Paraguay	Uruguay
Water Quality				
Subsecretaría de Recursos Hídricos de la Nación (Marina Jakomin)	Ministerio de Medio Ambiente y Agua (Geovana Rocabado)	Agencia Nacional de Aguas (Maurrem Ramon Vieira)	Universidad Nacional de Asunción (Inocencia Peralta); Secretaria del Ambiente (Sofía Vera, Aida Olavarrieta)	MVOTMA (Luis Reolón)
Groundwater				
Subsecretaría de Recursos Hídricos de la Nación (Jorge Santa Cruz, Lida Borello)	Servicio Geológico Minero (Jorge Bellot)	Departamento de Aguas y Energía Eléctrica (Gerôncio Rocha); Servicio Geológico de Brasil (João Alberto Diniz, Fernando Feitosa, Roberto Kircheim)	Facultad de Ingeniería de la Universidad Nacional de Asunción (Andrés Wehrle); Secretaria del Ambiente (Daniel García Segredo)	MVOTMA (Lourdes Batista, Ximena Lacués); CEREGAS (Alberto Manganelli) Ministerio de Industria, Energía y Minería (MIEM) (Enrique Massa, Javier Techera); Obras Sanitarias del Estado (OSE) (Pablo Decoud, Andrés Pérez)
Aquatic Ecosystems				
Secretaría de Ambiente y Desarrollo Sustentable de la Nación (Sara Sverlij); Subsecretaría de Recursos Hídricos de la Nación (Laura Pertusi)	Dirección General de Biodiversidad y Áreas Protegidas (Sharbel Gutierrez)	Universidad Estadual Paulista (Marcos Nogueira, Danilo Naliato)	Secretaría del Ambiente (Mirta Medina, Nora Neris, Reinilda Duré)	MVOTMA (Guillermo Scarlato); Ana Laura Martino; Ministerio de Agricultura, Ganadería y Pesca (Alfredo Pereira); UDELAR (Alejandro Brazeiro)
Environmental Degradation				
Secretaría de Ambiente y Desarrollo Sustentable de la Nación (José Cuevas; Pablo Viegas Aurelio)	Ministerio de Desarrollo Rural y Tierra	Empresa Brasileña de Investigación Agropecuaria (Celso Vainer Manzatto)	Secretaria del Ambiente (David Fariña, José Silvero)	Ministerio de Ganadería, Agricultura y Pesca MGAP (Carlos Clerici); Facultad de Agronomía de la Universidad de la República - UDELAR (Mario Pérez Bidegain, Fernando García Prechac)
Development Opportunities				
Secretaría de Ambiente y Desarrollo Sustentable de la Nación (Martín Reymúndez)	Ministerio de Relaciones Exteriores	Ministerio de Transportes (Luiz Eduardo García)	Secretaría Nacional de Turismo (Antonio Van Humbeeck)	Ministerio de Turismo (Marcelo Canteiro)

National Units of the Framework Program

Thematic Groups of the Framework Program (continuation)

Argentina	Bolivia	Brazil	Paraguay	Uruguay
PPD Biodiversity				
Subsecretaría de Recursos Hídricos de la Nación (Laura Pertusi); Secretaría de Ambiente y Desarrollo Sustentable de la Nación (Sara Sverlij)	Ministerio de Medio Ambiente y Agua	Universidad Estadual Paulista (Marcos Nogueira); Itaipú Binacional (Carla Canzi)	Secretaria del Ambiente (Darío Mandelburger)	
PPD Confluence				
Administración Provincial del Agua del Chaco (Patricia Parini)		Itaipú Binacional (Jair Kotz, Carla Canzi)	Entidad Binacional Yacyretá (Lucas Chamorro)	
PPD Cuareim				
		Comité de las Aguas Estaduales de la cuenca del río Quaraí (Ivo Lima Wagner); Secretaria do Ambiente e Desenvolvimento Sustentável do Rio Grande do Sul; Departamento de Recursos Hídricos (Fernando Meirelles)		Referente Local (Laura Marcelino); Comisión Cuenca Río Cuareim; MVOTMA (Silvana Alcoz); Ana Laura Martino
PPD Pilcomayo				
Unidad Provincial Coordinadora del Agua de Formosa (Horacio Zambón); Secretaría de Recursos Hídricos de Salta (Alfredo Fuertes)	Ministerio de Relaciones Exteriores (Juan Carlos Segurola, Mayra Montero Castillo); Ministerio de Medio Ambiente y Agua (Oscar Cespedes)		Secretaria del Ambiente (Rosa Morel, Daniel García)	
Hydroclimatic Scenarios				
Instituto Nacional del Agua (Dora Goniadzki)	Servicio Nacional de Meteorología e Hidrología (Gualberto Carrasco)	Instituto Nacional de Investigaciones Espaciales (Gilvan Sampaio de Oliveira)	Dirección de Meteorología e Hidrología (Julián Baez); Facultad Politécnica de la Universidad Nacional de Asunción (Benjamín Grassi)	UDELAR (Rafael Terra, Gabriel Cazes, Marcelo Barriero); INUMET (Mario Bidegain)

Thematic Groups of the Framework Program

Argentina	Bolivia	Brazil	Paraguay	Uruguay
Monitoring and Early Warning				
Instituto Nacional del Agua (Juan Borús)	Servicio Nacional de Hidrografía Naval (Luis Miguel Carrasco)	Agencia Nacional de Aguas (Valdemar S. Guimarães, Augusto Bragança)	Entidad Binacional Yacyretá (Lucas Chamorro); Universidad Católica Nuestra Señora de la Asunción (Cristián Escobar)	UDELAR (Luis Silveira, Jimena Alonso); MVOTMA (Luis Reolón, Gabriel Yorda, Javier Martínez, Juan Carlos Giacri, Adriana Piperno) CECOED Artigas (Juan José Eguillor)
Radar				
Subsecretaría de Recursos Hídricos de la Nación (Juan Carlos Bertoni, Carlos Lacunza)	Servicio Nacional de Meteorología e Hidrología (Gualberto Carrasco)	Centro Nacional de Monitoreo y Alertas de Desastres Naturales (Carlos Frederico de Angelis)	Dirección de Meteorología e Hidrología (Julián Baez)	UDELAR (Gabriel Cazes); INUMET (Daniel Bonora, Néstor Santayana); CTM-SG (Juan Badagian)
Great Basin Models				
Instituto Nacional del Agua (Juan Borús)	Servicio Nacional de Hidrografía Naval (Luis Miguel Carrasco)	Instituto de Investigaciones Hidráulicas (Walter Collischonn)	Universidad Católica Nuestra Señora de la Asunción (Cristián Escobar, Pedro Takahashi)	UDELAR (Christian Chreties)

GLOBAL ENVIROMENT FACILITY - GEF

The GEF promotes international cooperation and fosters actions to protect the environment of our planet. Since its inception, it has become a catalyst and source of funding to consider global environmental issues in the development process in an integrated way, which is crucial to achieving a sustainable balance between man and nature. It provided the grants which funded the Framework Program.

UNITED NATIONS ENVIRONMENT PROGRAMME - UN ENVIRONMENT

UN Environment directs and encourages participation in caring for the environment by inspiring, informing and giving nations and peoples the means of improving their quality of life without endangering future generations. In the organizational structure of the Framework Program, it has been the GEF implementing agency, and its goal has been to ensure that the project is implemented for the benefit of the global environment. Member of the Project Board.

ORGANIZATION OF AMERICAN STATES - OAS

The OAS has maintained a historical relationship of technical cooperation with the La Plata Basin and the CIC on issues related to sustainable development, natural resources and management of water resources. For the preparation of the Framework Program for the La Plata Basin, it was the regional organization selected both by UN Environment and by the CIC, as the executing agency with technical and administrative responsibility for GEF funds. Member of the Project Board.

Framework Program

GEF - FMAM

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UN ENVIRONMENT

Isabelle Van Der Beck
Program Manager

OAS - OEA

Cletus Springer
Director of the Department of Sustainable Development (DDS)

Maximiliano Campos
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Enrique Bello
Adjunct Chief of the Technical and Administrative Unit GS/OAS Argentina

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ADJUNCT TECHNICAL COORDINATOR

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Roberto Montes (2015)

SECRETARIES

Aliene Zardo Ferreira (2011)
Danielle Carvalho (2011-2012)
Lourdes Martins (2012-2015)
María Paula Giorgieri (2015-2016)

Publications of the Framework Programme

Main Documents

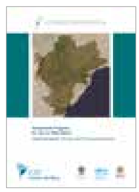
Versions in Spanish, Portuguese and English

Transboundary Diagnostic Analysis for the La Plata Basin
TDA

Strategic Action Program for the La Plata Basin
SAP

Transboundary Diagnostic Analysis (TDA) and Strategic Action Program (SAP) for the La Plata Basin

Executive Summary



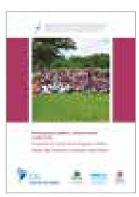
Framework Program for the La Plata Basin

Implementation Process and Primary Outcomes

Thematic Documents

Sistema soporte para la toma de decisiones de la Cuenca del Plata

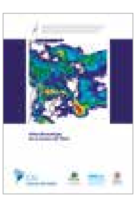
Marco institucional y legal para la gestión integrada de los recursos hídricos en la Cuenca del Plata



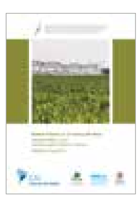
Participación pública, comunicación y educación

Proyectos del Fondo de Participación Pública

Réplica del Programa Cultivando Agua Buena



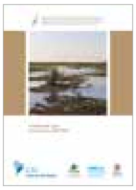
Hidroclimatología de la Cuenca del Plata



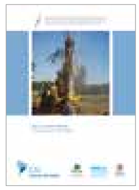
Balance hídrico en la Cuenca del Plata

Disponibilidad y usos, considerando escenarios futuros

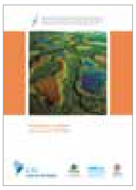
Modelos de gestión



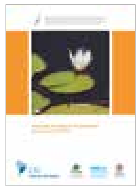
Calidad del agua
en la Cuenca del Plata



Aguas subterráneas
en la Cuenca del Plata

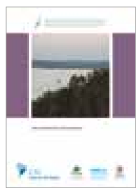


Ecosistemas acuáticos
en la Cuenca del Plata



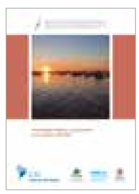
Inventario de Regiones
de Humedales de
la Cuenca del Plata

Degradación de tierras
en la Cuenca del Plata



Selva Misionera
Paranaense

Hidroelectricidad
y navegación en
la Cuenca del Plata



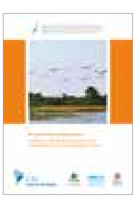
Tecnologías limpias
y ecoturismo
en la Cuenca del Plata

Buenas prácticas
en el uso del suelo
en la Cuenca del Plata

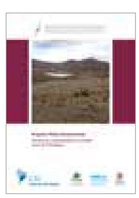
Boas práticas
para o cultivo do arroz
na Bacia do Prata

Proyecto Piloto Demostrativo
Conservación de la biodiversidad
íctica en una zona regulada
del río Paraná

Proyecto Piloto Demostrativo
Resolución de conflictos por
el uso del agua en la cuenca
del río Cuareim/Quaraí



Proyecto Piloto Demostrativo
Sistema de alerta hidroambiental
en la confluencia de los ríos
Paraguay y Paraná



Proyecto Piloto Demostrativo
Control de contaminación
y erosión en el río Pilcomayo

The Framework Program for the Sustainable Management of La Plata Basin's Water Resources, with respect to the effects of climate variability and change

ISBN 978-987-4187-18-5

CIC
Cuenca del Plata

gef
GLOBAL ENVIRONMENT FACILITY

UN environment
United Nations Environment Programme

OAS