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SAP BERMEJO transbounday diagnostic analysis of the binational basin of the bermejo river

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PROGRAMA ESTRATEGICO DE ACCION PARA LA CUENCA DEL RIO BERMEJO

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TRANSBOUNDARY DIAGNOSTIC ANALYSIS FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER

FINAL VERSION

Republic of Argentina
Republic of Bolivia

MAY 2000

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1. INTRODUCTION

This **Transboundary Diagnostic Analisys (TDA)** is one of the principal results of the Project to formulate a **Strategic Action Program** (**SAP**) for the Bermejo River Basin and is intended to provide technical support and a strategic framework for that Program.

1.1. The Strategic Action Program for the River Bermejo Basin

The Strategic Action for the Bermejo River Basin (SAP) was prepared as a joint effort by the governments of Argentina and Bolivia, through the Binational Commission for the Development of the Upper Bermejo River Basin and Grande de Tarija River Basins. The work was carried out in both countries, beginning in August 1997, and was completed in December 1999. The executing agency was the **Organization of American States** (OAS), which is responsible for administering the funds supplied for the project the **Global Environment Facility** (GEF) through the **United Nations Environment Program** (UNEP).

The principal objective of the **Strategic Action Program** is to promote sustainable development in the binational and inter-jurisdictional basin of the Bermejo River by: (i) incorporating environmental concerns into the development policies, plans and programs of the various jurisdictions, (ii) fostering an integrated management vision of the basin and its natural resources, (iii) promoting the establishment of mechanisms for regional articulation and coordination and public participation in consultation, through (iv) implementation of programs, projects and actions that will (v) prevent or overcome unsustainable use and environmental degradation of natural resources and (vi) stimulate the adoption of sustainable practices for managing natural resources.

1.2. Location and Political Structure

The Bermejo River basin is located in the extreme southern portion of Bolivia, in the department of Tarija, and in northern Argentina, where it embraces portions of the provinces of Chaco, Formosa, Jujuy and Salta. **Figure Nº 1** shows the location of the basin with respect to the South American continent, and **Figure Nº 2** shows its political and administrative boundaries within the regional context.

The political and administrative structure in the two countries is different (**Figure Nº 10**). In Argentina, the system is that of a federal government, based on a confederation of states known as Provinces. Bolivia has a centralized government system, under which the country is divided into Departments.

The binational nature of the Bermejo River, and the federal system of organization prevailing in Argentina, gives the basin an inter-jurisdictional character that makes the institutional setting of this project particularly complex. The following levels of government are involved:

Binational:	Binational Commission for Development of the Upper Bermejo River and the Rio Grande the Tarija Basin

Regional: Argentina: Regional Commission for the Bermejo River1 (COREBE)[1]
Bolivia: National Commission for the Pilcomayo and Bermejo River (CONAPIBE)

Provincial level: Argentina: Provinces of Chaco, Formosa, Jujuy and Salta

Departmental level: Bolivia: Department of Tarija

1.3. Contents of the Transboundary Diagnostic Analysis

1.3.1. Background

Preparation of a Transboundary Diagnosis was a specific objective of one of the three major areas of work undertaken by the project to formulate the SAP, namely: (i) transboundary diagnosis, (ii) public participation and pilot demonstrations projects, and (iii) formulation of the Strategic Action Program. The work involved analysis of a local and regional character, as well as sector studies, that served to update and supplement the regional and transboundary diagnosis by addressing issues such as the generation and transportation of sediments, water quality, environmental zoning, integrated water resource management, the legal and institutional framework, and transboundary migration, among others. As well, pilot demonstration projects were carried out in different representative zones of the basin. On the basis of the studies and consultations undertaken during the project, it was possible to incorporate additional valuable information on various aspects (natural and social) of the basin, its major regional and transboundary problems, their basic causes and the strategic areas for action that make up this diagnosis and provide a foundation and context for the Strategic Action Program.

In addition to generating information for the project itself, with the participation of more than 30 institutions and more than 260 experts in different disciplines (Annex I lists the completed SAP work elements. Chapter 4 of this report presents the documents and reports produced by those Elements between 1997 and 1999) who helped in preparing this environmental diagnosis, we drew upon available information from primary and secondary sources and input from experts, government agencies and NGOs, including the following, among others:

- A great number of sector and environmental studies, at the local or regional scale throughout the Bermejo River basin, that have been produced over the last few decades. Several bibliographic compilations, such as those produced in Argentina in 1986 by the Federal Investment Council (CFI), with nearly 800 entries, and the one produced by COREBE in 1991, are typical of the many efforts that have been made at both the central and provincial level in this regard[2]. Similarly, the National Commission for the Pilcomayo and Bermejo Rivers (CONAPIBE) and other

[1] Federal agency created in Argentina by representatives of the national government, the riparian provinces of Chaco, Formosa, Jujuy and Salta and the provinces of Santa Fe and Santiago del Estero.

2 Much background material was also compiled by central institutions such as the National Agricultural Technology Institute, local universities and provincial agencies.

institutions in Bolivia have made an important effort to develop a greater understanding of the basin.

- Among the studies, we wish to note in particular those that were produced with the support of the Organization of American States on the Bermejo River (OAS 1971-1973. *Water Resources Study of BermejoRiver Basin*) and La Plata River Basin (OAS 1981. *Río de la Plata: Basin; Study for the Planning and Development. Bermejo River Basin. I Upper Basin; II Lower Basin*), and those sponsored in Argentina by COREBE, particularly those relating to the various stages and components of the Study on the Development of Water Resources conducted between 1993 and 1998, the latter within the context of the Binational Commission for the Upper Bermejo River and the Rio Grande the Tarija Basin.

- Reports produced during the previous stage of preparation of the **SAP** project (PDF Block B)[3] condensing the most representative information from the various background sources.

- The results and conclusions of the Workshops that were conducted in both countries as part of the public participation program. In Argentina, there were three workshops in the cities of Salta, Formosa and Jujuy (see bibliographic references **39, 40** and **41**, in Chapter 4) and in Bolivia six seminars and workshops were held in the city of Tarija, involving a total of more than 1000 participants.

Constant contact has been maintained with various stakeholders (governmental and nongovernmental) in the basin. Through their various activities under the **SAP**, they have contributed their knowledge and opinions on many different issues to this diagnosis. Of special importance were the contributions to meetings of the Governmental Working Group (GTG SAP)[4] in Argentina.

1.3.2. Structure of the Transboundary Diagnostic Analysis

On the basis of existing knowledge about the basin (see in Chapter 4 the bibliography generated by the various activities and work elements of the SAP between 1997 and 1999) a summary Environmental Profile has been prepared (an expanded version is found in Annex II), covering the most significant aspects of the basin's natural environment, its socioeconomic aspects and its legal and institutional setting. The environmental characteristics are frequently geo-referenced in terms of a series of Ecological Regions[5] (**Annexes II and III**). This categorization identifies and delimits homogeneous areas that are hierarchically related, as a tool for analyzing the principal ecological processes and their associated environmental restrictions and conflicts. The information provided by the various Work Elements (**Annex I**) makes it possible to dimension and locate geographically the problems and symptoms that were detected during the regional workshops in both countries.

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3 PDF-Project Preparation and Development Facility, Block B

4 The Working Group in Argentina consisted of representatives of the provinces of Chaco, Formosa, Jujuy and Salta, the Argentine delegation to the Binational Commission for the Upper Basin and COREBE

5 The relationship between these Eco-regions and those identified in Dinerstein et al (1995) is explained in Annex II.

The **Transboundary Diagnostic Analysis (TDA)** presents a characterization of the environmental problems and their transboundary manifestations under the following headings:

- Soil degradation. Intense erosion and desertification processes
- Water scarcity and availability restrictions.
- Degradation of water quality.
- Destruction of habitat, loss of biodiversity and deterioration of biotic resources.
- Conflicts from flooding and other natural disasters.
- Deteriorating human living conditions and loss of cultural resources

These major environmental problems show up in the water, the natural resources, the land and the societies within the basin, as a consequence of various processes and human activities, together with pre-existing or human-induced environmental limitations. In other words, they reflect the approach to development and environmental management followed in both the distant and recent past. These problems now make themselves felt as constraints on sustainable development.

Each environmental problem has been analyzed on the basis of the following factors:

- Symptoms and Effects.
- Transboundary Manifestations
- Direct Causes.
- Common and Specific Basic Causes.

The most significant symptoms and effects are assessed by means of ecological and socioeconomic indicators, either qualitative or quantitative, for dimensioning and assessing the severity of the environmental problems identified in the Bermejo River basin

Focusing on the watershed as the object of study and action, reveals more clearly the trans-border manifestations of existing problems, acting through the dynamic processes and components of the natural and social systems. The Bermejo river crosses the border between Bolivia and Argentina, passes through 4 federal states of the latter country and upon leaving the basin empties into the Paraguay River, influencing downstream in the Paraguay-Parana system and the Rio de la Plata estuary (shared by Argentina and Uruguay) (**Figures 1, 2** and **10**).

In turn, the explicit identification of these components underlines and confirms the need to induce society to take a comprehensive vision of the basin as the starting point for integrated and sustainable management of shared resources.

A series of causes have been identified and differentiated as the most significant determinants of specific problems. **Direct Causes** are the immediate causes determining the problem and are the result of a complex system of underlying factors; they may be of natural as well as of human origin.

Basic Causes are the root causes or origin of the identified problems; they generate the Direct Causes of human origin; therefore they are object of the interventions. Taking in account the characteristics of the Bermejo river basin , the Basic Causes were in turn divided into:

- **Specific Basic Causes**, defined in direct relation to each problem. The intervention on this kind of causes contribute to the solution of the specific problem.
- **Common Basic Causes**, are those of structural character originating in the political, social, economic and institutional framework; they determine to various degrees the existence of all the environmental problems and, therefore, they lye at the origin of the chain of causal relationships. The interventions on this kind of causes contribute to the solution of all the environmental problems.

During the various activities related to the SAP, and especially as a result of public participation in the workshops held in both countries and meetings with the Government Working Group in Argentina, a series of Strategic Action Areas, with their major component Strategic Actions, were defined to respond to each of the environmental problems identified. **Table 13** offers a summary of the relationships between environmental problems, causes and strategic actions.

Sketch Nº 1, methodologic framework**,** shows the relationships between the environmental problems, their causes, the strategic actions and projects.

1.4. The environmental profile of the basin

This Binacional Basin **(Figures Nº 1, 2 y 3)**, is characterized by the active and intense interplay of hydrological, geomorphologic and ecological processes. It has significant potential in terms of natural resources, the variety of its ecosystems and its biodiversity, but is also subject to sharp constraints and environmental risks, biogeophysical as much as social. In this context, the study identifies policy shortcomings and proposes instruments for management and development that will take due account of the basin as a whole.

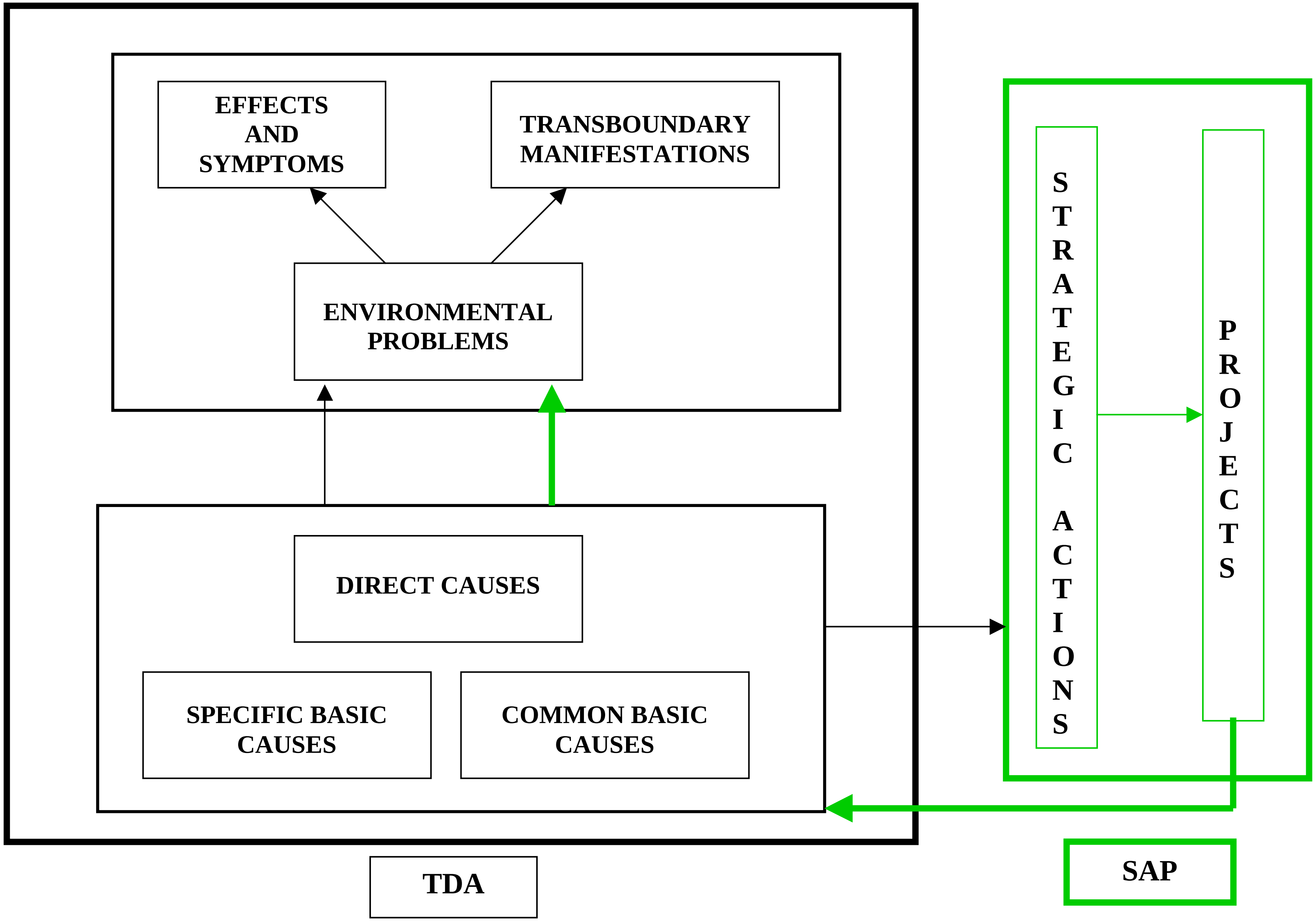
1.4.1. The natural environment

The Bermejo river basin, shared by Argentina and Bolivia **(Figure Nº 4)**, is an important part of the macro-region of the del Plata Basin. It embraces a surface area of 123,162 km^2 **(Table Nº 1)** and its principal watercourse has a length of more than 1,300 km. Because of its characteristics it is divided into the Upper Basin (Superior) and the Lower Basin (Inferior).

In Bolivia, the upper basin of the Bermejo is located entirely in the Department of Tarija. The remainder of the upper basin, and all of the lower basin, is located in Argentina. The hydrographic system is formed by four major tributaries: the Grande de Tarija River, the Upper Bermejo River, which after Juntas de San Antonio is known as the Bermejo, the Pescado River and the San Francisco River.

Of the surface area of the basin, 50,191 km^2 belongs to the upper basin (shared by both countries) and 72,971 km^2 in the lower basin (entirely within Argentina).

Sketch N° 1 METHODOLOGICAL SKETCH: IDENTIFICATION OF CAUSAL RELATIONSHIPS



Represents the intervention of SAP on the Basics and Directs Causes. SAP actions will results in the mitigation of the environmental problems and their consequences.

Table Nº 1
TERRITORIAL DISTRIBUTION OF THE BASIN

JURISDICTION		AREA (km^{2})	PROPORTION(%)
COUNTRY	**BOLIVIA**	**11,896**	**10**
Department	Tarija	11,896	10
COUNTRY	**ARGENTINA**	**111,266**	**90**
Provinces	Chaco	19,247	16
	Formosa	26,445	21
	Jujuy	21,053	17
	Salta	44,521	36
TOTAL		**123,162**	**100**

Environmental information on the basin was integrated and synthetized on the basis of a series of Ecological Regions **(31)**, which provided the geographic basis for analyzing a set of natural and socioeconomic indicators and their associated constraints. The territory was divided into hierarchically related spatial units, on the basis of different natural attributes, homogenous at each level of detail. This work relied essentially on the Thematic Mapping **(1, 13 and Figure Nº 9)** generated through the interpretation of satellite images and other information sources. In this way 5 Eco-regions, 17 Subregions and 68 Large Ecological Units were identified, as listed in **Table Nº 15** of **Annex II**.

From the viewpoint of its Geology, three large structural units may be identified in the Basin: the Eastern Range of the Andes (Eastern Andes), the Subandean Ridge and the Chaco Plain. In Bolivian the first unit is reflected in the ranges of Sama and Condor, which border the central valley of Tarija reaching heights of 3,000 to 4,600 meters respectively. The Central Valley bottom is formed by a fluvio-lacustrine plain. In Argentina, there is the Santa Victoria Sierra, which in the south is divided by the Quebrada de Humahuaca. It is a rugged, rocky range with maximum elevations of 6,200 m a.s.l like in Chani mountain. The Sub-Andean ridge, which has the Eastern Andes on the west and the Chaco Plain on the east, are formed mainly by narrow extended parallel ranges running in a north-south direction with an elevation of about 2,000 m.a.s.l. Lastly, the Chaco Plain, where the Lower Basin is located, presents a relief associated mainly to fluviomorpholigical dynamics.

From the viewpoint of its **Geomorphology**, the region has sectors that are very active in generating sediments, and these affect large areas, especially in the upper basin. Simulation models were applied to estimate the rate of sediment generation through surface erosion **(Figure I of Annex II**). **Figure II** of that **Annex** shows in qualitative terms the areas that are most susceptible to the generation of mass-movement processes in the upper basin. Such processes not only contribute greatly to the creation of sediments but also constitute a natural hazard for the local population, many of whom are highly socially vulnerable. The major volume of material mobilized in the upper basin is carried by the river system into the lower basin, where the plain serves as the principal receptor for medium and course material, while the finer sediment is transported downstream out of the basin.

The study of transboundary sediment transport was a focus of interest of the TDA in both countries **(2 and 14).** In terms of sediment production per unit area, the San Francisco river carries about 700 t/km^2 year and the Bermejo river about 3,050 t/km^2 year upstream of the confluence with said river. Bermejo basin comprises sub basins with highly variable sediment production; for example, 1,400 and 1,700 t/km^2 year the Grande de Tarija and Bermejo sub basins respectively, upstream of the Juntas de San Antonio junction and over 14,800 t/km^2 year the Iruya river subbasin up to El Angosto. It is estimated that on average about 100 million tons of suspended sediment a year are carried from the Bermejo river into the Paraguay-Parana system. The National Water and Environment Institute of Argentina **(2 and 14)** and other specialists **(3)** analyzed the incidence of sediments carried by the Bermejo river in shaping the Delta of the Parana and the Rio de la Plata. The studies indicate that the contribution of sand from the Bermejo river to the Paraguay-Parana Rivers is not significant. On the other hand, silt and clay constitute 90 percent of suspended sediments carried by the Parana, which are deposited primarily in the Rio de la Plata. The annual amount of fine materials (silt and clay) dredged from the navigation channels in the Rio de la Plata is equal to 23 percent of the total contribution of the Bermejo River.

The climate presents a sharp rainfall gradient (**1)**, from 2,200 to 200 mm annually (**Figure Nº 5**), and large portions of the territory suffer water shortages, including periods of extreme precipitation and drought (**Figure III of Annex II)**.

The hydrology of the rivers is rain-controlled, with sharply defined seasonal variations: volumes are highest during the rainy season (January to March, which accounts for up to 75% of annual flow (it amounts up to 85% considering the whole summer period), and are lowest during the dry season (April to September).

The mean discharge of the Upper Bermejo river at Aguas Blancas is about 92 m^3/s and that of the Grande de Tarija river at Algarrobito-San Telmo reaches 127 m^3/s, with specific discharges ranging between 18 and 12 l/s.km^2, respectively. Thus the mean annual discharge at the Juntas de San Antonio junction amounts to 219 m^3/s. After the confluence of Pescado river, the average flow is 347 m^3/s escalating to 448 m^3/s downstream of the junction of the Bermejo with San Francisco river, which constitutes the contribution of the Upper into the Lower Basin. The average specific flow of the various rivers in the Basin ranges between 2.0 and 30 l/s.km^2.

The scale of these basins and the heterogeneity of their environmental conditions, and especially their use, produces wide variations in water quality: some stretches are unfit for human consumption, because of bacteriological contamination, the discharge of semi-treated or raw urban sewage, the dumping of industrial wastewater, or excess salinity (**Tables Nº 2 and 3** of **Annex II)**

The physiography, genesis, climate and fluvial shaping, among other factors forming the soil, have generated a high degree of taxonomic heterogeneity of soils, which also shows up in their capacity for use (Figure 6). Against this variability, there is a wide diversity of uses, current and past, that have determined a mosaic of conditions from the viewpoint of soil conservation. **Table 5**, in **Annex II**, shows the relative importance of each class of soil use capacity. It highlights the absence (at the working scale adopted) of soils of class I, which have the greatest agricultural potential (no limitations on use), and the dominance of soils of class VI (42 percent), which present severe limitations and are generally not suitable for growing crops. Only 27.3 percent of the surface area of the basin has soils of class II to IV.

The heterogeneity of environment, climate and relief makes itself felt in a great diversity of biomes and vegetation physiognomies (**Figure 7** and **Tables Nº 6** and **7** of **Annex II**). The dominant typologies in the basin, accounting for more than 47 percent (58,186 km^2) of the surface, are forests and rainforests, which include montane and piedmont cloud forests, dry forests, sub-humid or humid forests, evergreen forests, semi-deciduous or deciduous forests, accompanied by grasslands, shrubby and grass steppes.

The principal risk factors for wildlife fauna are modifications to habitat, especially through deforestation (massive or selective), and the advancing agricultural frontier. In some cases of species with economic value, legal or illegal hunting has been an important source of pressure. **Table Nº 8** of **Annex II** shows the number of species of reptiles, birds and mammals at varying degrees of conservation risk. It will be noted that the Sub-Andean and the Sub-Humid Chaco and Humid Chaco Eco-regions are those where said risks are relatively highest. Mammals are the group at greatest risk.

Conservation of Natural Heritage is examined from three complementary points of view: Nature Protected Areas, Wetlands, and Biodiversity. Both countries have special provisions for land use in Nature Protected Areas (NPA), although within different legal frameworks **(24 y 25)**. **Table Nº 9** of **Annex II** contains full information on those NPAs that are wholly or partially included in the basin, NPAs in surrounding areas, and wetlands of importance from conservation viewpoint. Considering the basin as a whole, 6489 km^2 is under some form of conservation cathegory, representing more than five percent of the total area. While the number of these areas throughout the basin, and the surface area in the Bolivian sector, are numerically important indicators, the protection of biodiversity and natural heritage is not assured. This reflects the fact that these NPAs are not fully representative in terms of bio-geography, there is discontinuity of habitats and ecological corridors, frequent occupancy with incompatible uses, and an insufficient degree of control and surveillance.

The Bermejo River basin, thanks to its hydrographic network and associated wetlands, acts as a complex system of bio-geographic corridors connecting, from west to east, the ecosystems of the Eastern Andes and the Yungas with the ecosystems of the Chaco and the Paraguay-Parana.

1.4.2. Legal and Institutional Framework

The political and administrative structure (**Figure 10**) of Argentina is federal, based on a confederation of provinces subdivided into departments, within which the municipalities are defined. From the political and administrative viewpoint, Bolivia is a centralized country, structured into Departments, formed territorially by the integration of Provinces which are divided into Municipalities.

The strengths and weaknesses of this political and institutional framework are dealt with in detail by studies **(24 y 25)**. The legal framework in both countries is shown in a simplified form in **Table 10**, **Annex II**.

1.4.3. Socioeconomic aspects

The socioeconomic aspects of the basin have been analyzed in the following studies listed in the bibliography in Chapter 4: **(6, 10, 12, 19, 20, 27, 28, 29, 30, 33, 36 y 37)**.

The total population of the basin was 1,063,285 inhabitants, according to the most recent census data available, and is estimated at about 1,200,000 at the end of 1999. It is distributed heterogeneously, including both heavily populated areas and relatively empty spaces. The total population of the Argentine sector is 874,980, according to the 1991 Census, and that of the Bolivian sector is 188,305 according to the 1992 Census (**Table Nº 2** and **Figure Nº 11**). For the basin as a whole (**Figure Nº 12**), about 41 percent of the population suffers from Unmet Basic Needs (UBN), illustrative of the high poverty level in the region.

Illiteracy amounts to about 9.9 percent among the total population (older than 10 years for Argentina, and older than 15 years for Bolivia). The proportion of the population without health coverage in the Argentine provinces was 53 percent; these people are dependent on public health services. The same indicator reaches 37 percent in Tarija. This indicator reflects critical conditions from the socioeconomic viewpoint in major sectors of the population, conditions that become even more acute in certain sectors of both Argentina and Bolivia.

An analysis of major social indicators, carried out with the studies indicated in the bibliography **(10, 28, 29, 33 y 37),** shows that in much of the basin living conditions are extremely precarious for a large portion of the population.

The socioeconomic changes that have occurred in recent decades have accentuated the vulnerability of broad sectors of the population, and of their economic livelihood, in the face of natural threats such as floods, landslides, and drought and other extreme climatic events.

Land use, in relation to economic activities, is shown in **Table Nº 12 of Annex II** and in **Figure Nº 13**. Extensive agricultural uses dominate, covering about 14 percent of the total area. **Figure Nº 24** shows a high degree of land subdivision in the upper basin, and in a band that includes the provinces of Salta, Chaco and Formosa in Argentina.

The area occupied by agro-industrial crops (sugar cane, cotton, tobacco and others) is still relatively restricted, as can be seen in **Figure Nº 14**, but has been growing in recent years. **Figure Nº 15** shows values for industrial employment, which are high in only a few areas of the basin. **Table Nº 14** of **Annex II** describes these aspects in further detail.

TABLE N° 2

POPULATION CHARACTERISTICS OF THE BASIN: ESTIMATED DATA

POLITICAL/ ADMINISTRATIVE DIVISION IN THE BASIN		POPULATION CHARACTERISTICS OF THE BASIN			POPULATION DISTRIBUTION IN THE BASIN		UNMET BASIC NEEDS (UBN) IN THE BASIN		ILLITERACY IN THE BASIN
		Total Population of Basin (Persons)	Total surface area of Basin km^2	Population Density P/km^2	Total Rural Population (persons)	Total Rural Population Density P/km^2	Total Population with UBN	Rural Population with UBN	Ratio to school-age population
ARGENTINA		874,980 (83%)	111,266 90%	8	216,977 24.8 %	1.9	37% of total population	65.6% of rural population	48,449* illiterate 7.5%
PROVINCE	**CHACO**	87,708	19,247	5	37,583	1.9	53%	66%	17.9%
	FORMOSA	111,330	26,445	4	42,474	1.6	37%	60%	8.0%
	JUJUY	472,653	21,053	24	71,397	3.4	34%	59%	6.3%
	SALTA	203,289	44,521	5	65,523	1.5	35%	70%	6.5%
BOLIVIA		188,305 (17%)	11,896 10%	15.8	74,967 39.8%	6.3	64.1% of total population	90.2% of rural population	18.5%**
DEPART MENT	**TARIJA**	188,305	11,896	15.8	74,967	6.3	64.1%	90.2%	34,836 illiterate
BINATIONAL BASIN		1,063,285 100%	123,162 100%	8.6	291,944 27.5%	2.4	41.7 % of total population	73.5% of rural population	9.9%

References: * % of illiterate population, in Argentina, older than 10 years
** % of illiterate population, in Bolivia, older than 15 years

Socioeconomic conditions in the basin have historically led to transboundary migration. In the sub-basin of the Bermejo River within Bolivia, 42 percent of the population surveyed (rural population) had left at some time for Argentina. Of these, 69.9 percent declared as their reason the search for work, in most cases related with agriculture. Nevertheless, such migrations appear to have little impact on natural resources and infrastructure in destination areas within the Argentine portion of the basin, when compared with the pressures of the local population and migratory movements within Argentina.

Broad sectors of the basin have a precarious economic existence **(32, 36, 37)**. While in many cases output has been growing, farming has been expanding, and exports have been rising during the 1990s, these figures have not translated into improved welfare of the population. Gross income is growing but is not being redistributed, compounded by the fact that Argentina has suffered a steady deterioration of its fiscal situation, which has left provincial governments short of financial resources.

The high degree of social vulnerability identified within the basin and its region makes it essential to strengthen the institutional framework and the organization of the various sectors of civil society.

1.4.5 Environmental forecast on the Basin

The predictable scenarios for the region´s future **(32)** show at present the existence of weak markets in the context of a restricted supply of and demand for natural resources, and of a society generally characterized by extensive poverty in which economic and social processes falter and the natural and human habitat is degraded. This undeniably indicates vulnerability, both environmental and social, upon which the effects of MERCOSUR and world-wide economic globalization become apparent.

Therefore, the probable scenario is that:

- Local and regional stakeholders will continue to show a lack of vision, understanding, and sense of belonging to the Basin.
- Regional and local planning remains insufficient, preventing development agents from acting on the real needs of society.
- The perception and management of the natural resources, particularly water, will remain fragmented. An understanding of the real potentialities and restrictions of natural resources is still incomplete or insufficient.
- Unsustainable practices will still predominate. The complex diversity of the various natural and social environments that make up the region will not be sufficiently taken into account. An assessment of competitiveness, both between and within regions, remains uncompleted.
- Environmental degradation will increase and the problems identified will worsen, especially those related to the production and transport of sediments, water pollution, and soil capacity. Low productivity continues to affect the income of the inhabitants, particularly the indigenous communities and small farmers, thus exacerbating the non-sustainable extractive use of resources, deforestation, and the expansion of the agricultural frontier. The pressure on high-risk areas in terms of erosion, sediment production, and damage to biodiversity conservation will increase.
- The impacts of productive activities and large infrastructure projects will be perceived in

fragments and mainly not until after their implementation. The announcement of projects will generate migratory movements from “push” areas within and beyond the basin. Interregional migratory movements will increase and change direction, which may affect production and the use of natural resources in rural areas, depending upon the timing and stages of the projects. According to the forecast, this process will have no possibility of changing the present socioeconomic framework significantly, owing to the lack of a planning process capable of mitigating the negative effects.

- Individual expectations of improving the relative position of the various micro-regions, in particular of those better positioned, will hamper attempts at regional and basin-wide integration.
- Attention to productive activities and the improvement of living conditions will remain limited to welfare actions undertaken by national and local governments, international organizations, etc.
- The strengthening of municipalities and grassroots organizations may remain limited to occasional support from various levels, which may even weaken them and create even greater anarchy in local government or an increase in dependency and political partisanship.
- Lack of regulation will intensify some problems with large agricultural corporations–usually from outside the region and without links to local culture–whose impact, although temporarily benefitial, may deepen imbalances within the region and enhance vulnerability, social as well as environmental.
- The government will keep a regulatory rol of medium intensity. Projects will develop inorganically and land will be put into production without a proper assessment of their environmental capacities and constraints, awarding ownership, orderly procedures for or consideration of the characteristics of the beneficiaries.
- Less- favoured communities will remain physically and socially isolated and localized conflicts between interests from outside the region for the control and management of resources may arise.
- Nature protected areas and other heritage sites may become at risk in the contact zone with the areas where projects will be carried out, giving rise to conflicts with environmental groups and/or those that are traditionally oriented to a harmonious relation between nature and society.

The present situation is characterized by a lack of equity for the various social sectors and by an insufficient response to the threats to which the communities, their environment, and the associated water resources are exposed. If the situation remains unchanged, it will become impossible to achieve objectives of sustainable development; at the same time, the environmental degradation and social vulnerability in the Bermejo River Basin identified in this TDA, will be aggravated.

2. ENVIRONMENTAL PROBLEMS AND TRANSBOUNDARY MANIFESTATIONS

2.1. Introduction

A basin of the scale and complexity of the Bermejo River will suffer from many environmental problems that make themselves felt in different forms and degrees of intensity. To identify and evaluate these problems, information was drawn from various sources, in particular from the different SAP Work Elements and the inputs from the various participation mechanisms. The division of the basin into ecological regions **(31)** provided a comprehensive overview, in which context the most significant and critical environmental problems were examined, particularly those associated with significant problems or conflicts over water and natural resources in the Basin, which have transboundary manifestations.

The analysis and synthesis of environmental problem indicators was conducted at the scale of Large Units and Subregions (**Annex III** and **Figure Nº 9**), shown in geographic terms in **Figures Nº 16** and **22**.

These indicators were discussed at regional workshops of the SAP, in Jujuy (December 1998) and in Tarija (May 1999) **(39, 40 and 41)**, as well as at Working Group meetings. These problems are:

- Soil degradation. Intense erosion and desertification processes
- Water scarcity and availability restrictions
- Degradation of water quality
- Destruction of habitats, loss of biodiversity and deterioration of biotic resources
- Conflicts from flooding and other natural disasters
- Deteriorating human living conditions and loss of cultural resources

2.2. Characterization of the principal environmental problems

Characterization of environmental problems was carried out by identifying their symptoms and effects, transboundary manifestations, and main causes. **Sketch Nº 2**, at the end of the chapter, shows the causal chain relationships of said environmental problems. **Table Nº 10** describes the environmental problems in terms of their effects, symptoms and transboundary manifestations. **Annex V** summarizes the quantitative, geographical and weighting aspects.

2.2.1. Soil degradation. Intense erosion and desertification processes

The symptoms and effects of soil degradation as a result of intensive processes of erosion and desertification make themselves felt in the destruction of the soil's natural productive capacity, the reduction in the quality and quantity of agricultural output, the loss of productive areas, the degradation of water quality, the loss of organic material and nutrients in the soil, as a result of the decline or loss of vegetation cover, compacting of the soil, thereby reducing its water-retention capacity and making the land more vulnerable to erosion. The movement of sediments also affects the useful life of reservoirs.

Erosion occurs in virtually all Eco-regions. A number of Large Ecological Units (**Figure Nº 9**) have been identified with critical erosion conditions. These include the western flank and the upper and lower sectors of the Quebrada de Humahuaca; the Fluvio-lacustrine plain of Valle Central de Tarija; the Sub-Andean Valleys, the banks of the Grande Tarija and Bermejo rivers; the lower course of the Río San Francisco; El Ramal; the confluence zone of the rivers Lavayén and Grande, La Almona; the valleys of Siancas and Perico; the piedmont of the Sierras de Tartagal and of the Sierras de Maíz Gordo and Centinela. The location of these critical areas as a whole reflects corresponding climatic and edaphic restrictions.

The occurrence of mass-movement processes is critical in the headwaters of the rivers Iruya, Pescado and Quebrada de Humahuaca **(2 and 31),** and the presence of rills and badlands is evidence of intensive processes of erosion in the Valle Central de Tarija. Critical erosion situations are often found along the banks of rivers, especially in the upper basin. Some 13.35% of the surface of the Large Units is affected by severe or very severe mass-movement processes (**Figure Nº 22a** and **Figure II** of **Annex II**)

The processes of soil degradation (understood as degradation from misuse and overgrazing of pastures, shrub lands or forests where the original vegetation remains but has been altered by over-use), erosion and desertification, have been evaluated on the basis of the Ecological Regions **(31)**.

In terms of **erosion**, it may be noted that 52.3% of the basin presents conditions ranging from significant to very severe, and only 47.63 % of the surface of the Large Units shows minimal, restricted or insignificant erosion **(Table N° 3** and **Figure N° 17)**.

Desertification (figure n° 18) constitutes an indicator covering all the processes of degradation of environmental conditions in arid and semi-arid areas, among which soil erosion and vegetation destruction are especially important. The highest degrees of desertification in Argentina are found in the ***peladares*** [barelands or denuded areas] of the Bermejo (**figure nº 22b)**, and in the eastern andes eco-region, in the headwaters of the rivers and in the valley of the Quebrada de Humahuaca and in the Semi-arid Chaco Eco-region, in the Subregion of the Current Overflow Channels and Washouts of the Bermejo. In Bolivia, they occur in the fluvio-lacustrine plain of the Valle Central de Tarija, where degraded areas cover more than 57% of its area. Taken together, the sectors that show significant to very severe desertification represent about 38.9 % of the total surface area of the basin, while 61.1% shows conditions of non existing, minimal or limited desertification **(table nº 3)**. In this respect, soil degradation through the processes of erosion and desertification decreases the agricultural suitability of the basin.

Among the transboundary manifestations we may note:

Increased transport of sediments, with its impact on the active fluviomorphological dynamics. While this phenomenon is primarily of natural origin, human intervention increases the associated environmental conflict and affects the existing infrastructure downstream, the processes of formation of the Delta of the Paraná and the navigation channels of the Río de La Plata.

The SAP has been particularly interested in deepening understanding of the processes of generation and transport of sediments, especially in Element 1.1 in both countries (**2, 3, 4 and 14**). The mathematical models used for the study show that the total of the material produced by surface erosion alone and transported to the final section of the Upper Basin of the Bermejo (Juntas de San Francisco) amounts to some 18,500,000 m^3/year (corresponding to 49,000.000,t/yr), of which 64 % is generated in Argentine territory and the remaining 36 % in Bolivia **(2).**

Table Nº 3
Total areas of the Basin affected by processes of
Soil Degradation, Erosion and Desertification

Problem	**Degradation**		**Erosion**		**Desertification**	
Category	**Area km²**	**%**	**Area km²**	**%**	**Area km²**	**%**
None	1,674	1.36	9,198	7.47	34,864	28.31
Minimal	12,903	10.48	26,262	21.32	13,084	10.62
Limited	32,920	26.73	24,472	19.87	27,342	22.20
Significant	**54,793**	**44.49**	**36,232**	**29.42**	**25,892**	**21.02**
Severe	**9,164**	**7.44**	**26,174**	**21.25**	**11,786**	**9.57**
Very severe	**11,708**	**9.51**	**824**	**0.67**	**10,195**	**8.28**
	123,162	100.00	123,162	100	123,162	100

The processes of erosion and desertification to be found in the Basin reflect different natural and man-made causes**.**

The amount of sediments (produced by all the processes of **erosion, mass removal**, etc.) carried by the river as far as Juntas de San Antonio was estimated at 24,000,000 t/year, corresponding to about 15,500,000 t/year from the Rio Grande de Tarija and 8,500,000 t/year from the Upper Bermejo River. Expressed as quantities per unit of surface of the basins, the figures amount to approximately 1,400 t/km².year and 1,700 t/km²**.**year, respectively.

Using data from simultaneous records, between the station at Alarache, which covers essentially the area corresponding to the Eco-region of the Eastern Andes, and the station at Aguas Blancas, which covers 96% of the Upper Bermejo basin, we can obtain by subtraction the amount of sediments generated in the Subandean Eco-region, at 2,539 t/km².year. This same difference can be observed in the Río Grande de Tarija.

In terms of the impact of this problem on infrastructure, information is available for the Valle Central de Tarija on the amount of sediments flowing into the San Jacinto reservoir, which is more than 2,000 t/km².year (equal to a load of 1,697 $m^3/km^{2\cdot}$year), calculated on the basis of records for 1989 and 1995) **(2)**. On the other hand, in the Argentine portion of the upper basin, the specific solid flow in the Río Blanco reaches 3,743 t/km².year and in the Río Iruya, 14,869 t/km².year.

In comparative terms, according to estimates based on available records, about 80% of the suspended load carried to the lower basin downstream Junta de San Francisco comes from the upper Bermejo basin, and the remaining 20 % from the sub-basin of the San Francisco. In fact, taking the series of solid measurements at Pozo Sarmiento - Zanja del Tigre (Bermejo) and Caimancito (San Francisco), we obtain for the first an average figure for transport in suspension of 70,508,100 t/yr (3,047 t/km².year), and for the second, 18,901,200 t/yr (720 t/km².year), which gives a total of 89,409,300 t/yr (1.811 t/km².year). This value reaches 120 million tons when we apply the solid/liquid flow ratio to that of average monthly flows.

In short, based on the period 1969-1989, we may say that the contribution of fine sediments from the Bermejo River to the Plata system is about 100 million tons a year.

The intensifying migratory processes would appear to be another result of soil degradation and the consequent loss of yields, increased production costs and declining standards of living, which have produced or exacerbated socioeconomic imbalances to varying geographical scales in the basin. This aspect is examined in greater detail in i**tem 2.2.6**.on the environmental problem of **Deteriorating human living conditions.**

These impacts on productive and socioeconomic systems are reducing yields and living standards for producers (especially small and medium-scale producers). This situation appears to be one of the factors driving population movements (seasonal or permanent, domestic or transboundary) especially among rural people. In Bolivia, there is a strong spatial correlation in the Valle Central de Tarija between its status as a net source of migration and the degradation of its soils. In this sub-basin, according to the surveys conducted (**29)**, 42% of the population has migratory experience, at some time for Argentina, and of this latter group 69.9% did so for reasons of work. The surveys conducted in other areas of the Basin in Bolivia found figures of the same order, and agricultural limitations were identified as one of the major causes.

Causes

The following are some of the **direct causes** determining the problem:
:

- The susceptibility of the geological substrata and geomorphological instability, where the characteristics of the Eastern Andes and Subandean Ranges Eco-regions are particularly restrictive. Occurrences of mass-removal and landslide were estimated in the studies on sediments and division y ecological regions (**2 and 31)** and are shown in **Figure Nº 22a.**
- The characteristics of the soil itself, where 65.75% of the Basin's land area is classified with use aptitudes of category VI, VII or VIII, are frequently associated with high susceptibility and fragility because of structure, composition or slope.
- The **rainfall regime**, and especially the tendency to torrential rains, that dominates the basin as a whole.
- The strongly sloping topography, dominant in all of the Upper Basin (gradient map in **Figure V** in **Annex II**) and geomorphological instability.
- **Deforestation**, where the area affected by massive deforestation for agricultural purposes exceeds 26% of forest or cloudy cover. For the basin as a whole, nearly 23% of the Large Units examined show evidence of deforestation, ranging from significant to very severe.
- **Poor management of farm lands and overgrazing**, such that 61.4% of the Large Units

into which the Basin was subdivided show situations of over-use, ranging from significant to very severe. This numbers are coincident with data for the Bolivian sector, according to which 60% of the pasture lands of the Eastern Andes show signs of overgrazing.

A general conclusion to be derived from these studies **(2)** is that there are no identifiable management measures in the upper Bermejo River basin that would substantially affect the quantity of sediments generated by the Basin as a whole. From this point of view, it may be said that the most productive sediment zones in the Upper Bermejo River basin are not significantly affected by human activity at this time.

This is not to say that specific local problems, related to sediment production at certain points in the basin, cannot be dealt with by structural and/or non-structural measures designed for that specific objective. In this respect, it would be advisable to examine in greater detail the technical and economic possibilities for structural and non structural intervention in the drainage networks of the valleys feeding into the Bermejo River, as well as possible techniques for mitigating non point erosion.

Among the **specific basic causes**, the direct manifestations of which were discussed earlier, are:

- Unsuitable use of the land, without considering its aptitude
- Unsustainable forestry and sylvo-pastoral practices.

These **direct causes and basic specific causes** affect the development of the basin, through the loss of natural productivity, the reduction of the land's agricultural output capacity, greater risks of crop and livestock failure, loss of productive areas, greater risk from salinization and degradation of water quality and increased soil compaction from over-use, leading to the loss of the soil's water retention capacity and greater susceptibility to erosion.

2.2.2. Water scarcity and availability limitations

Constraints on the development and exploitation of water and natural resources for sustainable economic uses are related to natural fluctuations in the availability of water and in fluviomorphological dynamics, associated with both seasonal and extraordinary factors, among which we may point to the general scarcity of water during dry periods, both for human consumption and for farming and livestock use, and low levels of production and economic return. This latter aspect affects farmers who must compete with other economic sectors. As well, the water shortage implies a heavy seasonal pattern to agricultural employment, coincidental with the rainy period.

Annual or seasonal water shortages in various parts of the basin affect various natural and human components in different ways. This problem makes itself felt most acutely in connection with agricultural needs.

Under other criteria, this water shortage affects the reserves of water for human consumption, and its availability for ecological processes such as vegetation growth and biological productivity. With respect to the scarcity of water for human consumption, this affects a wide area of the basin, and brings in its wake problems of public health and severe limitations on development. In the arid and semi arid Subregions of the Eastern Andes (**Figure Nº 21b**) (such as the Valle Central de Tarija and the Quebrada de Humahuaca) and the Subandean Eco-region, as well as the Semi-Arid Chaco Eco-region, a high percentage of the rural population has no access to safe drinking water. This deficit becomes critical during the dry season, when human living conditions decline: **(20)** has analyzed the importance of limited water resources as one of the environmental and socioeconomic factors that restrict the adoption of sustainable development practices in the lower basin. Some 31% of the basin's surface area is affected by severe or very severe conditions of water shortage during the dry season (nearly 38,000 km^2).

The average annual flows in the rivers of the Eastern Andes and Subandean Eco-regions show wide fluctuations. The Bermejo River at Juntas de San Antonio, the last point in Bolivian territory, has an average annual flow of 220 m^3/s, of which 92 m^3/s corresponds to the Upper Bermejo and 127 m^3/s to the Grande de Tarija rivers; with specific flows of 18 and 12 $l/s.km^2$ respectively. Upon leaving the Upper Basin, after Junta de San Francisco, the Bermejo river has an average annual flow of about 480 m^3/s. If we look at flows during the dry season, in the most critical month (generally September), the Bermejo River at Juntas de San Antonio has an average monthly flow of 19 m^3/s and at Junta de San Francisco the minimum monthly flow is about 30 m^3/s.

These magnitudes constitute the available water in the Lower Basin, which includes an immense plain where soil and climatic conditions are favorable to the growing of a wide variety of crops, and where the fundamental limit on development is the reduced availability of water.

The transboundary manifestations include the following:

The growing population in the Bolivian portion of the basin means that the water shortage is growing, and placing increasing pressure on migration as a transboundary manifestation, both seasonal and permanent as a consequence of restrictions on the permanent use of available agricultural land.

These shortages and restrictions on the exploitation of water resources can ignite or exacerbate conflicts over the use of surface and underground water, seasonal or permanent, especially in the areas where the water shortage is most severe, in the upper basin and in the Eco-region of the Semi-arid Chaco. The lack of understanding of existing resources makes it more difficult to assess the conflict and propose solutions. Shortcomings in legislation and organizational weaknesses **(24 and 26)**, together with a complex institutional framework that is inadequately articulated and organized with respect to management of the basin, make it difficult to forestall such conflicts. The low incomes of the local population, reflecting restrictions on the use of water resources and the uncertainties of seasonal employment, are producing population movements both within and beyond the basin. It is to be noted the temporary migration of people seeking to complete year round employment, which otherwise is concentrated in the rainy season.

Causas

The difficulties in exploiting water resources are linked to a number of causes.

The **direct causes** include:

- **Climatic limitations** owing to increasing seasonal variations (from east to west), the inter annual variability and the scarcity or deficit of precipitation, which reflects on the hydrological regime. It should be noted that the summer (December - March) is the time of maximum flow, when 85% of the run-off from the upper basin in Bolivia occurs, while the flow is exhausted from April to September, posing a severe limitation to productive use.
- **Flow restrictions**, which become progressively more severe as one moves from the Eco-region of the Sub-Humid Chaco to the west, where during the dry season there is a generalized water shortage for both human consumption and agricultural and livestock use. For example, at the Juntas del San Francisco, the mean annual flow of the Bermejo can drop from 480 m^3/sec. to a monthly minimum of around 30 $\mathbf{m^3}$/sec. The water shortage (**Figure Nº 21b**) is a dominant fact of life in the Eco-regions of the Semi-Arid Chaco and in the Eastern Andes, where the situation is critical in the Valle Central de Tarija and in the Quebrada de Humahuaca.
- **High sediment content in the water system,** which reaches concentrations exceeding 10 kg/m^3. In addition to the issues discussed in i**tem 2.2.1**, sediment can be considered as a factor limiting the aptitude of the water resource (for human and agricultural use) and as responsible for the rising costs of maintenance and the declining useful life for infrastructure.
- **High fluviomorphological dynamics**, which work through processes (such as undermining of river banks, cut off meanders, overflow or change of channels) to damage, destruction or loss of efficiency of water-capture infrastructure.
- **Local depletion of the water table**
- **High salt content.** In Bolivia, **t**he assessment of water quality from the viewpoint of its suitability for irrigation shows that of 20 sites sampled, 17 showed medium salinity (without restrictions), 2 were highly or very salinated, and only 1 showed low salinity (according to the classification of the Soil Conservation Service-USDA). On the Argentine side, there are frequently use restrictions due to the concentration of salts in underground waters. The localized presence of arsenic and other minerals (of natural origin) in underground waters, well above quality standards, has been recorded in the Eco-region of the Semi-Arid Chaco.
- **Relief limitations**. In the upper basin, the valleys are narrow and slopes are steep, giving rise to torrents that carry massive deposits of course sediments. This limits the possibilities of regulating and diverting the flow. In the lower basin, the fluviomorphological dynamics and the weak energy afforded by the relief are factors restricting use of the resource.
- **Inadequate hydric infrastructure,** which fails to offset or mitigate the climatic limitations discussed above, or those deriving from present or past processes of soil degradation. This is frequently aggravated by inefficiencies in water management or applied technologies as well as by “irrigation culture” shortcomings of the users.

Among the **specific basic causes** we may cite

- **Inefficient exploitation of water resources and low utilization of the existing potential. I**n Bolivia, current exploitation of the Bermejo and Grande de Tarija rivers is limited to irrigating small fields, and to human and livestock consumption. Based on current use patterns, demand is estimated at approximately 110 hm^3/year, less than 2% of the available volume; in other words, exploitation is not significant. Yet toward the end of the dry season, this level of exploitation consumes virtually 100% of the available flow in rivers of the Eastern Andes, especially in the sector corresponding to the Valle Central de Tarija (where most of the population and the irrigated farming is concentrated) and where there is only one man-made flow regulator, the San Jacinto dam (on the Tolomosa river) with a useful storage capacity of 48.7 hm^3. The cultivated area under irrigation is 2% of the Bolivian portion of the basin. In the Argentine sector, the exploitation of water resources focuses on irrigated farming and water supply for human and livestock consumption. The most recent census data available (1988) show that in the Argentine basin, only 6 % of agricultural land was devoted to crops. There are a few examples of more intensive exploitation. In Jujuy, the level of water resource exploitation is high, thanks to the reservoirs of Las Maderas and La Ciénaga. Together with the Los Molinos dam on the Río Grande they supply irrigation water to the Valle de los Pericos, in addition to providing water for drinking and for electricity generation. In Salta there has been a major expansion of the area under irrigation, and its water sources are fully committed. In the Upper Basin in Salta and Jujuy piedmont runoff supplies local irrigation systems. In the Lower Basin, water is drawn for irrigation and human consumption (e.g. the Laguna Yema system, in Formosa), and there are in fact some major irrigation works, privately owned, such as in the rice-growing area now being developed in the Chaco. The cultivated area under irrigation accounts for about 4% of the Argentine sector of the Upper Basin, and 2% of the Lower Basin. **(1 and 37).**

- **Inadequate understanding of the supply and usable potential** of surface and underground waters. In this respect, **(2)** and more particularly **(23)** have made progress in systematizing and understanding the functioning of the system, in order to establish the hydrometeorological and hydrosedimentological component of the Environmental Information System for the Bermejo River Basin, as an input for policy definition and resource use planning. There also is a need to improve the understanding of underground water resources.
- **Inadequate financial resources** for implementing existing water exploitation projects for irrigation and other uses.
- **Low levels of output and economic return.** Low intensity of agricultural use in general, little or no land devoted to agroindustrial crops (**Figure Nº 14**). This latter aspect affects farmers who must compete for water rights with other economic sectors. The impacts include current and potential inter-jurisdictional conflicts among the different users in a region, and effects on health that are contributing to unsustainable development in the basin.
- Inadequate legal and institutional framework for handling and managing water resources **(24 and 26)**.

2.2.3. Degradation of water quality

At present, stretches of the watercourses are affected by pollution from rural activities, and this is made worse when the water passes through towns and major cities. Indeed, some stretches of the rivers show significant organic and bacterial pollution from the dumping of agricultural and industrial wastes, and from poor livestock management.

Transboundary manifestations include:

The transport of organic and microbiological pollutants and other agents of sanitary significance, of urban and industrial and even agricultural origin. The trend here is rising. The impacts of this problem include: direct degradation of water quality, risks to human health, damage or loss of riparian flora and fauna and fish mortality in the most critically polluted situations, loss of biological productivity in aquatic communities (both lotic and lentic environments) and shoreline communities, effects on the uses of water resources, and increased costs of treating water for domestic or productive consumption.

All of these aspects have both direct and indirect transboundary manifestations. The indices of organic pollution in frontier rivers are fairly high, but they affect only short stretches, and the problem is significantly attenuated by the effect of dilution. While organic, bacterial and industrial contaminants are localized at specific points in the basin, there is a potential and growing risk if adequate prevention measures are not taken. If the situation worsens, this would affect both countries, and other basins downstream. Physical pollution, which appears during the wet season in the form of high sediment concentrations, is the most significant transboundary manifestation, since the massive transport of sediments affects water use both within the basin and beyond it, into the Paraná - Río de la Plata system.

Among the **direct causes** we may cite:

- **Degradation of soils and erosion**. The impact of sedimentation on water quality has already been examined in item 2.2.1. As an example, we may note that the concentration of sediments in the water system can exceed 10 kg/$\mathbf{m^3}$. Related to this problem, and also to that of water quality, poor water management has led to salinization of the soil that has reached severe proportions in the following areas: terminal overflows in Bañados del Quirquincho, the terminal portion of the Itiyuro alluvial fan, areas around Rivadavia and the headwaters of the Río Guaycurú, accounting for about 7% of the basin's total surface area.
- **Dumping of raw or semi-treated sewage** from populated centers. Industrial pollution at some points in the basin. Pollution from improper livestock and agricultural management. Water pollution in several stretches of the river results from the dumping of urban and industrial wastes, draining of residual agricultural chemicals, leaching of salt and sediment transport. This environmental problem reaches critical proportions a) locally, through organic and bacterial pollution and salt content in the dry season (April to December), when river flows are at their lowest, and b) regionally, because of the high sediment content during the rainy season (January to March).
  In Argentina, sampling conducted to examine the water quality situation for the basin as a whole show that, of 14 control points, 6 present some type of use restriction, due in all cases to bacterial contamination (total and fecal coliforms), frequently compounded by excessive concentrations of iron or sulfates. Readings exceeding permissible guidelines for Total and Fecal Coliform Counts, which imply restrictions on human consumption (with conventional treatment) and on recreational activities have been found in the San Francisco river, when crossing Provincial Highway N° 15, in the Bermejo river when crossing Provincial Highway N° 34 in Salta; the Los Molinos Dam, the Grande river in Las Lajitas, the San Francisco River in El Piquete and the San Francisco river in Jujuy. In Formosa and Chaco, studies show that permitted levels of total and fecal coliforms have been exceeded at the sampling stations for Bermejo (Teuco) river, in El Sauzalito and in Puerto Lavalle. The problem of water quality was dealt with in **(22),** particularly in its relationship to the design of a Hydrometeorological and Water Quality Network, a component of the Environmental Information System for the Bermejo River Basin.
  In Tarija, Bolivia, according to current legislation, the following stretches have been identified as unfit for human consumption (Level D)[6] with conventional treatment: in the Río

6 Criteria contained in legislation (Law 1333, Bolivia).

Guadalquivir from the locality of Tomatitas to the confluence with the Camacho river, in the Camacho river from the locality of Chaguaya to the confluence with the Guadalquivir river , in the Salinas river from the locality of Entre Ríos to La Cueva, in the Grande de Tarija river from the confluence of the Quebrada 9 to the confluence with the Bermejo river and in the Bermejo river from the monitoring station at Aguas Blancas to the confluence with the Grande de Tarija river. The stretches where water is only fit for human consumption with full physical and chemical treatment (Level C), are: in the Tarija river from the confluence of the Camacho and Guadalquivir rivers to 30 km downstream, in the Chiquiacá river from Chiquiacá Norte to Chiquiacá Sur, in the Itaú river from Itaú Norte to 13 km downstream of the community of Aguas Blancas and the stretch of the Bermejo river between Emborozú and the city of Bermejo.

By way of reference (complete data in **Annex II**), of 41 control points analyzed in the Bolivian sector of the Bermejo River Basin, 28 showed some degree of contamination (essentially from bacterial or organic materials).

The **specific basic causes** include the following

- **Inadequate or unenforced environmental standards.** It was shown that legislation is asymmetric, incomplete or lacking in the area of protecting shared resources (water in particular and natural resources in general), managing urban and industrial wastes (incomplete) and the environment as a whole (asymmetric rules), and there were also difficulties (such as organizational weaknesses) in enforcing regulations. To this must be added inadequate or non-existent legislation on management instruments, or the lack of regulations, which makes them unenforceable. The need for inter-institutional coordination in environmental management and for integrated management of the basin was made clear in **(24 and 25)**.

- **Inadequate sanitary infrastructure and weaknesses (primarily financial and others) of the institutions responsible for administering sanitary infrastructure systems.** This is clear from the high proportion of the population that has no access to drinking water or sanitation services, and the lack of procedures for final disposal of urban and industrial wastes. In the Argentine sector, 47% of dwellings in the basin as a whole were found to be deficient[7]. The most critical situations are to be found in departments with a very high proportion of families living in deficient housing (over 70%). These are, by province: Iruya, Santa Victoria, Rivadavia, La Caldera and Anta, in Salta; Bermejo, Patiño, Matacos, Laishi and Pirané, in Formosa; Valle Grande, San Antonio, Santa Bárbara, Tumbaya and Tilcara, in Jujuy: Gral. Güemes, Sgto. Cabral, Libertador Gral. San Martín, Bermejo and Donovan, in Chaco. These departments are located in two clearly differentiated areas of the basin: in an extensive portion of the central lower basin, and in the north of the upper basin. As an example of the Bolivian sector, 48.3% of the dwellings in the locality of Bermejo have no sanitary service (1992).
- **Inadequate health education and awareness in the community.** A number of aspects can be highlighted in relation to the need to improve and strengthen public perceptions,

7 Deficient housing is that defined by the census as houses with at least one of the following conditions: no provision for piping water within the house; no flushing toilet; or other conditions rendering a house uninhabitable.

awareness and conduct as they pertain to environmental issues. In the case study for **(20)** several communities located in the Humid Chaco and the Semi-arid Chaco were examined and several environmental and socioeconomic factors were identified that limit the adoption of sustainable development practices. This revealed the importance of education and training about access to and proper use of water sources (for human use and irrigation). In **(12),** the socioeconomic and environmental survey conducted in the communities of the middle and lower reaches of the Bermejo River basin (Eco-regions of the Chaco as a whole) yielded a greater understanding of these aspects. In **(30)**, case studies were undertaken with regard to promoting awareness of forest resources through joint action of the schools and municipalities *(*Formosa, Argentina).

- **Inadequate information systems on water quality.** Information on this issue is incomplete, sporadic, scattered or non-existent. On this aspect, **(21 and 22)** the examination of existing situation of the hydrometeorologic information systems showed these weakneses and set the grounds for designing a Hydrometeorological Network as a contribution to a proposed Environmental Information System for the Bermejo River Basin

2.2.4. Habitat destruction, loss of biodiversity and deterioration of biotic resources

The destruction of habitat and the loss of biodiversity is an environmental problem that appears with differing degrees of intensity across broad sections of the basin. It is affecting the natural heritage of the basin, changing the composition of its fauna and flora and the structure and function of ecosystems, reducing the productive capacity of both land-based and aquatic ecosystems, and frequently diminishing the esthetic qualities of the landscape.

Transboundary manifestations include:

From a transboundary perspective the destruction of habitat, the loss of biodiversity and the deterioration of terrestrial and aquatic biotic resources can be seen in the interruption of biological corridors, the interruption of migratory routes, fragmentation of habitat and greater vulnerability for wildlife populations, with a reduction in their area of distribution and increased risk to species conservation (particularly for endemic species).

The biological or bio-geographic corridors that appear most at risk are: a) that formed by the montane rainforest, montane forest and other forest ecosystems of the Sub-Andean Eco-region, b) ecosystems associated with the river systems and other wetlands, particularly in the semi-arid Chaco Eco-region. In this respect, the SAP included three components for the Sub-Andean corridor, which is considered most at risk from a conservation viewpoint. The study on the Baritu-Tariquia corridor **(27)** focused on optimization and conservation of wildlife through the formulation of common policies for the Baritu National Park (Argentina) and the National Flora and Fauna Reserve of Tariquia (Bolivia) in order to preserve biodiversity and promote nature conservation. It included a bio-ecological inventory and alternative arrangements for the biological corridors. The pilot study for **(16)** focused on identifying alternative sustainable uses of an eco-tourism type in the buffer zone surrounding the El Rey National Park. **(19)** conducted a series of evaluations in the municipality of Los Toldos and its surroundings (Salta) on actions now underway to reinforce productive diversity under conditions of sustainability.

The loss of habitat and connectivity for wildlife populations is changing historical distribution patterns, and introducing new areas of distribution and migration. This frequently involves the movement of species (predators, pests, etc.) or vectors of health concern[8], which are forced out of their native habitat and impinge upon agricultural production and human settlements.

This deterioration of habitat may mean the loss of productive aptitude for biotic and natural resources, contributing indirectly to displacement of the local population, as a result of diminishing prospects for socioeconomic development. The indigenous population and small-scale farmers are most vulnerable. As well, habitat deterioration in the higher zones can affect the quality of water resources in basin.

As **direct causes**, we may cite:

- **Deforestation of native woodlands and uncontrolled invasion of forest lands for agricultural use.**
  Deforestation for farming purposes has led to the clearing of large sections in Argentina between the towns of Embarcación and Tartagal, the farming area of Las Lajitas, the area surrounding the lower reaches of the San Francisco river; El Ramal; the area of confluence of the Grande-Lavayén river; los Valleys of Siancas and Perico; the Pedemontes of Sierras de Tartagal; of Maíz Gordo and Centinela; the large farming area in Northern Chaco and Southern Formosa; the right bank of the Río Guaycurú in the final portion of the Teuco-Bermejito interfluve; San Martín-El Colorado, Las Palmas and the higher lands of Chaco and Formosa **(Figure N° 16)**.
  In Bolivia's Montane Subregion (Sub-Andean Eco-region), forests on the middle and lower slopes have been destroyed by human pressure, and only a few small and scattered remnants are left. In the Subregion of the central valley of Tarija, these processes are associated with deforestation for farming and livestock grazing, and have resulted in loss of carrying capacity, loss of the soil's biological properties and erosion, the spread of denuded areas and an increase in vegetation that is toxic to livestock. Over grazing affects more than 60 percent of pasture lands in the Eastern Andes Eco-region.
  There is severe deforestation through selective cutting, especially in the alluvial plain of the so-called Bermejo Triangle (250 km^2) belonging to the Sub-Andean Eco-region. This process of habitat destruction also affects the region's overall biodiversity, and in conjunction with indiscriminate hunting and fishing has had a severely negative impact, especially on large mammals, birds and fish of commercial importance.
  Nearly 13 percent of the surface area (representing about 26 percent of existing forest and jungle cover) shows severe or very severe degrees of deforestation. In terms of Large Units, almost 15 percent of the basin's total area is threatened with loss of biodiversity.
  Even more alarming is the increased pace of deforestation over recent decades. The predominantly forested or cloud forest-covered area that has been clear-cut for crop planting now amounts to 7 percent of the total basin.

  Unsuitable farming practices, such as clearcutting and slash and burn, planting on slopes, etc., have intensified the damage to ecosystems with the consequent loss of species and frequent reduction of biodiversity. One example of this is the change in the balance between the herbaceous stratum and the arboreal stratum through the invasion of woody species such as Vinal (*Prosospis ruscifolia*), which reduces the land's suitability for livestock. This

8 In the interviews reported in **(28),** reference was made not only to endemic diseases such as malaria and cholera but also to increased cases of dengue fever and Leishmaniasis.

process can be seen in the lower basin, where invasion by Vinal is critical, as well as in the major units of the Derrames del Bermejo and the *Albardones* [fertile interfluvial ridges], depressions and lagoons in the Sub-humid Chaco. In addition to Vinal, which is seriously disrupting production, other extensive areas in the current Teuco-red floodplain have been taken over by alders ("*bobadales*"), but this has had no effect on production so far.

- **Overgrazing**, which was examined above in item 2.2.1. **Soil Degradation** is also a direct threat to biodiversity because of its effect on habitats in general. Degradation through overuse also occurs to a critical extent in the Large Units of the upper slopes, the west flank and the upper sector of the Quebrada de Humahuaca; las Colinas, the Piedmont and the fluvio-lacustrine plain of the Valle Central de Tarija; the lower course of the San Francisco river; El Ramal; the area at the confluence of the Grande and Lavayén rivers; La Almona; the valleys of Siancas and Perico; the Piedmont where there is no alluvial cone; the left and right sectors of the current diversion of the Bermejo; the northern Chaco and southern Formosa; and the high lands of eastern Chaco and Formosa.

Table Nº 4 shows the intensity of deforestation and biodiversity loss for the entire basin, at the Large Unit scale.

Table Nº 4
DEFORESTATION AND LOSS OF BIODIVERSITY

DEFORESTATION			LOSS OF BIODIVERSITY		
Category	**Area in km^2**	**%**	**Category**	**Area in km^2**	**%**
0	51,817	42.07	0	14,150	11.49
1	41,952	34.06	1	39,234	31.86
2	1,360	1.10	2	42,496	34.50
3	11,662	9.47	3	8,954	7.27
4	**6,997**	**5.68**	**4**	**9,929**	**8.06**
5	**9,374**	**7.61**	**5**	**8,399**	**6.82**
	123,162	100.00		123,162	100.00

- **Uncontrolled and indiscriminate hunting and fishing[9], e**specially for commercial purposes, is placing heavy pressure on biotic resources. In this respect, there is an urgent need for symmetrical and coherent legislation for the management of wildlife species (both in terms of hunting and fishing and other forms of management) among the different jurisdictions that share the basin's biotic resources (flora and fauna, terrestrial and aquatic), as well as to control the quality and use of mobile resources, such as water, which have a direct impact on aquatic ecosystems. There is also need for inter-institutional coordination in managing biotic resources, and for an integrated approach to stewardship of the basin. **(25).**
- **Increasing water pollution**, which was examined under item 2.2.3, is of such a magnitude that it is affecting the biodiversity of aquatic and riparian communities, and of wetlands as a whole. While at this time the effects are still site specific (in the vicinity of urban settlements)

[9] For example, sophisticated sport fishing methods coexist with the use of explosives for catching fish in the upper Bermejo River zone and other areas.

and sporadic (for example fish kills due to massive sugar refinery effluents), there incidence shows a rising trend.

Among the **specific basic causes** we may cite:

- **Lack of land-use regulation**, in both countries. The study **(31)** developed a conceptual and operational basis for establishing ecological regions in the basin and identifying and locating environmental restrictions, as essential information to be taken into account for land-use planning. Currently Argentina has no regulatory framework for a provincial system of Nature Protected Areas (NPA).
- **Ineffective enforcement and inadequate harmonization of rules** governing the protection and use of soils, water, flora and fauna, as appears from the analysis of legal and institutional aspects of environmental and biotic resource management **(24** and **26)**.
- **Lack of biodiversity management plans**: national biodiversity strategies are either rudimentary or nonexistent in both countries, and the institutional and organizational framework for enforcing them is inadequate. The issue of NPA management will be dealt with below.
- **Unsustainable farming, forestry and sylvo-pastoral practices**, giving rise to various environmental problems analyzed above.
- **Inadequate knowledge of native flora and fauna**. Although there are some areas and sectors where major efforts have been made to catalog and evaluate the state of conservation of flora and fauna, knowledge of the current status of the basin's biodiversity is fragmentary and unsystematic.
- **Shortcomings in the management and administration of protected areas**. While there are 21 protected natural areas (**Figure Nº 8**) covering a total of 6,489 km^2, or 5.3 percent of the basin's surface area (a percentage generally considered as adequate), their degree of representativeness of the natural heritage and their degree of control are inadequate. The areas are unevenly distributed between the two countries: in Bolivia, they account for 26.5 percent of this part of the basin, but only 2.2 percent in the Argentine sector. **Table Nº 5**, constructed on the basis of partial data, shows that more than 60 percent of the area included in NPAs of any category have inadequate or no control.

Table Nº 5
NATURE PROTECTED AREAS

Inclusion in the basin	**Total NPA Partial land areas**		**Partial land areas by Degree of control (has)**	
	Quantity	Area (has)	Acceptable	Insufficient or none
Total	16	More than 481,413	120,468	360,945
Partial	5	More than 118,500	No data	108,500

The data on the degree of control are taken from national reports

The establishment of NPAs in the basin is closely related to the conservation of habitat and biodiversity. For Argentina, out of a total of 17 areas included partially or wholly within the basin, it was found that three have an inadequate degree of control, two have an acceptable degree and two have none at all, while the degree of control in the other 10 areas is unknown. In Bolivia, of the four areas within the basin, three have inadequate control and one has none (**Figure Nº 8**), which means that conditions there are more critical.

Table Nº 6
SIZE OF PROTECTED AREAS BY ECO-REGION

ECO-REGION	AREA ECO-REGION (km^2)	TOTAL AREA ANPs (km^2)	% COVERED
I Eastern Andes	16,640	859	5.2
II Subandean	46,890	4,302	9.2
III Semiarid Chaco	34,149	1,250	3.7
IV Sub-humid Chaco	13,992	0.10	0.0
V Humid Chaco	11,491	7,811	0.7
TOTAL	123,162	6,489	5.3

Without considering the current degree of control, the status of conservation of their ecosystems and the degree of threat, or the conservation alternatives that exist outside the basin, **Table Nº 6** shows that within the basin there is: (i) a high presence of ecosystems of the Subandean Eco-region, a dominance that could be justified in light of their protective role in the upper basin, their carbon fixation capacity and their high biodiversity, (ii) an under-representation of the Semi-arid Chaco, and (iii) a critical lack of NPAs under public (national or provincial) ownership in the ecosystems of the Sub-humid and Humid Chaco.

The *Immediate Conservation Status* of all Eco-regions in the basin was classed as vulnerable in a document, "An Evaluation of the Conservation Status of Terrestrial Eco-regions in Latin America and the Caribbean", sponsored by the World Wildlife Fund (WWF) and the World Bank and prepared by Dinerstein et al (1995). With respect to conservation priorities, it assigns maximum regional priority to Eco-regions covering a large portion of the semi-arid Chaco and nearly all of the Eastern Andes (except for the dry montane forest sector of Bolivia, which is assigned a high regional priority). For the Sub-Andean region, moderate regional priority is assigned (in the Latin American and Caribbean context).

The destruction of habitat and loss of diversity is closely related to the degree of threat to flora and fauna in the basin's Eco-regions.

Table N° 7
NUMBER OF SPECIES OF FLORA AND FAUNA AT RISK
BY ECO-REGION

		FLORA		**FAUNA**		**TOTAL**	
ECO-REGION	**COUNTRY**	**VU**	**EP**	**VU**	**EP**	**VU**	**EP**
Eastern Andes	Argentina	**-**	**3**	**5**	**1**	**5**	**4**
	Bolivia	**3**	**-**	**3**		**3**	
Subandean	Argentina		**11**	**11**	**7**	**11**	**18**

[10] No data available on the area of ANPs under private ownership in the Eco-region.
[11] Ibidem

	Bolivia	**15**	**3**	**10**	**3**	**25**	**6**
Semiarid Chaco	Argentina	**-**	**11**[12]	**10**	**5**	**10**	**16**
Sub-humid Chaco	Argentina	**-**	**-**	**-**	**-**	**-**	**-**
Húmid Chaco	Argentina	**-**	**-**	**12**	**9**	**12**	**9**

References: VU: vulnerable; EP: at risk (according to IUCN, 1994)

Of all the Eco-regions, the Sub-Andean has the greatest number of endangered species of flora and fauna (vulnerable or at risk), especially in the Argentine sector of the basin. Next in this ranking come the Eco-region of the semi-arid Chaco, where the proportion of species at risk is one-third lower, and the humid Chaco, where the proportion is slightly lower still.

2.2.5. Conflicts from flooding and other natural disasters

These problems arise from natural phenomena, primarily overflowing rivers and drought, but also frost and hail, which can cause damage to rural and urban infrastructure and to economic production systems, including the destruction of crops and livestock in rural areas, and can pose a threat to public health. Conflicts from flooding have had the greatest impact on the population, and the efforts to geo-reference and quantify them **(31)**, highlighted the following aspects: a) **Inundation** in the strict sense, produced by rivers swelling and overflowing, was estimated to affect more than Large Units representing 7 percent of the basin with severe or very severe conflicts; b) **Waterlogging**, caused by temporary accumulation of rainfall or small overflows in low-lying or poorly drained areas (**Figure N° 19**), is estimated to have a severe affect on about 7.5% of the area of the Large Units in the basin, although no situations at the very severe level have been identified at this scale.

At the regional scale both processes are limited in the Eco-regions of the Eastern Andes and the Subandean Ranges, except in areas under the influence of the alluvial plains of the Bermejo, Grande de Tarija, San Francisco and Grande de Jujuy rivers. In Bolivia, several critical situations have been found: Municipality of Bermejo (where the urban population and infrastructure were affected), sites of Talita, Campo Grande, Naranjitos, Porcelana, Candado Grande and Arrozales (where crop lands are highly vulnerable) and urban infrastructure damage in the city of Tarija. In the three Eco-regions belonging to the great Chaco plain there is a clear differentiation between the two problems. Waterlogging occurs to varying degrees of intensity depending on the topographic and textural conditions of the site. Flooding appears with higher values, linked to the flood plains and overflow areas of the Bermejo-Teuco or Paraguay rivers and also appears with high values in areas around the outlets of the Dorado and Del Valle rivers, particularly in the marshy grassland and swamps of eastern Chaco and Formosa. As noted below, during the extraordinary high-water episode of 1984, the area under water was considerable in the lower basin. For example, the area affected by both phenomena in the province of Chaco was 390,000 ha. This meant great damage to roads and rural infrastructure and land use, as well as isolation for many rural communities, particularly indigenous ones.

With respect to **drought, hail and frost** these occur primarily in the Eco-region of the Eastern Andes, where they affect farming output most severely in the valleys, causing in some instances drastic disruption to the rural economy and sparking an increase in migration. Fruit and

[12] This number is for the Chaco ecosystem, reported in A. Vila and C. Bertonatti, 1993. *Lista de Vertebrados Argentinos amenazados de extinción*. It is shown here for illustrative purposes.

vegetable crops are frequently damaged by these phenomena in the Valle Central de Tarija

Table Nº 8
CONFLICTS FROM FLOODING AND WATERLOGGING
BY LARGE UNITS

FLOODING			INUNDATION		
Category	**Area in km^2**	**%**	**Category**	**Area in km^2**	**%**
0	56,352	45.75	0	89,932	73.02
1	5,575	4.53	1	4,959	4.03
2	31,574	25.64	2	16,615	13.49
3	20,462	16.61	3	2,080	1.69
4	9,198	7.47	4	2,536	2.06
5	0	0.00	5	7,040	5.72
	123,162	100		123,162	100

Transboundary manifestations include:

Because of their magnitude and incidence, high flows constitute transboundary phenomena and the flooding they unleash can reach a scale that constitutes a transboundary manifestation, both in the upper and lower portions of the basin individually and for the basin as a whole. In this case, there is an urgent need to make comprehensive and reliable information available and to have suitable warning systems and prevention plans for handling these extraordinary situations. On this point, **(21, 22 and 23)** developed the design of a Hydrometeorological Network as a contribution to the proposed Environmental Information System for the Bermejo River Basin. Alternative approaches to water excesses management have posed the potential for inter-provincial conflict in Argentina.

The permanent or temporary loss of habitability, destruction of infrastructure and rural and urban equipment, and losses in terms of material goods and regional output and productivity have an effect on living standards and are another factor prompting migration.

Causes

Among the direct causes we may cite:

- **Exception climatic phenomena**, in the form of intense episodes of precipitation in the Upper Basin and in the Humid Region of the Lower Basin, the effects of which are felt in the form of torrents or flash floods placing extensive areas under water. The torrential nature of the rains has already been mentioned.
- **Extraordinary water levels in the basin's major rivers**. Maximum flood peaks recorded for the Upper Bermejo and the Grande de Tarija rivers reach 5,000 and 8,000 m³/s respectively, and it has been estimated that the maximum probable peak at Juntas de San Antonio (the last point in Bolivian territory) is 12,000 m³/s and at Juntas de Francisco (the last point in the upper basin) is as much as 20,000 m³/s. The maximum flood wave recorded of the Bermejo at Zanja del Tigre (Salta), in the 1984/85 season reached a peak of 10,000

m^3/s[13]. Areas of the lower basin that form part of the alluvial valley of the Paraguay River are subject to influence from high water in the Paraguay-Paraná system.

- In the basin as a whole flooding affects the recent terraces and alluvial plains along the margins of the rivers. The frequent occupation of flood-prone areas for farming, rural settlements or urban expansion produces a gradient of conflict situations of varying severity. During the 1983-84 season, in the upper basin, flooding by the Rio Grande (with peak flows of 700 m^3/s) produced major damage to roads and inundated low-lying areas of the capital city of Jujuy. The city of Embarcación (Salta), on the border between the high and lower basin, was also affected. In the lower basin, the Teuco-Bermejito interfluve has been the main recipient of river spillovers, as occurred in 1983-84, when several aboriginal settlements, such as El Sauzalito, Sauzal, Tartagal, Tres Pozos were flooded and major damage was caused to productive systems and infrastructure, especially roads. In that same season, the area severely flooded amounted to 390,000[14] ha in the province of Chaco alone. In Bolivia, the most critical urban disaster points are the cities of Tarija and Bermejo, among others.
- At the local scale, it is believed that the destruction of vegetation cover along the banks and in the headwaters of rivers and creeks increases the negative environmental effects of the causes discussed above. As a consequence, the dragging of trunks and other plant debris by high flows restrict the various water uses, including direct effects to the population.

Among the **specific basic causes** we may cite:

- Unplanned and uncontrolled urban and rural development. This is another cause identified, as shown by the lack of a regulatory framework **(24)** or other planning tools to regulate or direct the occupation and use of land. Such rules exist in only a few cases, and they are sector-specific. In **(31)** a first attempt was made to identify and locate environmental restrictions for these variables as input to a strategic plan.
- Limited flood control and protection infrastructure, in both rural and urban areas. The existing infrastructure is not sufficient to protect the population and productive systems from flooding caused by intense rainfall and high river levels.
- Lack of integrated watershed management plans that, together with proper land-use regulation and bioregion planning, could enhance protective efforts, reduce risks and vulnerability for the local population and their livelihood.
- Lack, or poor enforcement, of water emergency plans that might prevent or mitigate damage to productive sectors and the population. In particular, the establishment of risk-classified zoning and appropriate warning and prevention systems, in addition to urban and rural land-use planning and other regulatory or economic and fiscal measures.

2.4.6. Deteriorating human living conditions and loss of cultural resources

In general it may be said that a broad segment of the population is affected by poverty, with the most vulnerable groups being those of indigenous and native origin, small farmers and marginalized groups in the major urban centers. This is in fact perhaps the most conspicuous manifestation of the basin's environmental problems. The urgency of meeting basic needs often

[13] COREBE. 1985. Creciente Año Hidrológico 1984-85. Informe de Evaluación.
[14] Ibidem

leads to the adoption of unsustainable practices and the failure to comply with environmental regulations.

Living conditions in a scenario as complex as that of the Bermejo River basin are determined by a series of factors that act through a dense web of interrelations. The studies undertaken through **(33)** and **(37)** selected the most representative indicators for geo-referencing and evaluating this problem. Declining living standards are in turn a cause of other problems that have been identified.

UBN (Unmet Basic Needs) indicators can be confirmed by measuring the current status of Human Development Indicators (HDI): for Chaco 0.758, Formosa 0.732, Jujuy 0.763 and Salta 0.813. The department of Tarija shows an HDI of 0.60, slightly higher than the national average for Bolivia, which stands at 0.59.

Within the basin, more than 80,000 residents were illiterate in 1991, or almost 10 percent of the reference population (over 10 years of age in Argentina and over 15 years in Bolivia). The incidence of illiteracy is generally associated with areas that are the most disadvantaged from the economic and social viewpoint. These coincide with the upper basin in the Bolivian sector, where illiteracy rates lie at about 18.5 percent. In the Argentine sector, the departments with very high illiteracy rates, ranging from 15 percent to 30 percent, are, by province: Santa Victoria, Rivadavia and Iruya, in Salta; Gral. Güemes, Sargento Cabral and Libertador Gral. San Martín, in Chaco; Bermejo in Formosa and Valle Grande en Jujuy. In these zones, illiteracy severely restricts people's ability to earn a livelihood, a situation that is made worse in the case of family heads with dependents.
The population without medical coverage (social security or medical plans) is very high in relation to the total population of the basin (95 percent). These people rely primarily on the public health system. In 1996, infant mortality in the Chaco stood at 34 o/oo, in Formosa at 31o/oo, in Salta at 26o/oo and in Jujuy at 24o/oo, while the national average was 21o/oo.

Transboundary manifestations include:

The decline in living standards aggravates the crisis at the local level and intensifies socioeconomic imbalances throughout the basin. This situation is increasing the pressure on natural resources (with inevitable consequences for the soil, water, biota, etc.) and is prompting migration, which constitutes a transboundary manifestation, both temporary and permanent. Studies undertaken in Tarija on transboundary migrations show that more than 42 percent of the rural population left for Argentina at some point in the search for work.

The conditions described above mean that the Bermejo River basin is a net exporter of population. It has given rise to both domestic and international flows of people seeking better living conditions **(28 and 29)**, from the Bolivian sector of the basin towards northern Argentina, Buenos Aires, urban settlements in Bolivia and other places. At the same time, the Argentine sector of the basin has been exporting people to other poles of attraction **(28)**. These processes have an impact on the habits and customs of both the receiving and the sending populations.

Causes

The direct causes may be described as:

- **Seasonal unemployment and underemployment. Inadequate levels of income**. The unemployment rate in Chaco (ranging from 6 percent to 15 percent in 1996) and in Formosa, around 8 percent, are very significant, although they are below the national average (in Jujuy, the unemployment rate in May of 1997 was higher, at 18 percent compared to 16 percent nationally). In Salta, on the other hand, the unemployment rate is generally at or above the national rate (18.7 percent in 1997).
  The four Argentine provinces (Chaco, Formosa, Jujuy and Salta) show a considerable lag in their development, in comparison with the national average measured in economic terms. GDP per capita for the four provinces is one-half the national average.

Table Nº9
GROSS GEOGRAPHIC PRODUCT IN THE BASIN

COUNTRY		**GGP**	**GGP /capita**
ARGENTINA	**PROVINCE** ($US, 1996)	$US	$US
	Chaco	2.640.000.000	2.930
	Formosa	908.000.000	1.996
	Jujuy	1.571.000.000	2.801
	Salta	3.666.000.000	3.771
BOLIVIA	**DEPARTMENT** ($US, 1995)		
	Tarija	246.246.000	764

Source. Instituto Nac. de Estadística, Depto de Cuentas Nacionales (Bolivia); INDEC (Argentina)

Agricultural output has been rising in general, because of steady expansion of farming into new lands and the planting of new crops, led by entrepreneurial farming. The problem is that the expansion of the agricultural frontier has been focused in heavily capital-intensive sectors, and this has done little to promote "distributive" development of the kind that would benefit the bulk of the population, expand employment opportunities, and raise family incomes.

Between 1993 and 1997 the four Argentine provinces increased their exports (Chaco, 180%; Jujuy, 112%; Salta, 106% and Formosa 80). Nevertheless, regional exports from the four provinces together represent only 4 percent of the national total (1998), with the Chaco accounting for 1.8 percent and Formosa for only 0.2 percent. These exports consist primarily of primary products, a trend that has in fact been accentuated recently with a decline in the export of processed agricultural goods, except in the case of Salta. Recent economic events have affected provincial yield with a consequent increase in unemployment, resulting from structural adjustment and privatization, and this has deepened the degree of social polarization in every province. On the other hand, the current trend towards globalization has tended to increase the concentration of economic activity in the metropolitan area of Buenos Aires, in particular, thereby widening the social and economic gap separating the capital from the less-developed provinces. At the same time, the very low level of human development indicators in broad sections of the basin provides conspicuous evidence of the region's environmental problems. Low income levels induce unsustainable management practices, which are at the source of the major problems observed.

- **Inadequate access to goods and services such as housing, sanitation, health and education.** In the basin as a whole, a high proportion of the population, 41.7 percent, shows Unmet Basic Needs (UBN), as shown in **Table Nº 2**. The proportion of the rural population with UBN in Bolivia stands at 90 percent; in Argentina the figure exceeds 65 percent, and reaches 70 percent in Salta. The indicator of substandard housing in the basin, betrays many shortcomings in the implementation of social assistance policies. Both components are reflected in the lack of sanitation facilities and proper housing (**Figure Nº 12**).

Among the **specific basic causes** we may cite:

- **Inadequate production support infrastructure (irrigation, roads, electricity**). In the Bolivian sector of the basin, transportation infrastructure in general is deficient. Roads are difficult to negotiate during the rainy season, an observation that applies as much to the main highways as to secondary roads. The total extent of roads of all types in the Bolivian sector amounts to 945.5 kilometers, of which 184 kilometers are paved, while the rest are surfaced with gravel or dirt. It is important to note that there has been a considerable increase in heavy vehicle traffic in the basin, and this has worsened traffic conditions considerably.
  In the Argentine sector of the basin, the road network offers good north-south connections between such cities as Salta and Jujuy and between Chaco and Formosa. On the other hand, communication between the upper and lower portions of the basin is poor, especially when the rivers are high.
  Connections between the Argentine and Bolivian sectors are also limited, although it is hoped that current road projects under way will improve communication. In general, heavy rains and landslides restrict accessibility and cause significant damage to transportation and energy infrastructure all over the basin. This in turn has a sharp impact on other public services and on sanitation, and has contributed to declining living standards for the population. In this respect, efforts to regulate seasonal hydrological fluctuations have been insufficient.
- **Inadequate sanitation and water supply infrastructure**. The difficult natural conditions existing in many parts of the basin, discussed under other points of this report (climatic and hydrological variability, relief, sediment production and transport, fluviomorphological dynamics, low quality and potential of underground water, dominance of soils with low use capacity, etc.) make it difficult to undertake water works and infrastructure in general. These problems must be added to weaknesses of the institutional, economic and financial framework, which have been identified as basic causes for the inadequacy of production support infrastructure, the low-level of resource exploitation and consequently of regional productivity, with its attendant impact on income levels. The situation is apparent in the poor level of sanitation services and water supply.
- **Unsustainable management of natural resources**. The environmental problems relating to these limitations, the destruction of natural resources, and improper use of natural resources through unsustainable farming and livestock practices, are destroying the productive base and raising the costs of production, thereby reducing agricultural yields and accelerating the decline in living conditions.

2.3. Identification of Common Basic Causes

Using the definition of causes presented in Chapter 1, we have identified in Chapter 2 the most important Common and Specific Basic Causes and Direct Causes, differentiating among them in terms of their role as determinants of selected problems.

With respect to Common Basic Causes, for the basin as a whole it was concluded that the major problems identified are determined by a set of political, institutional, social and economic factors. These causes, together with the Specific Basic Causes, lie at the root of the problems identified, and in turn they help to maintain and intensify them, so that they pose a growing threat to the stability, conservation and proper management of natural resources, the protection of the environment and the generation of sustainable development projects in the basin. Five principal Common Basic Causes of an anthropogenic nature[15] have been identified, and these are at the origin of the chain of causal relationships that determine those problems. This listing reflects the vision constructed during preparation of the transboundary diagnostic analysis and in the consultation processes that were undertaken.

2.3.1. Inadequate political, juridical and institutional framework

International experience shows that shortcomings in the political, legal and institutional framework can generate processes leading to the unsustainable use of natural resources and to environmental degradation.

Our studies and consultations in the region during preparation of the project concluded that in the different jurisdictions of the basin there are weaknesses in the legal framework governing the use and conservation of natural resources and protection of the environment, as well as in the institutional framework, characterized by fragmentation of duties and responsibilities, functional overlapping and gaps, absence of hierarchical ordering, and lack of independence in control functions.

Another Basic Cause identified is the fact that the principles of integrated water management and policies to promote integrated natural resource management in the basin have not been sufficiently assimilated at the decision-making level, nor explicitly incorporated into the legal and regulatory framework or in resource planning and management practices.

Weaknesses were found in institutional frameworks at both the binational level and within Argentina. They are apparent in the lack of an effective organization for the basin that could promote coordination and cooperation through direct participation by the various competent jurisdictions, in consultation with all stakeholders in the basin.

At the regional level, the disparities that arise from different levels of development in legal frameworks and their lack of harmonization compound are further compounded by the inadequacy of regulatory standards and common controls over the use and protection of shared natural resources, based on a consensus among all jurisdictions.

The insufficient capacity of organizations to carry out the functions of evaluation, planning, management and control over natural resources is another basic cause for most of the problems identified in the basin. Human resource shortcomings, in terms of quantity and capacity, shortages of equipment and lack of access to appropriate technologies for

[15] This does not imply disregarding the conditioning role of the natural environment on the manner in which anthropogenic causes ultimately make themselves felt in the major problems identified. But it is unsustainable forms of human intervention in nature that are their determining causes

government organizations and civil society contribute to these basic weaknesses. The situation is made worse by the scarcity of basic information, a low level of commitment among those responsible for applying regulations, and the lack of communication and coordination among technical sectors and government policymakers.

2.3.2 Inadequate inter-and intra-jurisdictional planning and coordination.

The fragmented and sector-specific approach to managing natural resources and the lack of appropriate mechanisms for planning and coordination constitute basic causes of unsustainable management and therefore contribute directly to the major problems identified. It is been found that there is no appropriate framework for coordination, programming and regional planning either at the regional level or among the various sectors and powers within each jurisdiction. This means that there is little awareness of the need for an integrated approach to managing natural resources and a lack of reliable and up-to-date information on the situation and resource use trends, or other environmental information. The lack of systematic planning shows up in glaring shortcomings in terms of land use management and regional planning, which are basic instruments for guiding the integrated and sustainable management of resources.

2.3.3. Inadequate knowledge, commitment and participation by the community and failure to promote such participation

The lack of public awareness, inadequate cultural motivation and widespread skepticism have led to a low level of community involvement in managing natural resources. This is reflected, directly or indirectly, in degradation of the environment and in the unsustainable use of resources, and it therefore contributes to the environmental problems identified. The lack of public participation also means that the community has inadequate access to essential information, and a limited capacity to take part in the decision-making process. Nor does the local regulatory framework do much to encourage participation.

2.3.4. Inadequate financial and support mechanisms

The inadequacy of funding sources for sustainable development projects, together with the existence of subsidies and incentives that promote unsustainable practices and activities, are basic causes behind most of the problems identified. They are reflected in the low value assigned to the environment in economic policies and the failure to internalize environmental and social costs when it comes to evaluating projects.

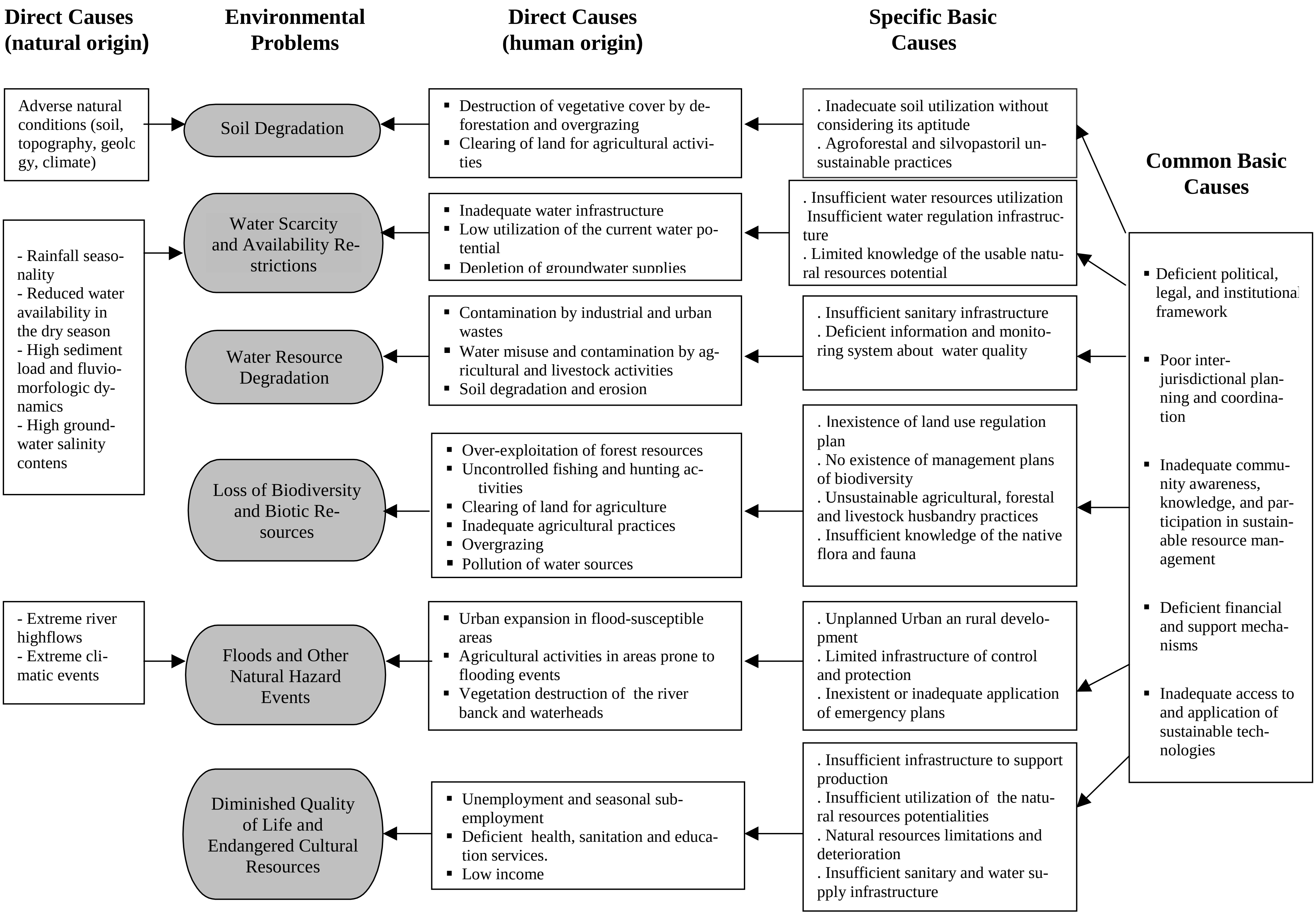
2.3.5. Inadequate access to and use of sustainable technologies

Technology has a decisive role in incorporating sustainable management practices for natural resources. Difficulties in gaining access to and applying appropriate technologies are identified as basic causes of environmental degradation and hence of several of the problems identified. The use of unsustainable primary production systems and agricultural practices, the application of unsuitable technological models and the under-use of the appropriate materials and technologies that are available have been identified as major aspects of this problem.

2.4 Causal chain

Based on the previous characterization, **Sketch Nº 2** presents a schematic of the cause-effect relationships between the identified environmental problems and the direct causes (of natural or anthropic origin), the specific basic causes and the common basic causes. The causal chain analysis provides information on the basic factors which originate or aggravate the environmental problems.

Sketch 2: CAUSAL CHAIN RELATIONSHIP FOR PRIORITY ENVIRONMENTAL PROBLEMS



2.5 Summary of environmental problems

The characterization of the environmental problems above described, is summarized in **Annex V**, which presents a quantitative assessment, the location and weighting of each problem in terms of the relevant selected indicators and their geographical distribution in the Basin. Each problem is referred to independently[16].

Under the heading "Quantification", the main aspects described in item 2.2 are summarized. The references in column "Location and Weighting" in **Annex V** corresponde to the division in Ecological Regions **(31),** using a numerical code (**Figure Nº 9**) where:

- The Eco-region is identified by the first digit, a roman number
- The Sub-region is identified by the second digit
- The Large Unit is identified by the third digit

There, it is only indicated the Eco-region, Subregion and Large Unit where the "Weighting" of the environmental problems (**Figures Nº 16 to 22**) reaches an intensity of severe (grade 4) or very severe (grade 5), according to the criteria of assessment developed in the above mentioned document (31). Both columns together provide complementary information originating from various cources.

On the other hand, **Table Nº 11** summarizes Effects, Symptoms and Transboundary Manifestations of the priority environmental problems which were described above.

[16] For example, Annex Va: Soil Degradation ... ; Vb: Water Scarcity and ...; Vc: Water Quality Degradation; .., and so on.

Table Nº 10

ENVIRONMENTAL PROBLEMS, SYMPTOMS AND EFFECTS AND THEIR TRANSBOUNDARY MANIFESTATIONS

	ENVIRONMENTAL PROBLEMS IDENTIFIED	EFFECTS AND SYMPTOMS	TRANSBOUNDARY MANIFESTATIONS
I	Soil degradation. Intense erosion and desertification processes	High sediment content in surface waters. Silting up of reservoirs. Increased salinization. Reduced productive capacity of soils. Reduced organic matter. Reduced farming and livestock productivity. Loss of productive areas. Increase in areas affected by erosion and desertification. Lower water retention capacity.	• Increased sediment transport, affecting the fluviomorphological dynamics and impacting on exploitation of the basin's water resources, with effects on formation of the Paranoia Delta and navigation channels of the Rio de la Plata. • Increased transboundary migration, within and beyond the basin, reflecting the impact of lower productivity of the land and advancing desertification, especially on small farmers.
II	Water shortages and use restrictions	Generalized water shortages in dry periods, both for human consumption and for agriculture and livestock use. Reduced area under irrigation. Low levels of output and productivity. Seasonal nature of farm labor. High percentage of population without access to drinking water. Sanitation problems. Sector conflicts over uncontrolled use of water during the dry season. Effect on water use during the wet season.	• Temporary or permanent transboundary migration within and beyond the basin reflecting constraints on domestic and productive activities, affecting incomes and living conditions, and promoting transience. • Potential conflicts over water use in the basin, because of variations and constraints on the usable flow

Table Nº 10

ENVIRONMENTAL PROBLEMS, SYMPTOMS AND EFFECTS AND THEIR TRANSBOUNDARY MANIFESTATIONS

	ENVIRONMENTAL PROBLEMS IDENTIFIED	EFFECTS AND SYMPTOMS	TRANSBOUNDARY MANIFESTATIONS
III	Degradation of water quality	High levels of organic, bacterial, chemical and probably agro chemical pollution in local stretches of rivers. High sediment content in watercourses. Increased salinity. Destruction of habitats for aquatic flora and fauna. Fish die-off. Presence of infectious diseases from consumption of contaminated water and food. Effect on water use.	• Increasing tendency for transport of organic and microbial pollutants and other agents of health concern, of urban and industrial and even agricultural origin, with effects on land use, public health and aquatic ecosystems. • Massive transport of sediments that affect water use in the valley and be on, in the Parana-Rio de la Plata system
IV	Destruction of habitats, loss of biodiversity and deterioration of biotic resources	Changed dynamics of wildlife populations and their distribution. Reduced wildlife populations of flora and fauna. Reduced biological properties of the soil, limiting its capacity for farming or livestock. Loss of natural scenic beauty. Increase in invasive woody plants. Increase in denuded areas. Impoverishment in the structure and composition of species and functions of woods and pastures. Fish mortality. Loss of wetlands	• Effect on distribution and transboundary dynamics of wildlife populations, significant changes to the natural heritage and ecosystem balance of the basin, and particularly terrestrial and aquatic biological corridors. • Migration of fauna including vectors of health concern, displaced for loss of habitat, and affecting agriculture and people. • Population migration caused by loss of productive capacity of biotic resources, implying fewer opportunities for socioeconomic development. The native population and small farmers suffer most. Effect on the usability of water resources from habitat destruction in upper reaches of the basin where most water originates.

Table Nº 10

ENVIRONMENTAL PROBLEMS, SYMPTOMS AND EFFECTS AND THEIR TRANSBOUNDARY MANIFESTATIONS

	ENVIRONMENTAL PROBLEMS IDENTIFIED	EFFECTS AND SYMPTOMS	TRANSBOUNDARY MANIFESTATIONS
V	Conflicts from flooding and other natural disasters	Loss of human life and displacement from flooding, in both urban and rural areas. Loss of productive activities through flooding, drought, frost and hail. Losses from destruction of rural and urban infrastructure and equipment. Chronic indebtedness of producers.	• Migrations from loss of habitability, infrastructure and urban and rural equipment and loss of regional output and productivity, which affects living conditions. • Possibility of interprovincial conflicts
VI	Deterioration of living conditions and loss of cultural resources	Low Human Development Indices. High percentage of people with Unmet Basic Needs. Presence of endemic diseases and increased public health risks. Conditions of poverty and extreme poverty in broad sectors of the population. Low capacity for self-management Loss of traditional cultural and educational values.	• The basin is a net exporter of population as a result of low living standards. • Domestic and international migratory flows seeking better living conditions, from the Bolivian sector into northern Argentina, Buenos Aires and other sites, and from the Argentine sector towards other poles of attraction. • Changes in practices and customs among sending and receiving populations, their human potential is frequently underused in the latter case.

3. ENVIRONMENTAL PROBLEMS AND ITS RELATIONSHIP TO THE STRATEGIC ACTIONS

3.1. Introduction

In the preceding chapter we characterized the major environmental problems or conflicts relating to water resources, land and society in the basin, as a result of different processes and human activities together with preexisting or anthropogenic environmental constraints. As a result of the style of development and environmental management followed throughout the history of the region, these problems appear today as constraints to sustainable development.

By focusing on the watershed as the object of study and action, the transboundary manifestations of existing problems stand out more clearly as results of dynamic processes and components of the natural and social system. The Bermejo River crosses the border between Bolivia and Argentina, passes through four federal states of Argentina and disgorges into the Paraguay River (the frontier between Argentina and Paraguay), finally depositing its waters downstream in the Paraguay-Parana valley and in the Rio de la Plata (shared by Argentina and Uruguay).

In turn, the express identification of these components underlines the need to instill in society an overall vision of the basin as a point of departure for ensuring the integrated and sustainable management of its shared resources.

3.2. Strategic Action Framework

As a result of the activities undertaken for this project, and in particular the public participation in the workshops that were held in both countries, as well as meetings of the Governmental Working Group in Argentina, four Strategic Action Areas were identified along with their principal Strategic Action components, to respond to the environmental problems identified by addressing their causes. These are shown in **Table Nº11.**

The Strategic Action Areas are:

- Institutional development and strengthening for integrated planning and management of the basin.
- Environmental prevention, protection and rehabilitation.
- Sustainable development of natural resources.
- Public awareness and participation.

3.3. Environmental problems, basic causes and strategic actions

Table Nº 12 presents a further level of characterization that relates environmental problems with their causes, together with the strategic actions that have been identified as essential for addressing those causes, resolving the problems and promoting sustainable development in the Bermejo River basin, consistent with the objectives of the Strategic Action Program.

The strategic actions are structured at three levels:

- DSA: Direct Strategic Action: directly related to the problem and its basic causes.
- CSA: Common Strategic Action,: common to all problems and basic causes.
- ISA: Indirect Strategic Action: related indirectly to the problem and is basic causes

3.4. Conclusions: priority actions, scope of application and fundamental diagnostic aspects.

Finally, **Table Nº 13** presents the strategic actions proposed as a response to the fundamental concepts arising from the Transboundary Diagnostic Analysis. In each case, we identify the priority geographic scope where initial efforts are recommended, in terms of the contents of the action considered, as well as the degree of criticality of the problems addressed.

Each of these actions is related, in **Table Nº 13**, to the Common and Specific Basic Causes, in order to provide a more complete vision of the total SAP cycle.

Table Nº 11. STRATEGIC ACTIONS

STRATEGIC AREAS OF ACTION		STRATEGIC ACTIONS
A	Institutional development and strengthening for integrated planning and management of the basin	A1 Upgrading and strengthening of the Binational Commission as a basin-wide agency for the integrated and sustainable management of water resources in the Bermejo River basin, with the effective participation of the provinces in Argentina, the prefecture of Tarija and the municipalities with jurisdiction in the Bolivian portion of the basin. A2 Development, harmonization and application of a legislative framework for sustainable use and conservation of natural resources A3 Introduction of effective mechanisms for sectoral and jurisdictional coordination and articulation. A4. Implementation and strengthening of an environmental information system for the basin A5 Formulation and implementation of integral watershed management plans, environmental zoning and land-use planning as basic instruments of the planning system. A6 Institutional strengthening at all levels for integrated management of natural resources and the environment. A7 Strengthening and/or development of economic instruments and financing mechanisms.
B	Environmental prevention, protection and rehabilitation	B1 Protection of biodiversity and the natural heritage. B2 Strengthening and consolidation of the system of protected areas in the basin. B3 Implementation of mitigation plans for flooding and other climatic disasters. B4 Prevention, pollution control and environmental cleanup of watercourses. B5 Prevention and control of erosion and sedimentation
C	Sustainable development of natural resources	C1 Development and implementation of integral watershed management plans. C2 Implementation of sustainable management programs for natural resources of watersheds at basin level C3 Development, validation and application of appropriate technologies, management practices and sustainable productive models. C4 Implementation of a project for the use and sustainable exploitation of water resources. C5 Research into the management and exploitation of natural resources
D	Public awareness and participation	D1 Strengthening public participation in the planning and implementation of development activities and the management of natural resources. D2 Environmental education and training programs for civil society. D3 Dissemination of sustainable production technologies. D4 Public dissemination of information in support of decision-making processes

TABLE Nº 12: PRIORITY ENVIRONMENTAL PROBLEMS, CAUSES [17] AND STRATEGIC ACTIONS

	ENVIRONMENTAL PROBLEMS	EFFECTS AND SYMPTOMS	DIRECT CAUSES	BASIC CAUSES	STRATEGIC ACTIONS (+)
I	Soil degradation. Intense erosion and desertification processes	• High sediment content in surface waters. • Silting up of reservoirs. • Increased salinization. • Reduced productive capacity of soils. Reduced organic matter. • Reduced farming and livestock productivity. • Loss of productive areas. • Increase in areas affected by erosion and desertification. • Lower water retention capacity.	• Adverse natural characteristics: susceptibility of soils to erosion, torrential rains concentrated in a few months, topography with sharp slopes and geomorphological instability. • Destruction of vegetation cover by overgrazing and deforestation. • Destruction of natural vegetation through occupation of land for agricultural purposes (clear-cutting and slash and burn).	**Specific Basic Causes**. • Improper use of soil without considering its suitability. • Unsustainable forestry and sylvopastoral practices. **Common Basic Causes** (*see list at end of Table)	DSA: b5, c1, c2, b1, c3,d3, CSA: a1, a2, a3, a4, a5, a6,a7, a8, d1, d2, d4 ISA: b2, c4, c5
II	Water scarcity and availability restrictions	• General shortage of water during dry periods, both for human consumption and for farming and livestock use. • Reduced area under irrigation. • Low levels of output and productivity.	• Pronounced seasonality of rainfall from east to west, concentrated in a few months of the year. • Reduced flows during the dry season. • High sediment content in	**Specific Basic Causes**. • Inefficient exploitation of water resources. Low use of existing potential. Inadequate infrastructure for regulation, irrigation and drinking water. • Limited awareness of the	DSA: c4, c1, c2, b5 CSA: a1, a2, a3, a4, a5, a6,a7, a8,d1, d2, d4

17 **Common Basic Causes:** resulting from the political, institutional, social and economic structure as the common root or origin of the problems identified.
Specific Basic Causes:: identifies specific or particular manifestations of Basic Causes applied to the problem, those that are most significant or that are part of the complex network of causal relations
Direct Causes: directly or finally responsible, emerging from a complex system of underlying factors

TABLE Nº 12: PRIORITY ENVIRONMENTAL PROBLEMS, CAUSES [17] AND STRATEGIC ACTIONS

	ENVIRONMENTAL PROBLEMS	EFFECTS AND SYMPTOMS	DIRECT CAUSES	BASIC CAUSES	STRATEGIC ACTIONS (+)
		• Seasonal employment for farm labor. • High percentage of population without access to drinking water. • Health problems. • Conflicts over uncontrolled water use in the dry season. • Limitations on water use in the rainy season.	the Bermejo River. • High fluviomorphological dynamics. • Exhaustion of aquifers. • Heavily celebrated areas. • High salts content in the underground waters in certain portions of the basin. • Relief limitations. • Inadequate hydrological infrastructure.	supply and potential of surface and underground waters. • Inadequate financial resources for implementing existing water supply projects for irrigation and other uses. • Inadequate legal and institutional framework for managing water resources **Common Basic Causes (*)**	ISA: b4, c5
III	Degradation of water quality	• High levels of organic, bacterial, chemical and probably agro-chemical pollution in certain stretches of the basin's rivers. • High sediment content in watercourses of the basin. • Increased salinity. • Destruction of habitat for aquatic flora and fauna. • Fish mortality. • Presence of infectious diseases from consumption of contaminated water and foods. • Limitations on water use	• Soil degradation and erosion. • Dumping of raw or semi-treated sewage from population centers directly into watercourses. • Industrial pollution in certain stretches of rivers. • Pollution caused by improper livestock and farming management	**Specific Basic Causes**. • Inadequate or unenforced pollution control standards. • Inadequate sanitation infrastructure. • Financial weakness of institutions responsible for administering sanitary sewer systems. • Inadequate health education and awareness among the community. • Inadequate information on water quality **Common Basic Causes** (*)	DSA: b4, b5 CSA: a1, a2, a3, a4, a5, a6,a7, a8, d1, d2, d4 ISA: b1, b2, c1, c2, c3, d3

TABLE Nº 12: PRIORITY ENVIRONMENTAL PROBLEMS, CAUSES [17] AND STRATEGIC ACTIONS

	ENVIRONMENTAL PROBLEMS	EFFECTS AND SYMPTOMS	DIRECT CAUSES	BASIC CAUSES	STRATEGIC ACTIONS (+)
IV	Destruction of habitats, loss of biodiversity and deterioration of biotic resources	• Changed dynamics of wildlife populations and their area of distribution and development. • Reduced populations of wildlife (flora and fauna). • Reduced biological properties of soils, restricting their use for farming and livestock. • Loss of natural scenic beauty. • Increase in invasive woody vegetation.	• Deforestation of native woodlands. • Uncontrolled and indiscriminate hunting and fishing. • Uncontrolled increase in forested areas cleared for agriculture. • Farming and forestry practices such as clear-cutting, slash and burn,	**Specific Basic Causes**. • Lack of land-use planning. • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Lack of biodiversity management plans. • Weakness in the management and administration of protected	DSA: b1, b2, c5, c3, b4, d3 CSA: a1, a2, a3, a4, a5, a6,a7, a8, d1, d2, d4 ISA: c1, c2

[18] See causal relation corresponding to Problem III

TABLE Nº 12: PRIORITY ENVIRONMENTAL PROBLEMS, CAUSES [17] AND STRATEGIC ACTIONS

	ENVIRONMENTAL PROBLEMS	EFFECTS AND SYMPTOMS	DIRECT CAUSES	BASIC CAUSES	STRATEGIC ACTIONS (+)
		• Increase in domestic clearings. • Impoverished structure and composition of species and functions of forests and pasture lands. • Fish mortality. • Loss of wetlands.	planting on slopes, etc. • Overgrazing. • Increase in water pollution[18]	areas. • Unsustainable Farming, forestry and sylvopastoral practices. I • Inadequate understanding of native flora and fauna. **Common Basic Causes** (*)	
V	Conflicts arising from flooding and other natural disasters	• Loss of human life and population displaced by flooding, in both urban and rural areas. • Losses in productive activities from flooding, drought, frost and hail. • Losses from deterioration of infrastructure and rural and urban facilities. • Chronic indebtedness of producers	• Exceptional climatic phenomena. • Extraordinary flood crests on rivers. • Use of flood-prone areas for urban expansion. • Extension of farming to unsuitable areas. • Destruction of vegetation cover along shorelines and at the headwaters of rivers and creeks	**Specific Basic Causes**. • Unplanned and uncontrolled urban and rural development. • Limited control and protection infrastructure, both in rural and urban areas. • Lack of integral watershed management plans. • Lack or inadequate application of emergency plans for natural disasters. **Common Basic Causes (*)**	DSA: b3, c1 CSA: a1, a2, a3, a4, a5, a6,a7, a8, d1, d2, d4 ISA: c2, c4, c3, c5 0
VI	Deteriorating living conditions and loss of cultural resources	• Low indices of human development. High percentages with Unmet Basic Needs (UBN). • Presence of endemic diseases and increased numbers of people at health risk. • Presence of poverty and extreme poverty among broad sectors of the population.	• Seasonal unemployment and under-employment. • Inadequate income levels. • Inadequate access to health, sanitation and education services	**Specific Basic Causes**. • Inadequate production support infrastructure (irrigation, roads, electricity etc.). • Inadequate infrastructure for sanitation and water supply. • Limited and deteriorated natural resources: soils, water	DSA: c4, b4, c3 CSA: a1, a2, a3, a4, a5, a6,a7, a8, d1, d2, d4 ISA: b1, c1, c2, d3, b3

TABLE Nº 12: PRIORITY ENVIRONMENTAL PROBLEMS, CAUSES [17] AND STRATEGIC ACTIONS

	ENVIRONMENTAL PROBLEMS	EFFECTS AND SYMPTOMS	DIRECT CAUSES	BASIC CAUSES	STRATEGIC ACTIONS (+)
		Low capacity for self-management. Decline in traditional cultural values and education		and vegetation. • Inadequate appreciation of the region's national natural potential. **Common Basic Causes**. (*)	

(*)Common Basic Causes:
1. Inadequate political, legal and institutional framework
2. Inadequate planning and coordination within and between jurisdictions.
3. Inadequate awareness, commitment and participation by the community and failure to promote such participation.
4. Inadequate financing and support mechanisms.
5. Inadequate access to and use of sustainable technologies

(+)
DSA: Direct Strategic Actions (directly related to the problem and its basic causes)
CSA: Common Strategic Action (common to all problems and basic causes)
ISA: Indirect Strategic Action (related indirectly to the problem and its basic causes).

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS

AREA OF ACTION	**A. INSTITUTIONAL DEVELOPMENT AND STRENGTHENING FOR INTEGRATED PLANNING AND MANAGEMENT OF THE BASIC**		
STRATEGIC ACTION	**PRIORITY FOCUS**	**DIAGNOSTIC CONCEPTS UNDERLYING THE STRATEGIC ACTION AND GUIDING PRIORITY ACTIONS**	**BASIC CAUSES ADDRESSED**
A1 Upgrading and strengthening of the Binational Commission as a basin-wide agency for the integrated and sustainable management of water resources in the Bermejo River basin.	The entire basin	The fact that the Argentine provinces and the department of Tarija and its municipalities have original or delegated ownership over natural resources means that they can and must take the lead in policy-making for the basin. Integrated management for the basin as a whole requires regional agreement on regulatory frameworks governing the quality and use of shared resources, the implementation of mechanisms for coordination, programming and control, and for participation by other stakeholders, which do not now exist but for which there is broad demand. What is needed is progressively to institutionalize these functions and others at the binational level and in each country, so as to overcome the functional limitations of the existing binational and Argentine bodies.	**Common Basic Causes: 1, 2 y 3** **Specific Basic Causes** • Inefficient exploitation of water resources. Low use of existing potential.. • Inadequate legal and institutional framework for managing water resources • Inadequate or unenforced pollution control standards • Lack of land-use planning • Lack of integral watershed management plans
A2 Development, harmonization and application	The entire basin, as a management unit, and the various	There are gaps in the inter-jurisdictional legal framework that governs aspects relating to the quantity, quality and use of shared water resources and other natural resources of interest, at the binational level and between the various jurisdictions within	**Common Basic Cause 1** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inadequate legal and institutional framework for managing water resources

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS

of a legislative framework for sustainable use and conservation of natural resources	jurisdictions.	Argentina. There are also asymmetries between these jurisdictions and in many cases a lack of rules governing the use and protection of natural resources (illegal hunting, trafficking in protected species, forest exploitation, deforestation, environmental impact assessment, water quality, pollution, land-use, etc.).	• Inadequate or unenforced pollution control standards • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Weakness in the management and administration of protected areas. • Unplanned and uncontrolled urban and rural development • Lack of integral watershed management plans
A3 Instrumentation of effective mechanisms for sectoral and jurisdictional coordination and articulation.	The entire basin, as a management unit, and the various jurisdictions	Through public consultation and participation it was found that there is a lack of communication and articulation among government agencies responsible for management of water and other natural resources, scientific and technological institutions, producers' organizations, NGOs and civil society in general, both between different jurisdictions and within the same jurisdiction.	**Common Basic Cause: 3** **Specific Basic Causes** • Inefficient exploitation of water resources. Low use of existing potential. • Inadequate legal and institutional framework for managing water resources • Inadequate or unenforced pollution control standards. • Lack of land-use planning • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Lack or inadequate application of emergency plans for natural disasters..
A4. Implementation and strengthening of an environmental information system for	The entire basin, as a management unit, and the various jurisdictions	Both countries and their various jurisdictions are making efforts to gather and process basic information on water, other natural resources and environmental indicators (bio-geophysical and social), at different levels of coverage and with varying degrees of technical, operating and institutional capacity. This information is being gathered at the basin level to some extent (by COREBE in Argentina), but steps	**Common Basic Causes; 1, 2 y 3** **Specific Basic Causes** • Limited awareness of the supply and potential of surface and underground waters • Inadequate information system on water quality • Inadequate understanding of native flora and fauna. • Inadequate appreciation of the region's natural potential

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS

the basin		are needed to improve and strengthen these systems and to compile the sectoral and jurisdictional data for purposes of integrated management.	
A5 Formulation and implementation of integral watershed management plans, environmental zoning and land-use planning as basic instruments of the planning system	The entire basin, as a management unit, and the various jurisdictions	There are significant shortcomings in terms both of sectoral and comprehensive planning, within each jurisdiction and for the basin as a whole. Many problems stemming from improper natural resource management (overuse, erosion, desertification, deforestation) and the occupation of unsuitable land (flooding, expansion of the agricultural frontier) betray a lack of knowledge of the environment's capacities and limitations for supporting human activities, and the lack of land-use planning to guide responsible agencies in their decisions. The lack of planning and a proper regulatory framework is critical when it comes to the basin's shared water resources. Water development projects are now undertaken from a strictly sectoral or local focus, without proper regard for other natural resources. The basin's hydrological variability and the massive transport of sediments place severe restrictions on the use of resources and make that use heavily dependent on other resources, particularly the soil and its vegetation. The regulatory framework must be based on agreed criteria for making equitable and sustainable of use of	**Common Basic Causes: 1, 2. 3, 4 y 5** **Specific Basic Causes** ▪ Improper use of soil without considering its suitability ▪ Inefficient exploitation of water resources. Low use of existing potential. ▪ Inadequate infrastructure for regulation, irrigation and drinking water ▪ Inadequate or unenforced pollution control standards. ▪ Inadequate information system on water quality ▪ Lack of land-use planning ▪ Lack of biodiversity management plans ▪ Weakness in the management and administration of protected areas. ▪ Unplanned and uncontrolled urban and rural development ▪ Lack of integral watershed management plans ▪ Lack or inadequate application of emergency plans for natural disasters. ▪ Inadequate appreciation of the region's natural potential ▪ Inadequate production support infrastructure (irrigation, roads, electricity etc.). ▪ Inadequate infrastructure for sanitation and water supply

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS

		resources, now and in the future	
A6 Institutional strengthening at all levels for integrated management of natural resources and the environment	The various jurisdictions	The organizations responsible for management and control of water and natural resources have shortcomings in terms of the human and technological resources needed for planning and for integrated management of the resource, including the need for multi- and interdisciplinary articulation with other sectors. This is a severe constraint on attempts to foster integrated management of the basin.	**Common Basic Causes: 1, 2, 4 y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inadequate financial resources for implementing existing water supply projects for irrigation and other uses. • Inadequate legal and institutional framework for managing water resources • Inadequate or unenforced pollution control standards • Lack of land-use planning • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Weakness in the management and administration of protected areas. • Lack of integral watershed management plans • Inadequate appreciation of the region's natural potential
a.7. Strengthening or development of economic instruments and financing mechanisms	The entire basin, as a management unit, and the various jurisdictions	Financial constraints have a decisive impact on water development projects and on water management activities. The former need to show clearly that they can meet the criteria of sustainability, which means that environmental and social considerations, in economic terms, must be incorporated in project planning, evaluation and decisions. In terms of management, genuine sources of funding must be designed, based on a proper economic assessment of water use and preservation and on suitable mechanisms for allocating that funding.	**Common Basic Causes: 1 y 4** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inadequate financial resources for implementing existing water supply projects for irrigation and other uses • Inadequate production support infrastructure (irrigation, roads, electricity etc.). • Inadequate infrastructure for sanitation and water supply • Financial weakness of institutions responsible for administering sanitary sewer systems.

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
AREA OF ACTION	**B. ENVIRONMENTAL PREVENTION, PROTECTION AND REHABILITATION**		
STRATEGIC ACTION	**PRIORITY FOCUS**	**DIAGNOSTIC CONCEPTS UNDERLYING THE STRATEGIC ACTION AND GUIDING PRIORITY ACTIONS**	**BASIC CAUSES ADDRESSED**
B1 Protection of biodiversity and the natural heritage	Primarily in the Large Units: I.1.1,. I.2.1, I.2.2, II.1.8, II.2.6, II.3.9, II.1.4, II.1.6, II.2.4	The intensive production and transport of sediments depends heavily on hydrological variability and on hydrogeological instability, vegetation cover and soil conditions in the Bermejo River basin, particularly in the upper basin. Habitat degradation and loss of biodiversity is closely related to those conditions, and protective measures must embrace them all. While human influence is minimal in the most active sediment producing areas, except for special cases such as the Valle de Tarija in Bolivia and the Quebrada de Humahuaca in Argentina, the natural instability of the landscape means that extensive areas of the Eastern Andes and Sub Andean will shift from potential to active sediment producers, thereby aggravating transboundary problems, if preventive measures are not taken.	**Common Basic Causes 1, 2, 3, 4 y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Unsustainable forestry and sylvopastoral practices.. • Lack of land-use planning • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Lack of biodiversity management plans • Weakness in the management and administration of protected areas. • Inadequate understanding of native flora and fauna. • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential
B2 Strengthenin g and	Primarily in the Large	For this reason, the system of protected natural areas must be reinforced and consolidated, particularly in the montane	**Common Basic Causes: 1, 2, 4 y 5** **Specific Basic Causes**

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consolidation of the system of protected areas in the basin	Units: I.1.1, I.2.1, I.2.2, II.1.2, II.1.3, II.2.1, II.2.2	rainforest, and measures must be adopted to protect the natural heritage, not only because they will help to preserve habitat and biodiversity, but because they are effective means for integrated management of water resources	• Improper use of soil without considering its suitability • Lack of land-use planning • Lack of biodiversity management plans • Weakness in the management and administration of protected areas. • Inadequate understanding of native flora and fauna. • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential
B3 Implementation of mitigation plans for flooding and other climatic disasters	Primarily in the Large Units: I.1.1, I.2.1, II.3.3, III.2.1, III.2.2, III.2.3, IV.1.1, V.3.1	Urban areas along the Guadalquivir river system in Tarija and rural and peri-urban areas in the lower Bermejo basin are critical zones in terms of massive inundation from overflowing rivers, as well as local flooding resulting from poor drainage. The economic, environmental and social risks arising from the situation must be mitigated by measures of prevention and control.	**Common Basic Causes: 1, 2, 3, 4 y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inadequate legal and institutional framework for managing water resources • Inadequate or unenforced pollution control standards • Lack of land-use planning • Unplanned and uncontrolled urban and rural development • Limited control and protection infrastructure, both in rural and urban areas. • Lack of integral watershed management plans. • Lack or inadequate application of emergency plans for natural disasters
B4 Prevention, pollution control and environmenta	Primarily in the Large Units: I.1.1, I.1.2, I.2.2,	While the problem is not yet widespread in the region, certain stretches of the river system show growing evidence of domestic and industrial pollution, with a transboundary impact. The affected areas must be	**Common Basic Causes: 1, 2, 4, y 5** 0 **Specific Basic Causes** • Inefficient exploitation of water resources. Inadequate infrastructure for drinking water

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l cleanup of watercourses	I.2.3, II.2.2, IV.3.1, IV.1.1, V.1.2	restored by environmental cleanup measures, and preventive action must be taken in terms of monitoring and strengthening the regional and jurisdictional regulatory framework.	• Limited awareness of the supply and potential of surface and underground waters • Inadequate legal and institutional framework for managing water resources • Inadequate or unenforced pollution control standards • Inadequate infrastructure for sanitation and water supply • Financial weakness of institutions responsible for administering sanitary sewer systems • Inadequate health education and awareness among the community. • Inadequate information system on water quality • Unplanned and uncontrolled urban and rural development • Inadequate infrastructure for sanitation and water supply
B5 Prevention and control of erosion and sedimentation	Primarily in the Large Units: I.1.1, I.1.2, I.2.1, I.2.2, I.2.3, I.3.2, I.1.9, I.1.5	Sediment production and transport is intense in the upper Bermejo basin, and is strongly influenced by natural conditions. In the Valle de Tarija and in parts of the Quebrada de Humahuaca, where the phenomenon is particularly active, it has a negative impact on economic activity related to water use. These areas will benefit most from measures to control erosion and protect watersheds and so limit the production and transport of sediments. In regional terms, environmental and land-use regulations are required, as well as measures to	**Common Basic Causes: 1, 2, 4, y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Unsustainable forestry and sylvopastoral practices. • Inefficient exploitation of water resources. • Inadequate legal and institutional framework for managing water resources • Lack of land-use planning • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Limited control and protection infrastructure, both in rural and urban areas.

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		control extensive farming practices, in order to preserve the natural conditions of the soil and vegetation cover in broad areas of potentially active erosion. A regional planning framework is needed for undertaking these measures of control and prevention.	• Lack of integral watershed management plans • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
AREA OF ACTION	**C. SUSTAINABLE DEVELOPMENT OF NATURAL RESOURCES**		
STRATEGIC ACTION	**PRIORITY FOCUS**	**DIAGNOSTIC CONCEPTS UNDERLYING THE STRATEGIC ACTION AND GUIDING PRIORITY ACTIONS**	**BASIC CAUSES ADDRESSED**
C1 Development and implementation of integral watershed management plans.	Primarily in the Large Units: I.1.1, I.1.2, II.1.3, II.2.1, I.3.1, I.3.2, I.1.4, I.1.6, I.1.5, I.1.9	The development of water resources within a framework of integrated and sustainable water management is a policy imperative in a region characterized by severe water shortages and social and economic problems. Planning this management at the subbasin and micro-basin level will form the basis of a regional approach to integrated management. Successful experiments undertaken in the basin and in other parts of the world must be extended to other units in areas identified as critical.	**Common Basic Causes: 1, 2 y 4** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inefficient exploitation of water resources. Low use of existing potential. • Limited awareness of the supply and potential of surface and underground waters • Inadequate legal and institutional framework for managing water resources • Inadequate or unenforced pollution control standards • Inadequate information system on water quality • Lack of land-use planning • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Weakness in the management and administration of protected areas • Unsustainable farming, forestry and sylvopastoral practices • Lack of integral watershed management plans • Lack or inadequate application of emergency plans for natural disasters. • Inadequate appreciation of the region's natural potential
C2	All of Eco-	A sound approach to management of soils	**Common Basic Causes: 1, 2, 3, 4, y 5**

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
Implementation of sustainable natural resource management programs	region II (Subandino), primarily in the Large Units II.1.2, II.1.3, II.2.1. All of Eco-regions IV (Subhúmid Chaco) and V (Húmid Chaco)	and forests within a nature conservation framework is a necessary and effective response to reducing transboundary problems from sediment transport and mitigating negative impacts on potentially active areas that are still in a relatively natural state. Management experiences should focus on the critical areas, addressing local issues and assessing their benefits in terms of water management at the micro or subbasin level, and for the region as a whole.	**Specific Basic Causes** • Improper use of soil without considering its suitability • Unsustainable forestry and sylvopastoral practices. • Inefficient exploitation of water resources. Low use of existing potential. • Limited awareness of the supply and potential of surface and underground waters • Inadequate financial resources for implementing existing water supply projects for irrigation and other uses • Lack of land-use planning • Lack of biodiversity management plans • Weakness in the management and administration of protected areas • Unsustainable farming, forestry and sylvopastoral practices • Unplanned and uncontrolled urban and rural development • Lack of integrated watershed management plans. • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
C3 Development, validation and application of appropriate technologies, management practices and sustainable productive models	The entire basin, as a management unit, and the various jurisdictions	Technological constraints have been identified as a common basic cause of environmental problems that must be resolved. The project has helped in this respect by developing pilot activities for demonstrating sustainable management practices that can be applied generally to other similar areas. This approach must be broadened and extended, focusing efforts on areas identified as critical, and building on other experiments within and beyond the basin, seeking the broadest extension of technologies validated for each ecological Subregion or Large Ecological Unit, and encouraging producers to participate actively.	**Common Basic Causes: 1, 2, 3, 4, y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Unsustainable forestry and sylvopastoral practices. • Inefficient exploitation of water resources. Low use of existing potential. Inadequate infrastructure for regulation, irrigation and drinking water • Limited awareness of the supply and potential of surface and underground waters • Inadequate financial resources for implementing existing water supply projects for irrigation and other uses • Unsustainable farming, forestry and sylvopastoral practices • Lack of land-use planning • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Lack of biodiversity management plans • Unsustainable farming, forestry and sylvopastoral practices • Unplanned and uncontrolled urban and rural development • Lack of integrated watershed management plans • Inadequate production support infrastructure (irrigation, roads, electricity etc.). • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential
C4 Implementati	The entire basin, as a	Use of the region's water resources has been limited by severe constraints on their	**Common Basic Causes: 1, 2, 3, 4, y 5**

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on of projects for the use and sustainable exploitation of water resources	manageme nt unit, and the various jurisdictions	availability, including quality problems caused by the transport of sediments and other pollutants. Infrastructure works (reservoirs, diversion dykes, irrigation and drainage systems) for regulating flows and putting the water to economic and social use are key tools for the basin's future development. The essential issues here are financial limitations, environmental and social concerns, and the development of an informed decision-making process to ensure the sustainability of such efforts.	**Specific Basic Causes** • Inefficient exploitation of water resources. Low use of existing potential. Inadequate infrastructure for regulation, irrigation and drinking water • Inadequate financial resources for implementing existing water supply projects for irrigation and other uses • Inadequate sanitation insufficient • Inadequate health education and awareness among the community. • Inadequate information system on water quality • Limited control and protection infrastr4ucture, in both rural and urban areas • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential
C5 Research into the management and exploitation of natural resources	The entire basin, as a manageme nt unit, and the various jurisdictions	Studies undertaken during the project have substantially improved our understanding of natural phenomena and of the functional relationships between human activity and natural ecosystems. Yet further research is required to close the gap between the large-scale regional focus and specific local experience, as the basis for defining policies, planning activities and strengthening the participatory decision-making process. The analytical basis that provides technical support for other strategic actions must also be expanded. This will involve a multidisciplinary and multi-sectoral	**Common Basic Causes: 1, 2, 4, y 5** **Specific Basic Causes** • Unsustainable farming, forestry and sylvopastoral practices. • Inefficient exploitation of water resources. Low use of existing potential. • Lack of biodiversity management plans • Unsustainable farming, forestry and sylvopastoral practices • Inadequate understanding of native flora and fauna. • Unsustainable farming, forestry and sylvopastoral practices • Inadequate understanding of native flora and fauna. • Inadequate appreciation of the region's natural potential

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
		approach.	

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
AREA OF ACTION	**D. PUBLIC AWARENESS AND PARTICIPATION**		
STRATEGIC ACTION	**PRIORITY FOCUS**	**DIAGNOSTIC CONCEPTS UNDERLYING THE STRATEGIC ACTION AND GUIDING PRIORITY ACTIONS**	**BASIC CAUSES ADDRESSED**
D1 Strengthening public participation in the planning and implementation of development activities and the management of natural resources	The entire basin, as a management unit, and the various jurisdictions	The project found that public participation was at its early stages in the Argentine portion of the basin, and was still insufficient in the Bolivian portion. It has also encouraged the development of participatory mechanisms at the government, non-government and local community level, with varying degrees of success. The lack of participation must be addressed gradually but as a priority, in order to ensure informed decision-making that will result in sustainable actions. The geographic scope and diversity of regions and jurisdictions within the basin is a particular challenge to institutionalizing such mechanisms.	**Common Basic Causes: 1, 2, 3, y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inefficient exploitation of water resources. Low use of existing potential. • Inadequate or unenforced pollution control standards • Inadequate health education and awareness among the community • Weakness in the management and administration of protected areas • Unsustainable farming, forestry and sylvopastoral practices • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Weakness in the management and administration of protected areas • Unplanned and uncontrolled urban and rural development • Lack of integrated watershed management plans • Lack or inadequate application of emergency plans for natural disasters. • Inadequate appreciation of the region's natural potential

Table Nº 13: STRATEGIC ACTIONS AND THEIR UNDERLYING CONCEPTS FROM THE TRANSBOUNDARY DIAGNOSIS AND BASIC CAUSES			
D2 Environmental education and training programs for civil society	The entire basin, as a management unit, and the various jurisdictions	The basin's communities and their leaders lack a proper perception and appreciation of the local, regional and basin-wide environmental consequences and interrelationships of development activities. This affects decision-making processes (projects for dams, gas pipelines, transmission lines, commercial agriculture) and distorts participation, in cases where channels have been opened (SAP regional workshops). The rational use of water and natural resources as an instrument of development is also lacking in the basin.	**Common Basic Causes: 1, 3 y 4** **Specific Basic Causes** • Improper use of soil without considering its suitability • Inefficient exploitation of water resources. • Inadequate health education and awareness among the community • Inadequate information system on water quality • Rules governing protection and use of soils, water, flora and fauna are inadequately applied and harmonized. • Unsustainable farming, forestry and sylvopastoral practices. • Weakness in the management and administration of protected areas • Unplanned and uncontrolled urban and rural development • Lack of integrated watershed management plans. • Lack or inadequate application of emergency plans for natural disasters. • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential
D3 Dissemination of sustainable production technologies	The entire basin, as a management unit, and the various	In many parts of the basin and even beyond its borders, appropriate management technologies and practices have been developed and tried out. They have been supported by research and development agencies (INTA, in Argentina, universities), producer organizations and economic and social development programs active within the basin. The scope and diversity of regions	**Common Basic Causes: 1, 2, 3, 4, y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Unsustainable forestry and sylvopastoral practices. • Inefficient exploitation of water resources. Low use of existing potential. Inadequate infrastructure for regulation, irrigation and drinking water • Rules governing protection and use of soils, water, flora

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	jurisdictions	and their institutional fragmentation make it difficult to give broad dissemination to experiences, lessons learned and cost-effective solutions, within the basin and across borders. The basin in fact can offer examples of sound practices for controlling the production and transport of sediments, suitable farming methods, joint management of water and soils in areas of water shortage or surplus.	and fauna are inadequately applied and harmonized. • Unsustainable farming, forestry and sylvopastoral practices • Unplanned and uncontrolled urban and rural development • Lack of integrated watershed management plans
D4 Public dissemination of information in support of decision-making processes	The entire basin, as a management unit, and the various jurisdictions	Channels of communication and community access to information are inadequate. In addition, there is a chronic lack of basic and specialized information on the status and use of natural resources, ecological processes and socioeconomic indicators. The lack of aggregate information for the region as a whole makes it difficult to instill an overall vision of the basin and to inspire people to commit themselves and to participate actively as responsible partners. It also prevents the many national and subnational agencies active in the basin from coordinating their programs effectively.	**Common Basic Causes: 1, 2, 3, 4, y 5** **Specific Basic Causes** • Improper use of soil without considering its suitability • Unsustainable agro-sylvopastoral practices. • Inefficient exploitation of water resources. Low use of existing potential.. • Limited awareness of the supply and potential of surface and underground waters • Inadequate health education and awareness among the community • Inadequate information system on water quality • Inadequate understanding of native flora and fauna. • Lack or inadequate application of emergency plans for natural disasters. • Limited and deteriorated natural resources: soils, water and vegetation • Inadequate appreciation of the region's natural potential

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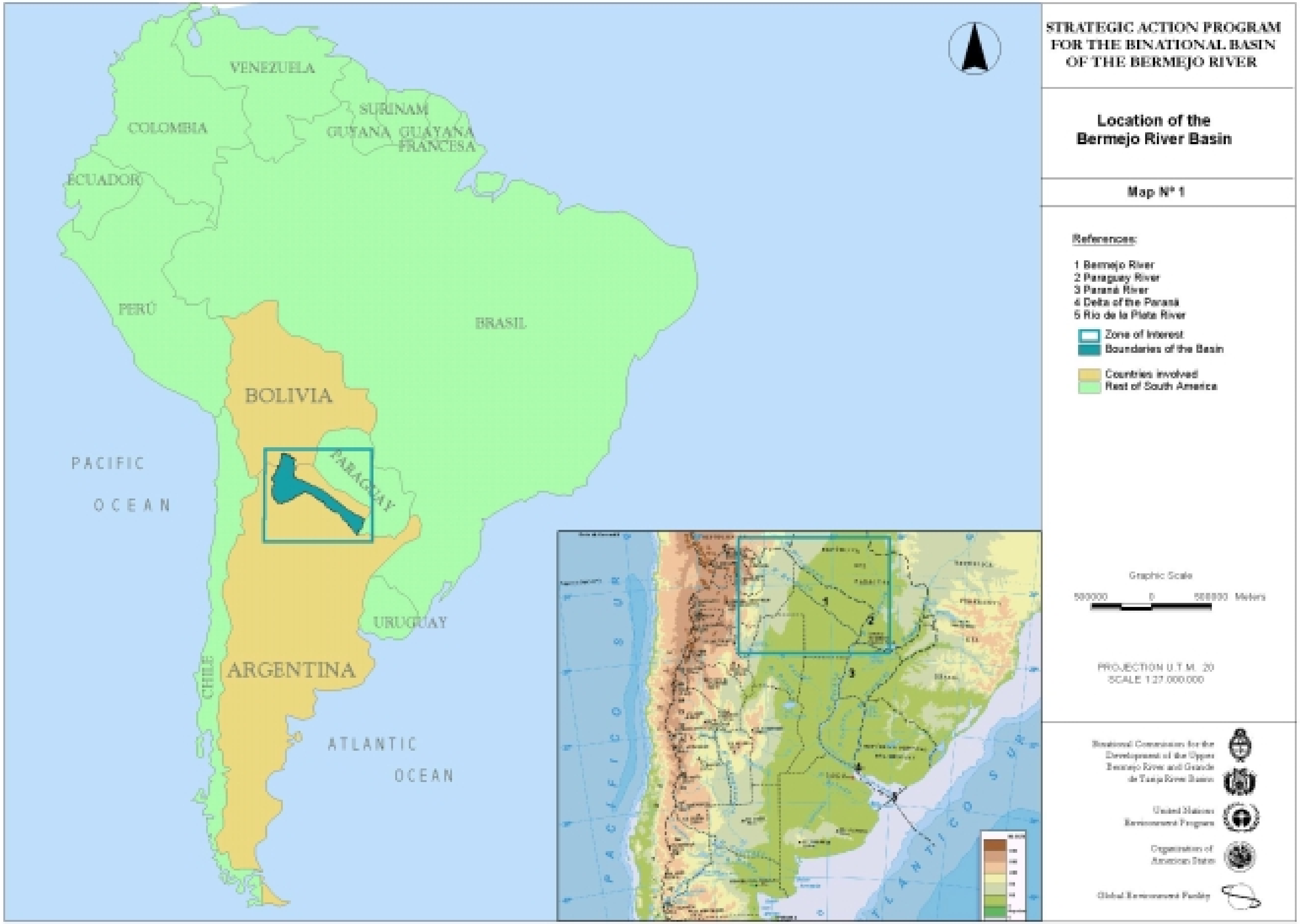
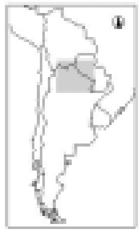

STRATEGIC ACTION PROGRAM
FOR THE BINATIONAL BASIN
OF THE BERMEJO RIVER
Location of the
Bermejo River Basin
Map N° 1
References:
1 Bermejo River
2 Paraguay River
3 Paraná River
4 Delta of the Paraná
5 Río de la Plata River
Zone of Interest
Boundaries of the Basin
Countries involved
Rest of South America
Graphic Scale
500000
0
500000
Meters
PROJECTION U.T.M. 20
SCALE 1:27.000.000
Binational Commission for the
Development of the Upper
Bermejo River and Grande
de Tarija River Basins
United Nations
Environment Program
Organization of
American States
Global Environment Facility
VENEZUELA
SURINAM
COLOMBIA
GUYANA
GUAYANA
FRANCESA
ECUADOR
PERÚ
BRASIL
BOLIVIA
PARAGUAY
PACIFIC
OCEAN
URUGUAY
CHILE
ARGENTINA
ATLANTIC
OCEAN

STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER

The Bermejo River Basin Region

Map N° 2



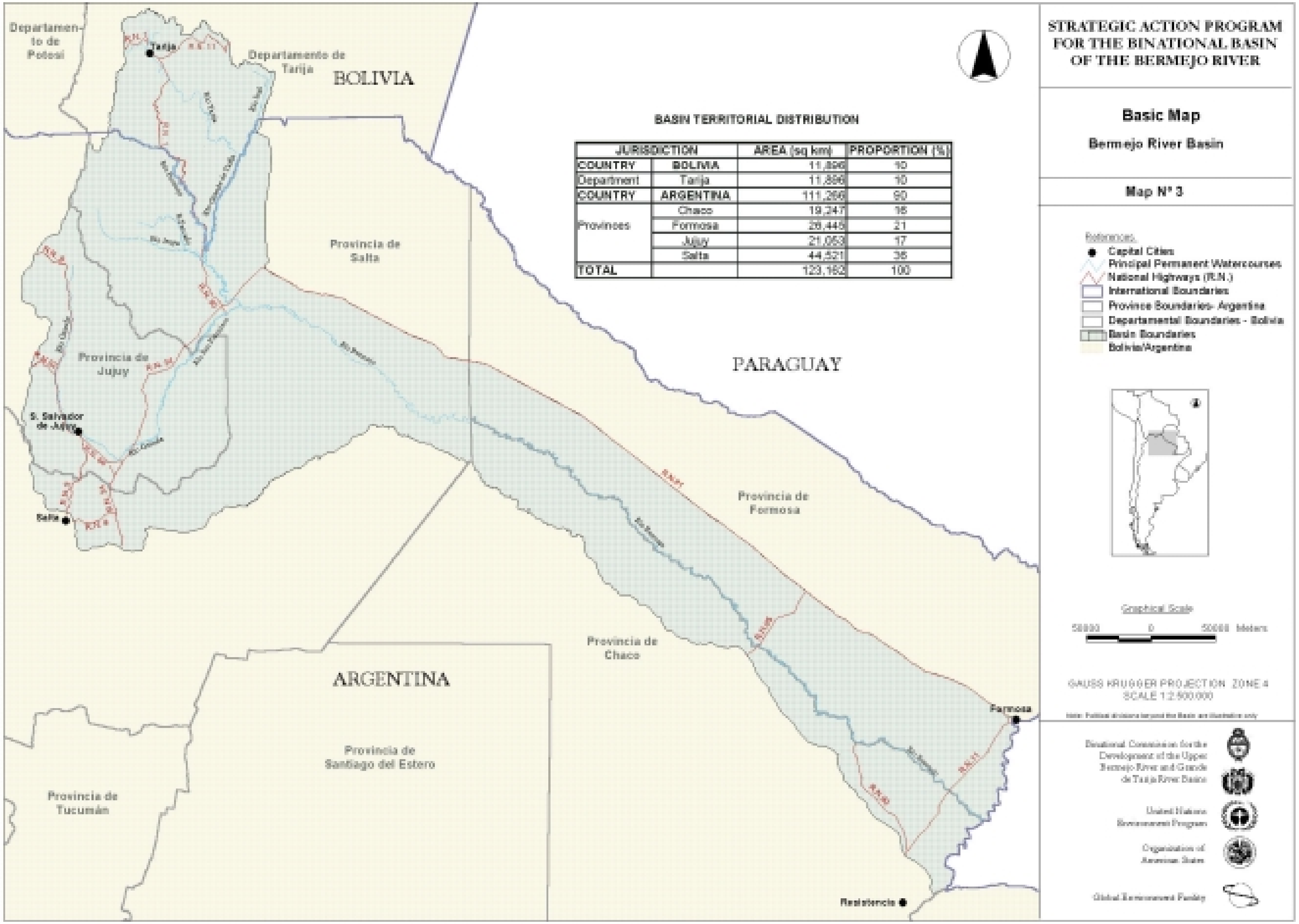
Source: World Atlas 99 Encarta. Microsoft

Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija Basins

United Nations Environment Program

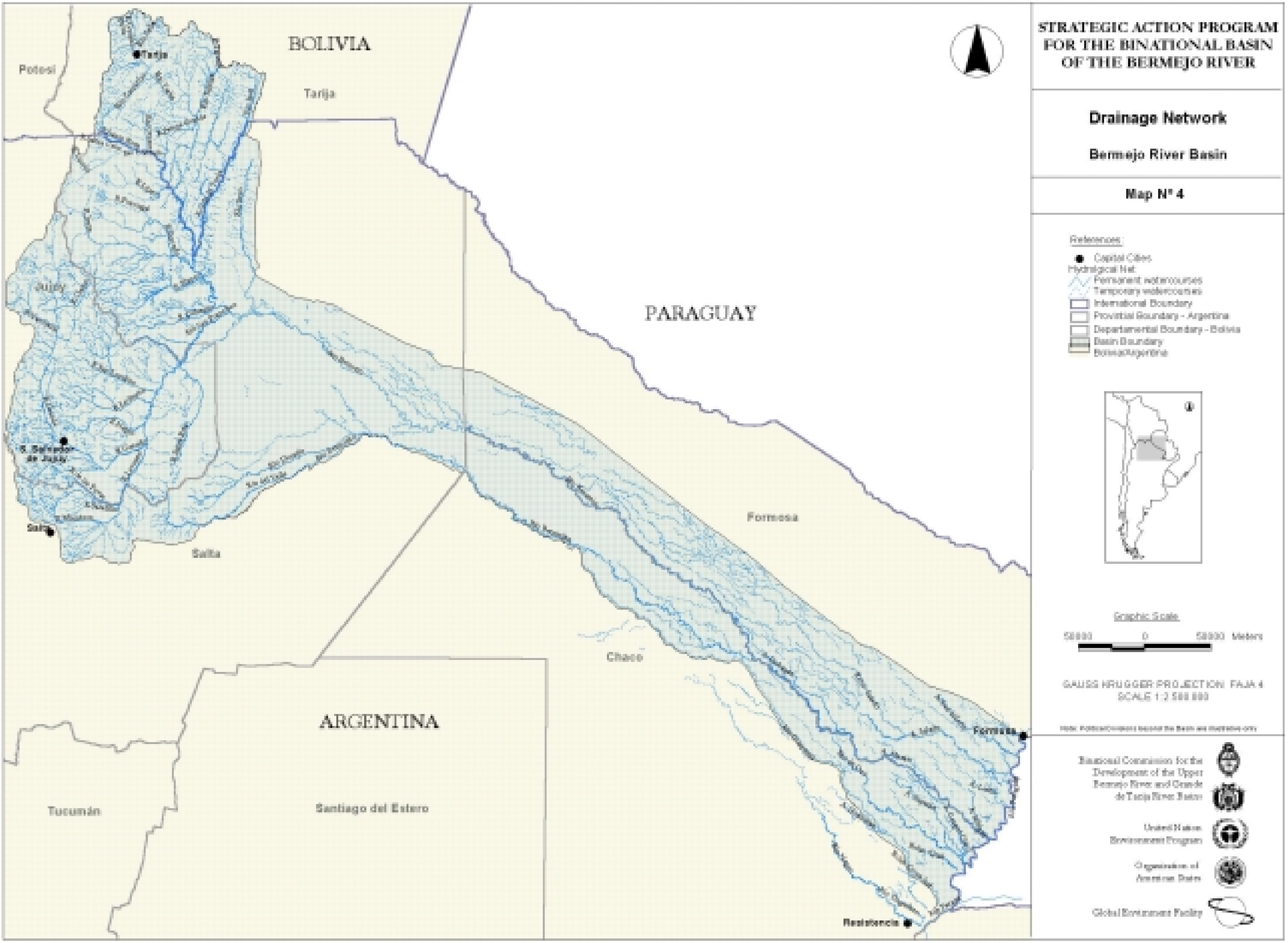
Organization of American States

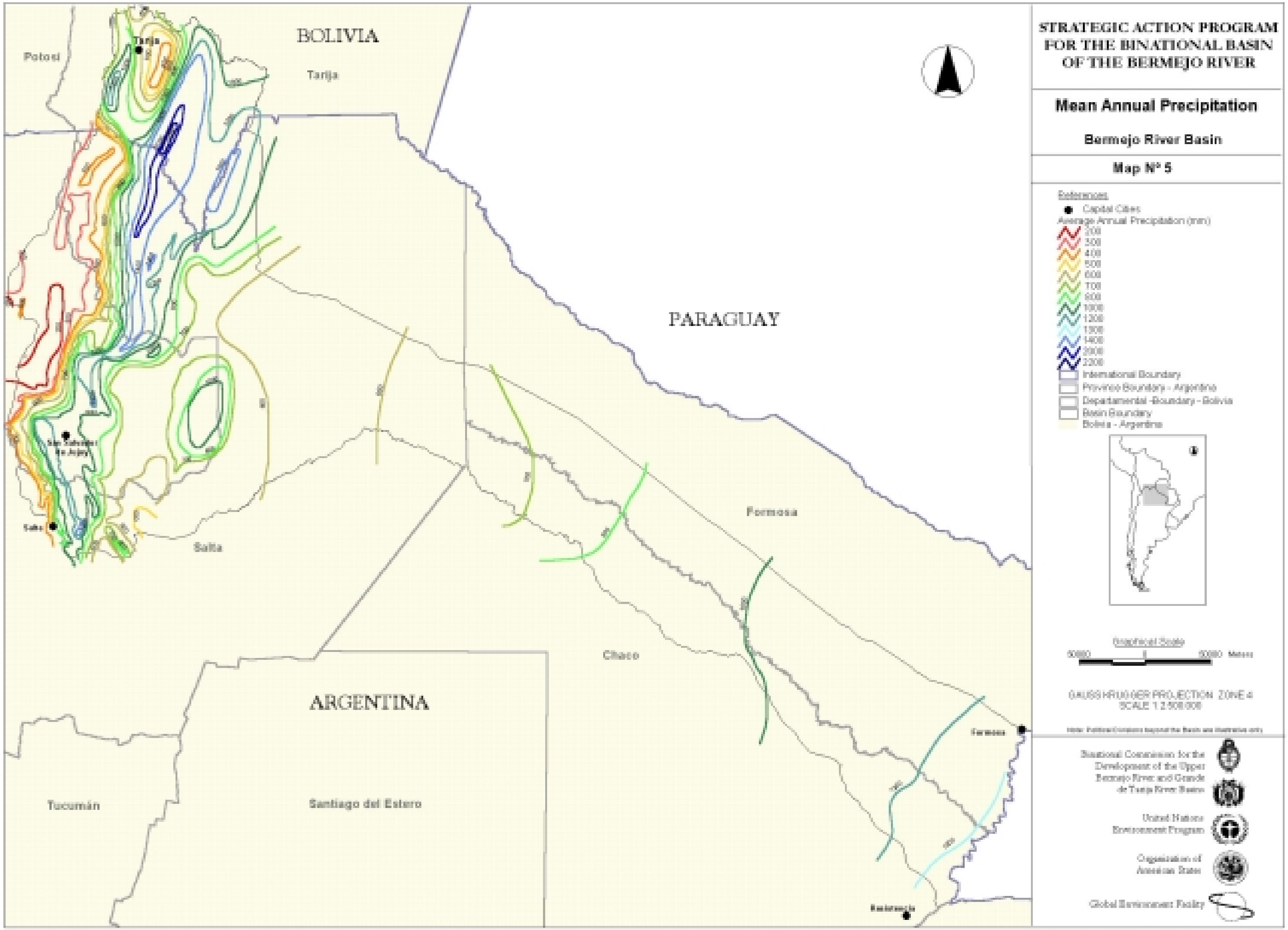
Global Environment Facility

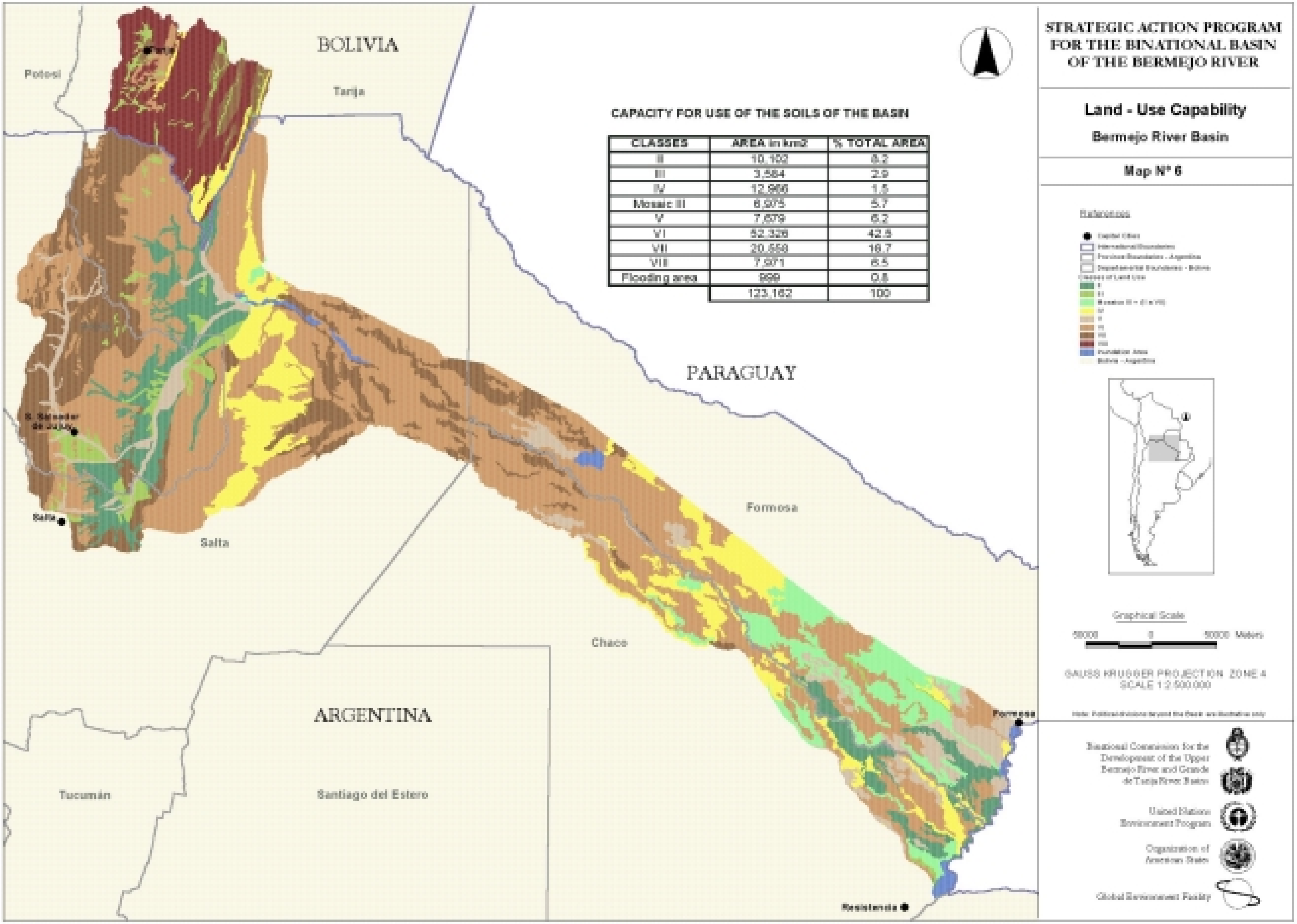


BASIN TERRITORIAL DISTRIBUTION

JURISDICTION		AREA (sq km)	PROPORTION (%)
COUNTRY	BOLIVIA	11,896	10
Department	Tarija	11,896	10
COUNTRY	ARGENTINA	111,266	90
Provinces	Chaco	19,247	16
	Formosa	26,445	21
	Jujuy	21,053	17
	Salta	44,521	36
TOTAL		123,162	100

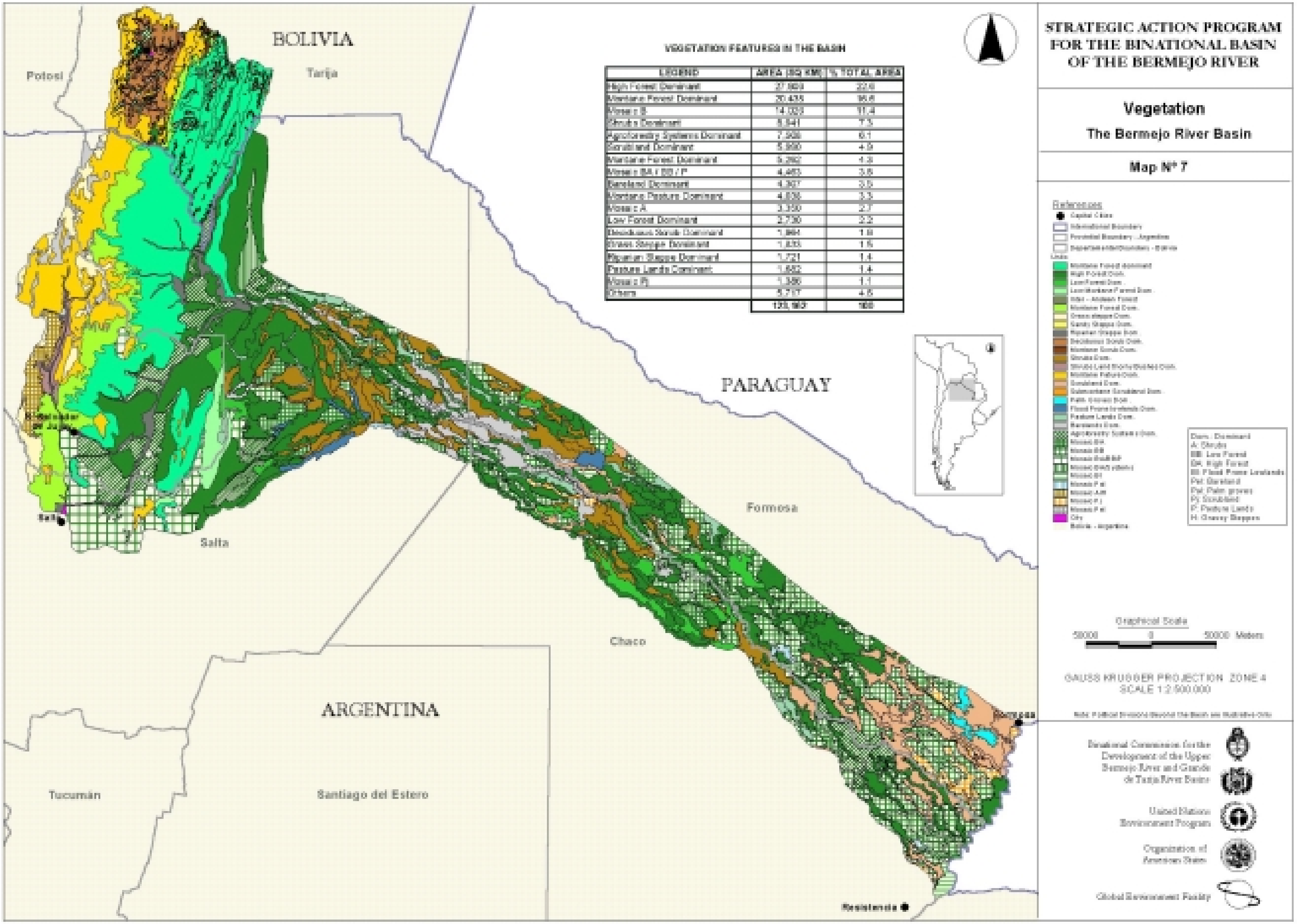

STRATEGIC ACTION PROGRAM
FOR THE BINATIONAL BASIN
OF THE BERMEJO RIVER
Drainage Network
Bermejo River Basin
Map N° 4
References:
Capital Cities
Hydrological Net
Permanent watercourses
Temporary watercourses
International Boundary
Provincial Boundary - Argentina
Departamental Boundary - Bolivia
Basin Boundary
Bolivia/Argentina
Graphic Scale
50000
0
50000
Meters
GAUSS KRUGGER PROJECTION FAJA 4
SCALE 1:2 500 000
Binational Commission for the
Development of the Upper
Bermejo River and Grande
de Tarija River Basins
United Nations
Environment Program
Organization of
American States
Global Environment Facility
BOLIVIA
Potosí
Tarija
Tarija
PARAGUAY
Jujuy
S. Salvador
de Jujuy
Salta
Salta
Formosa
Formosa
Chaco
ARGENTINA
Tucumán
Santiago del Estero
Resistencia


STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Mean Annual Precipitation
Bermejo River Basin
Map N° 5
References
Capital Cities
Average Annual Precipitation (mm)
International Boundary
Province Boundary - Argentina
Departamental -Boundary - Bolivia
Basin Boundary
Bolivia - Argentina
Graphical Scale
Meters
BOLIVIA
PARAGUAY
ARGENTINA
Potosí
Tarija
Salta
Formosa
Chaco
Tucumán
Santiago del Estero
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility



CAPACITY FOR USE OF THE SOILS OF THE BASIN

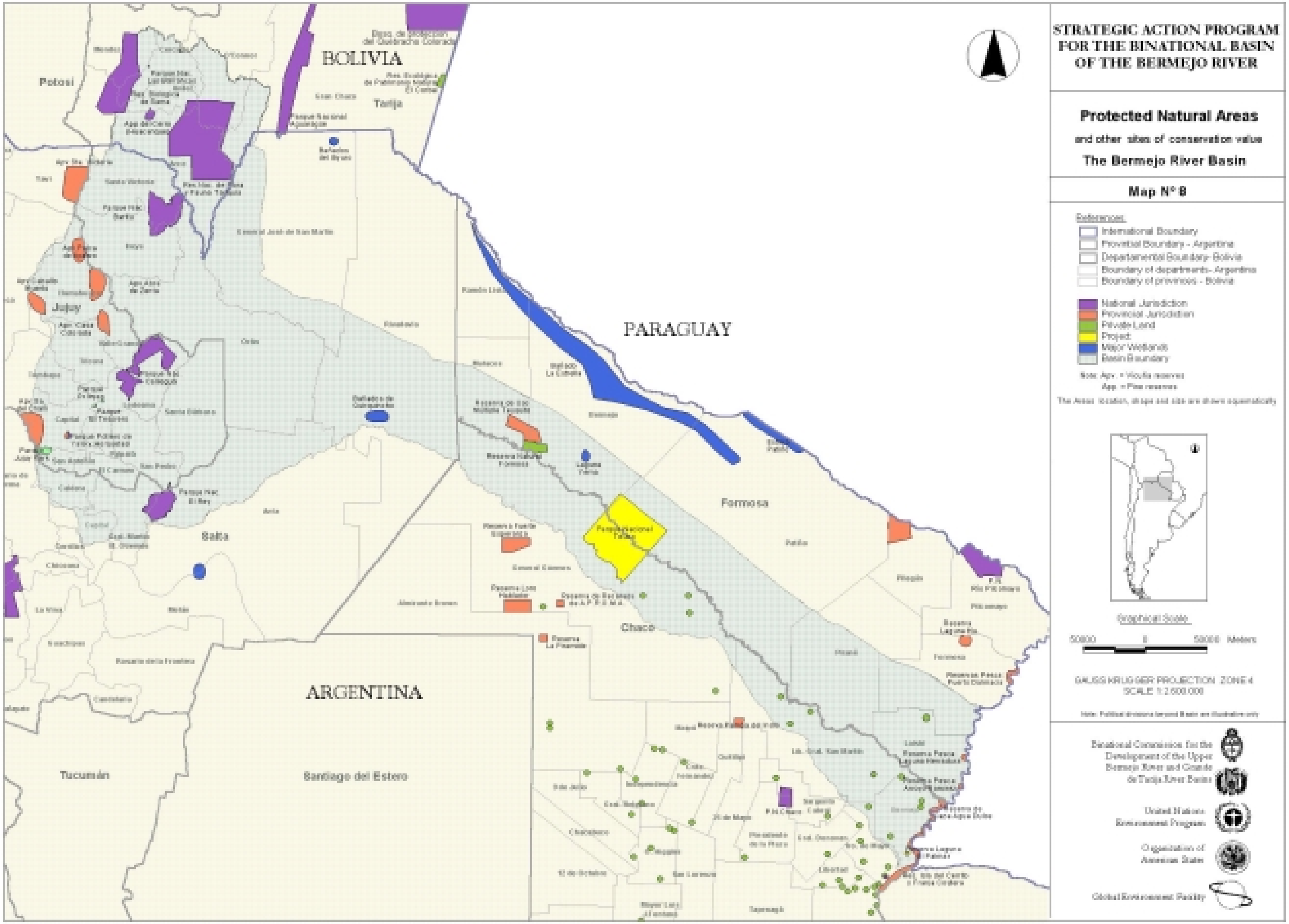
CLASSES	AREA in km2	% TOTAL AREA
II	10,102	8.2
III	3,584	2.9
IV	12,966	1.6
Mosaic III	6,975	5.7
V	7,679	6.2
VI	52,326	42.5
VII	20,559	16.7
VIII	7,971	6.5
Flooding area	999	0.8
	123,162	100

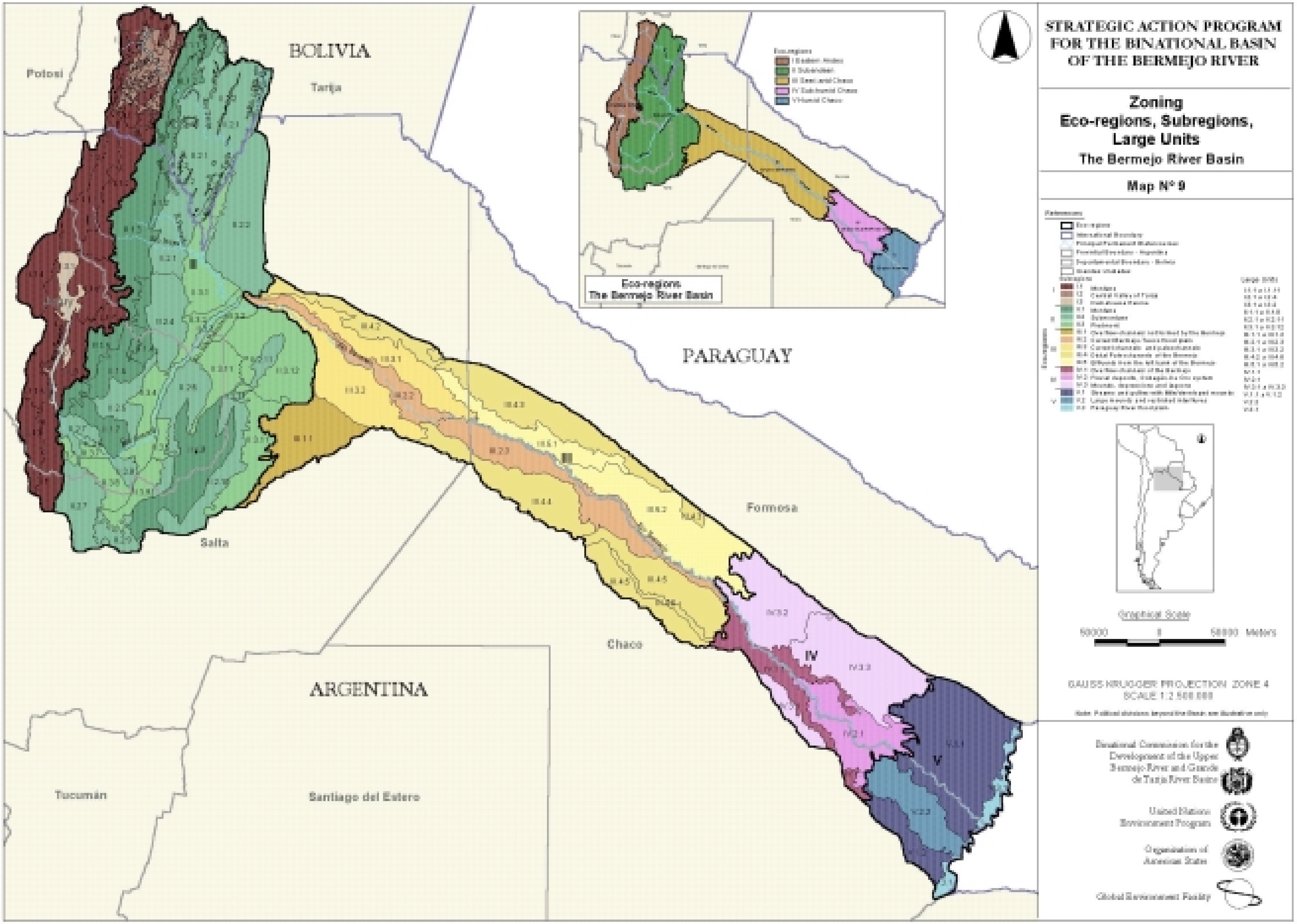


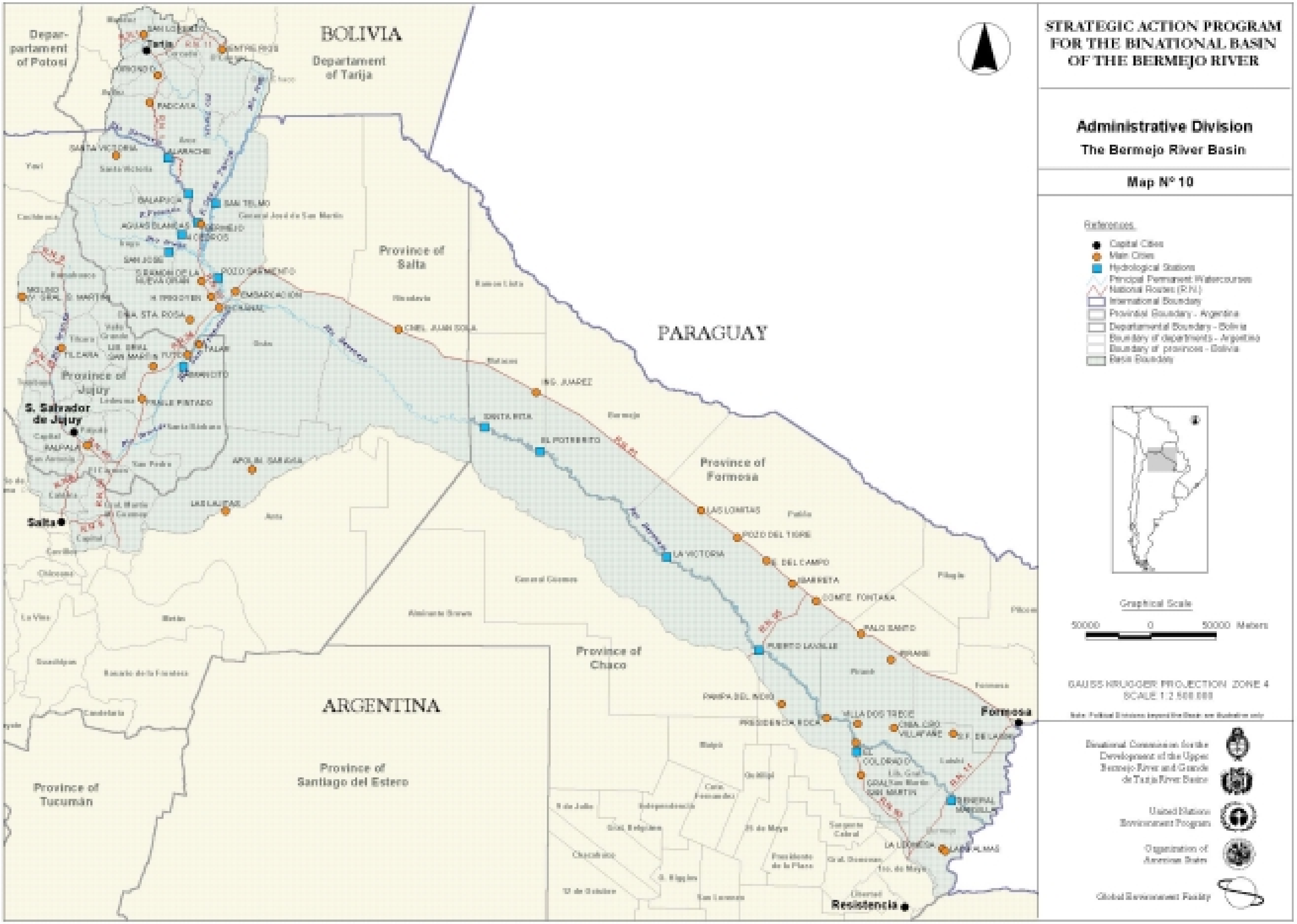
STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Vegetation
The Bermejo River Basin
Map N° 7
BOLIVIA
Potosí
Tarija
PARAGUAY
ARGENTINA
Salta
Formosa
Chaco
Tucumán
Santiago del Estero
Resistencia
VEGETATION FEATURES IN THE BASIN

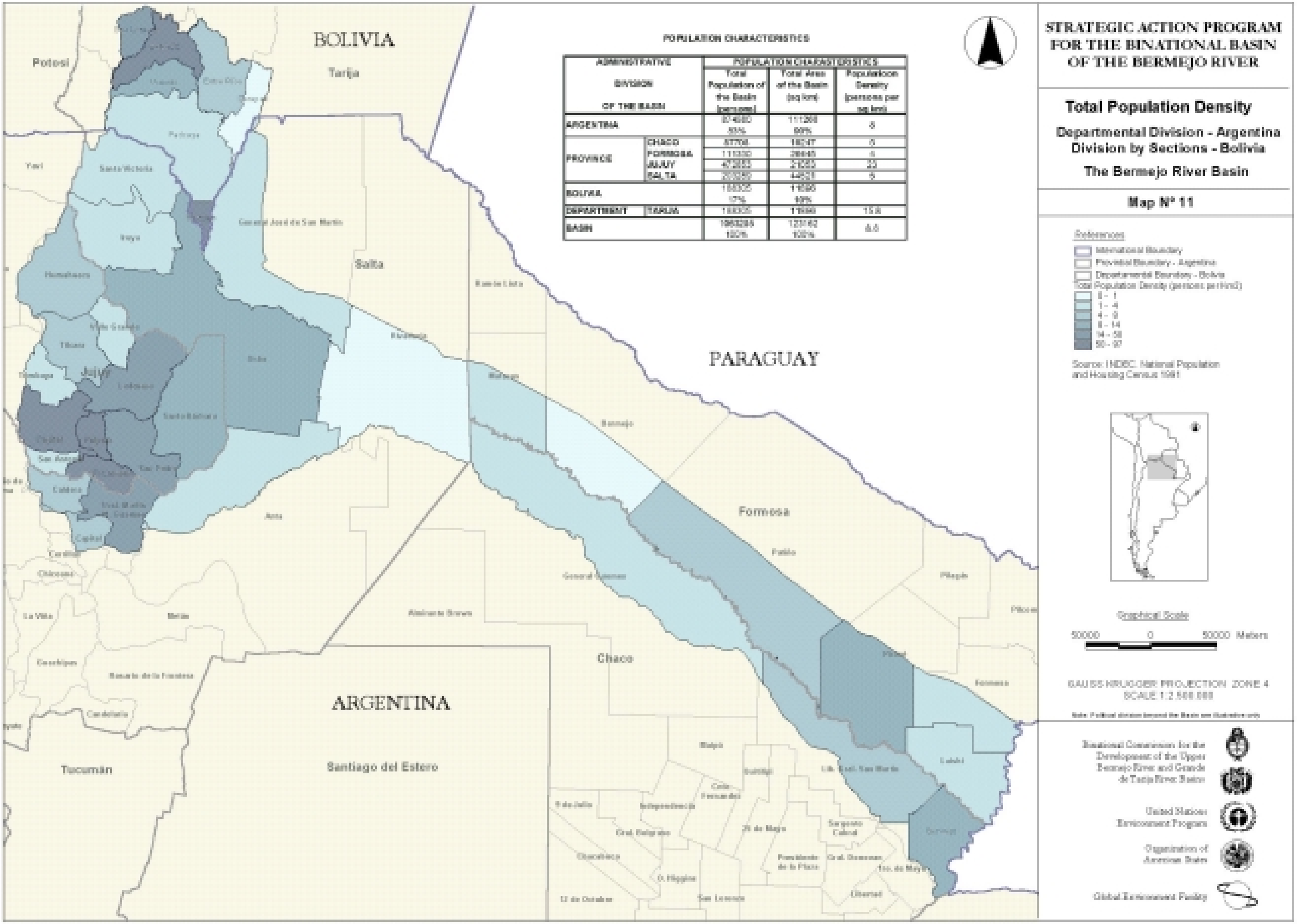
LEGEND	AREA (SQ KM)	% TOTAL AREA
High Forest Dominant	27,809	22.6
Montane Forest Dominant	20,435	16.6
Mosaic B	14,029	11.4
Shrubs Dominant	8,841	7.5
Agroforestry Systems Dominant	7,508	6.1
Scrubland Dominant	5,990	4.9
Montane Forest Dominant	5,262	4.3
Mosaic BA / BB / P	4,463	3.6
Barreland Dominant	4,307	3.5
Montane Pasture Dominant	4,036	3.3
Mosaic A	3,350	2.7
Low Forest Dominant	2,730	2.2
Deciduous Scrub Dominant	1,984	1.6
Grass Steppe Dominant	1,833	1.5
Riparian Steppe Dominant	1,721	1.4
Pasture Lands Dominant	1,682	1.4
Mosaic Pj	1,386	1.1
Others	5,717	4.6
	123,163	100

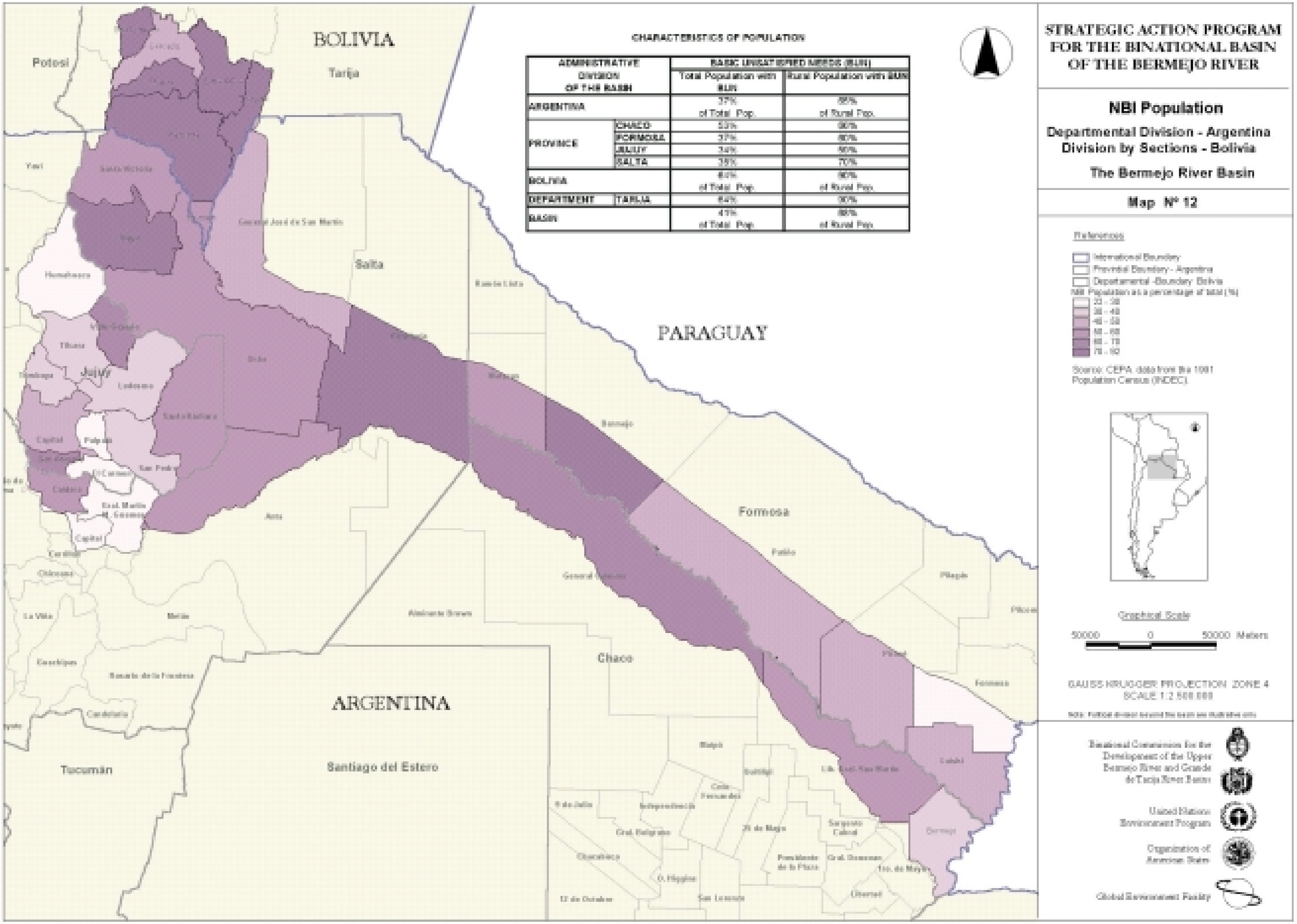
References
Capital Cities
International Boundary
Provincial Boundary - Argentina
Departmental Boundary - Bolivia
Dom.: Dominant
A: Shrubs
BB: Low Forest
BA: High Forest
BI: Flood Prone Lowlands
Pel: Bareland
Pal: Palm groves
Pj: Scrubland
P: Pasture Lands
H: Grassy Steppes
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility


STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Protected Natural Areas
and other sites of conservation value
The Bermejo River Basin
Map N° 8
References:
International Boundary
Provincial Boundary - Argentina
Departamental Boundary- Bolivia
Boundary of departments- Argentina
Boundary of provinces - Bolivia
National Jurisdiction
Provincial Jurisdiction
Private Land
Project
Major Wetlands
Basin Boundary
The Areas location, shape and size are shown squematically
Graphical Scale
50000
0
50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.600.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility
BOLIVIA
PARAGUAY
ARGENTINA
Potosí
Tarija
Jujuy
Salta
Formosa
Chaco
Tucumán
Santiago del Estero


STRATEGIC ACTION PROGRAM
FOR THE BINATIONAL BASIN
OF THE BERMEJO RIVER
Zoning
Eco-regions, Subregions,
Large Units
The Bermejo River Basin
Map N° 9
BOLIVIA
PARAGUAY
ARGENTINA
Potosí
Tarija
Salta
Formosa
Chaco
Tucumán
Santiago del Estero
Eco-regions
The Bermejo River Basin
Graphical Scale
50000
0
50000
Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the
Development of the Upper
Bermejo River and Grande
de Tarija River Basins
United Nations
Environment Program
Organization of
American States
Global Environment Facility


STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Administrative Division
The Bermejo River Basin
Map N° 10
References
Capital Cities
Main Cities
Hydrological Stations
Principal Permanent Watercourses
National Routes (R.N.)
International Boundary
Provincial Boundary - Argentina
Departmental Boundary - Bolivia
Boundary of departments - Argentina
Boundary of provinces - Bolivia
Basin Boundary
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility
BOLIVIA
Department of Tarija
Departamento of Potosi
PARAGUAY
ARGENTINA
Province of Salta
Province of Jujuy
Province of Formosa
Province of Chaco
Province of Santiago del Estero
Province of Tucumán
Tarija
S. Salvador de Jujuy
Salta
Formosa
Resistencia
SANTA VICTORIA
ALARACHE
BALAPUCA
SAN TELMO
AGUAS BLANCAS
BERMEJO
SAN JOSE
POZO SARMIENTO
EMBARCACION
CNEL. JUAN SOLA
ING. JUAREZ
SANTA RITA
EL POTRERITO
APOLIN. SARAVIA
LAS LAJITAS
LAS LOMITAS
POZO DEL TIGRE
LA VICTORIA
COMTE. FONTANA
PALO SANTO
PUERTO LAVALLE
PAMPA DEL INDIO
PRESIDENCIA ROCA
VILLA DOS TRECE
EL COLORADO
GENERAL MANSILLA
LA LEONESA
LAS PALMAS
FRAILE PINTADO
TILCARA
CARAPARI
PADCAYA


STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Total Population Density
Departmental Division - Argentina
Division by Sections - Bolivia
The Bermejo River Basin
Map N° 11
References
International Boundary
Provincial Boundary - Argentina
Departamental Boundary - Bolivia
Total Population Density (persons per Km2)
0 - 1
1 - 4
4 - 8
8 - 14
14 - 58
58 - 97
Source: INDEC. National Population and Housing Census 1991
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility
POPULATION CHARACTERISTICS
ADMINISTRATIVE DIVISION OF THE BASIN | POPULATION CHARACTERISTICS: Total Population of the Basin (persons) | Total Area of the Basin (sq km) | Population Density (persons per sq km)
ARGENTINA | 874980 83% | 111266 90% | 8
PROVINCE CHACO | 87708 | 16247 | 5
FORMOSA | 111030 | 28845 | 4
JUJUY | 473853 | 21055 | 23
SALTA | 202389 | 44621 | 5
BOLIVIA | 188305 17% | 11896 10% |
DEPARTMENT TARIJA | 188305 | 11896 | 15.8
BASIN | 1063285 100% | 123162 100% | 8.6
BOLIVIA
PARAGUAY
ARGENTINA
Potosi
Tarija
Salta
Jujuy
Formosa
Chaco
Tucumán
Santiago del Estero



CHARACTERISTICS OF POPULATION

ADMINISTRATIVE DIVISION OF THE BASIN		BASIC UNSATISFIED NEEDS (BUN)	
		Total Population with BUN	Rural Population with BUN
ARGENTINA		37% of Total Pop.	85% of Rural Pop.
PROVINCE	CHACO	53%	90%
	FORMOSA	37%	80%
	JUJUY	34%	50%
	SALTA	35%	70%
BOLIVIA		64% of Total Pop.	90% of Rural Pop.
DEPARTMENT	TARIJA	64%	90%
BASIN		41% of Total Pop.	88% of Rural Pop.

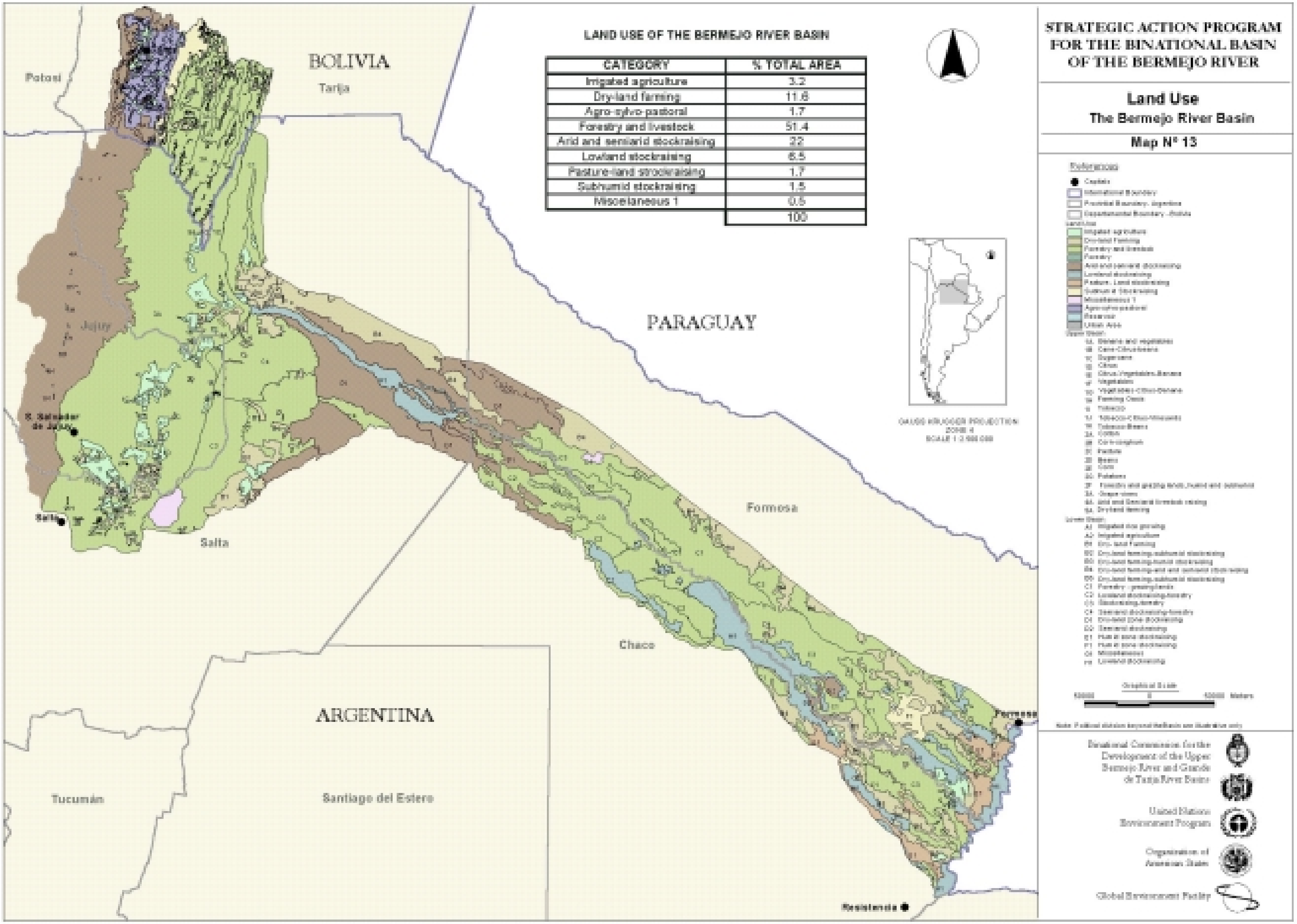
STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER

NBI Population

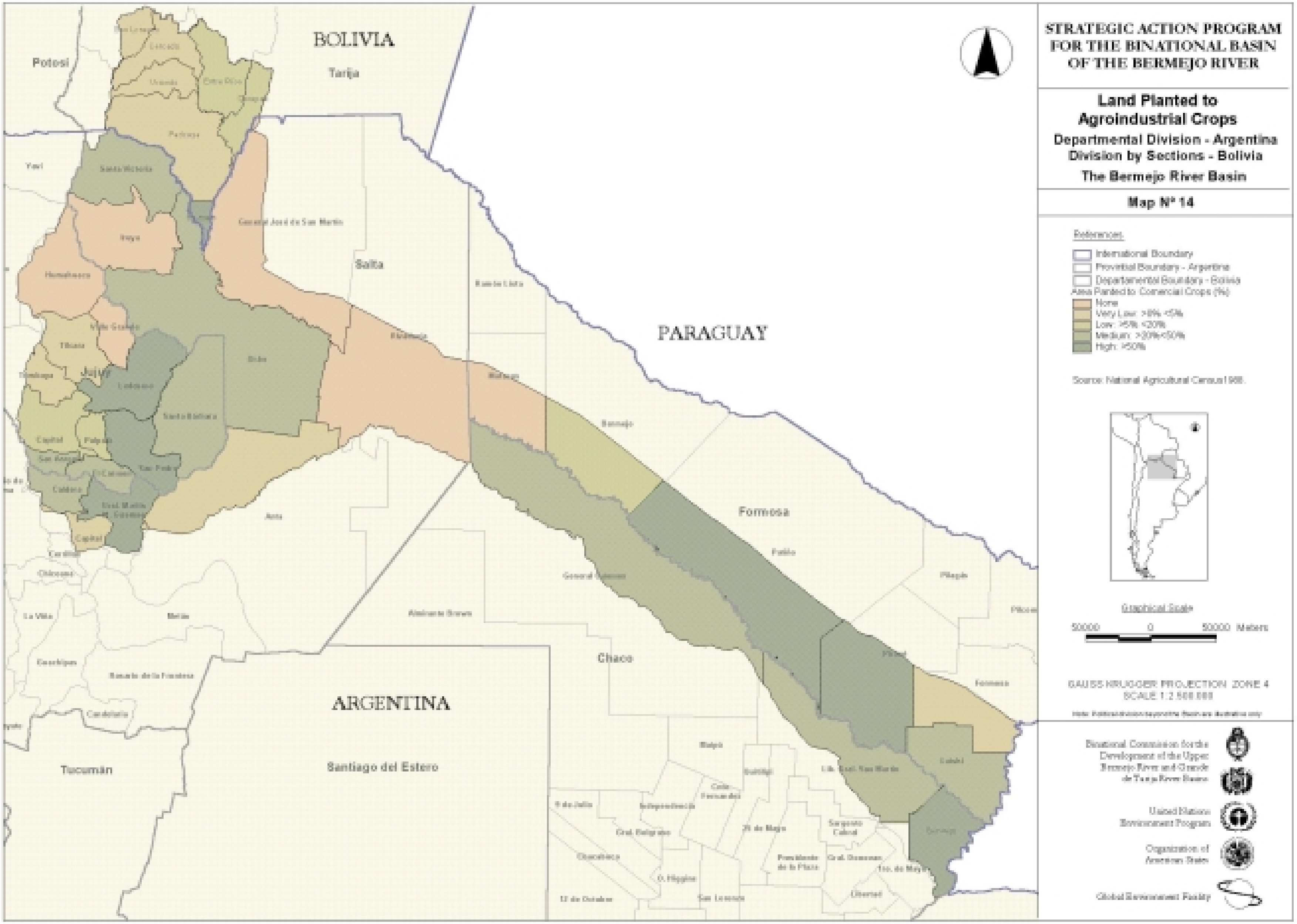
Departmental Division - Argentina
Division by Sections - Bolivia

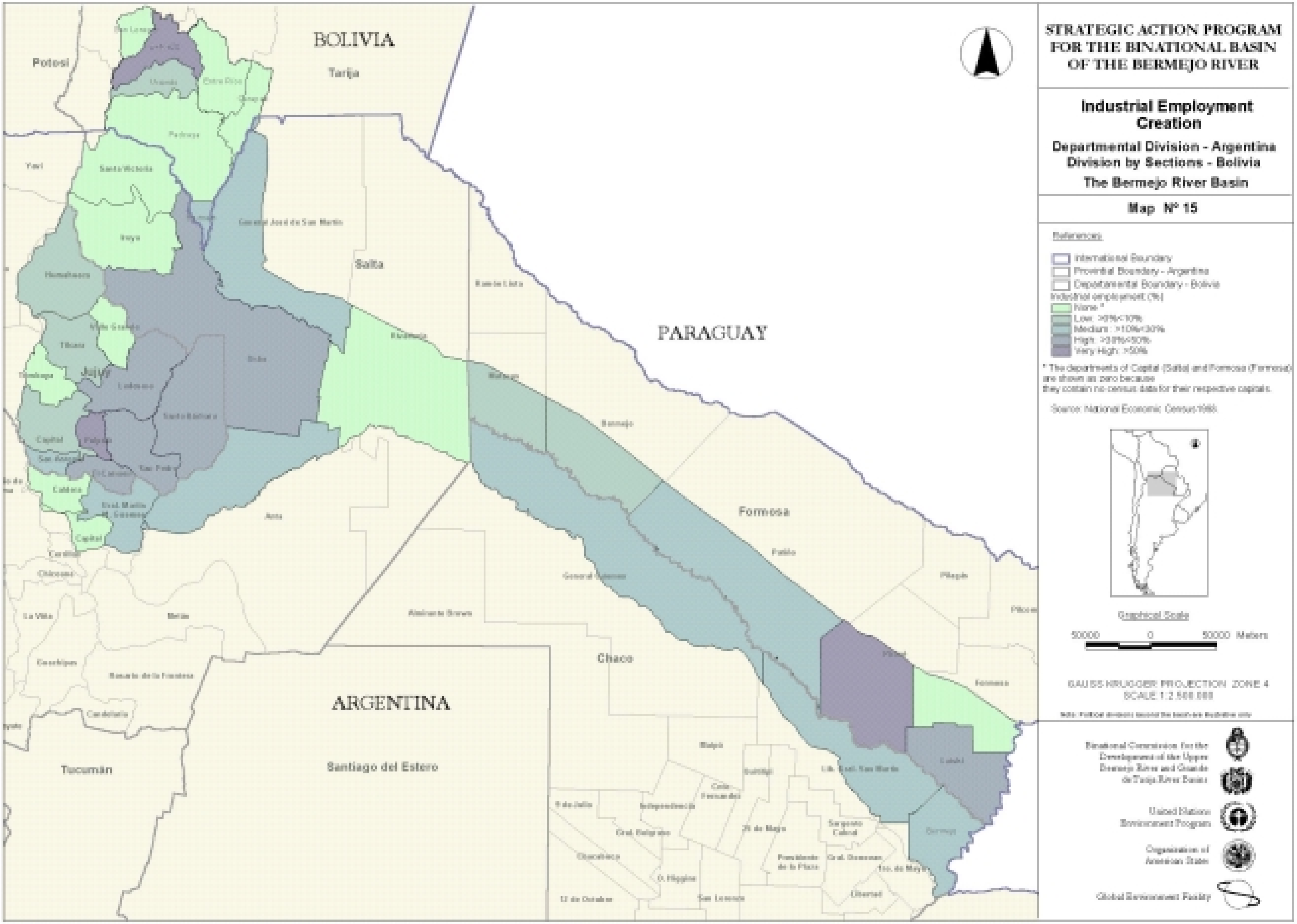
The Bermejo River Basin

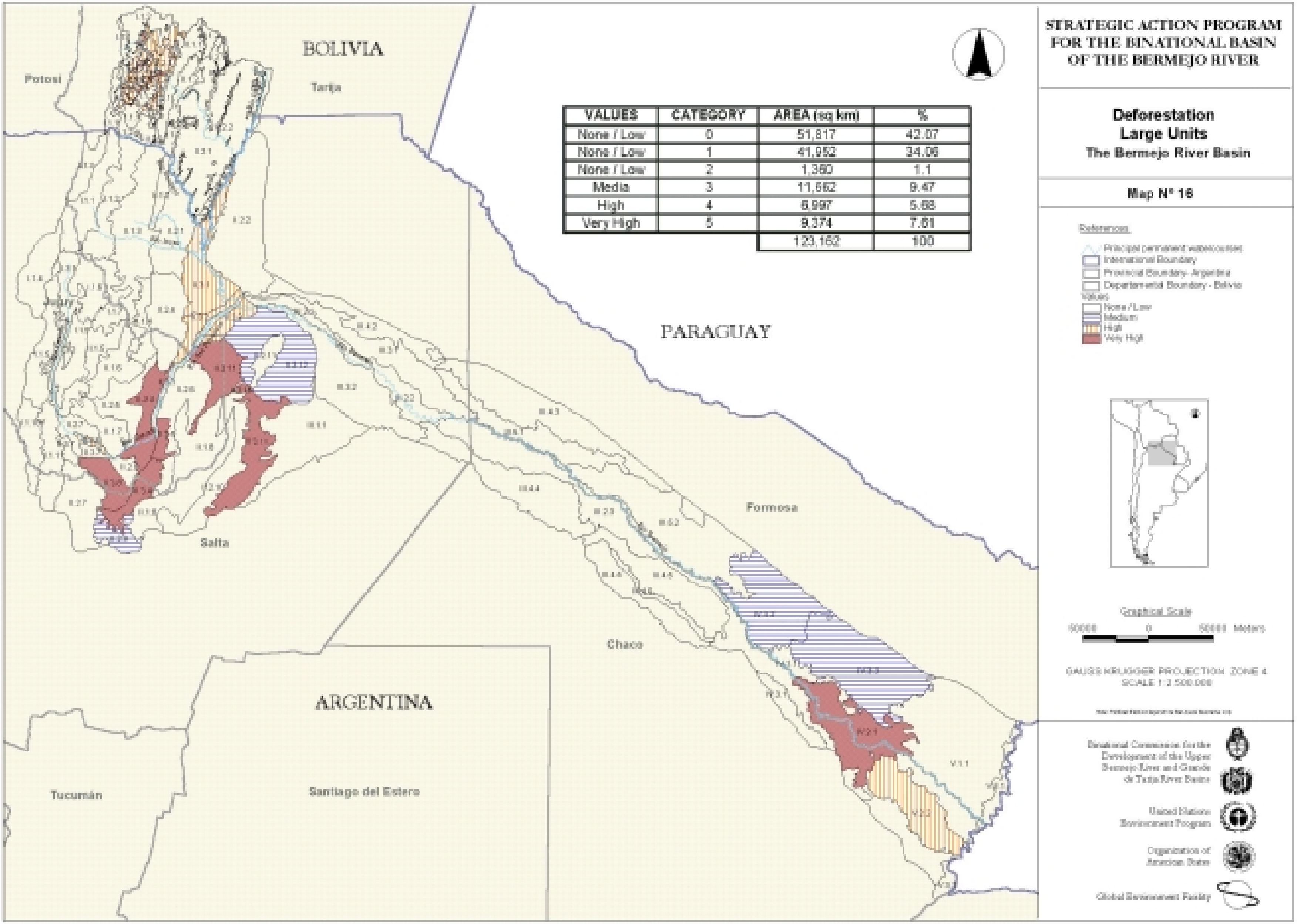
Map Nº 12



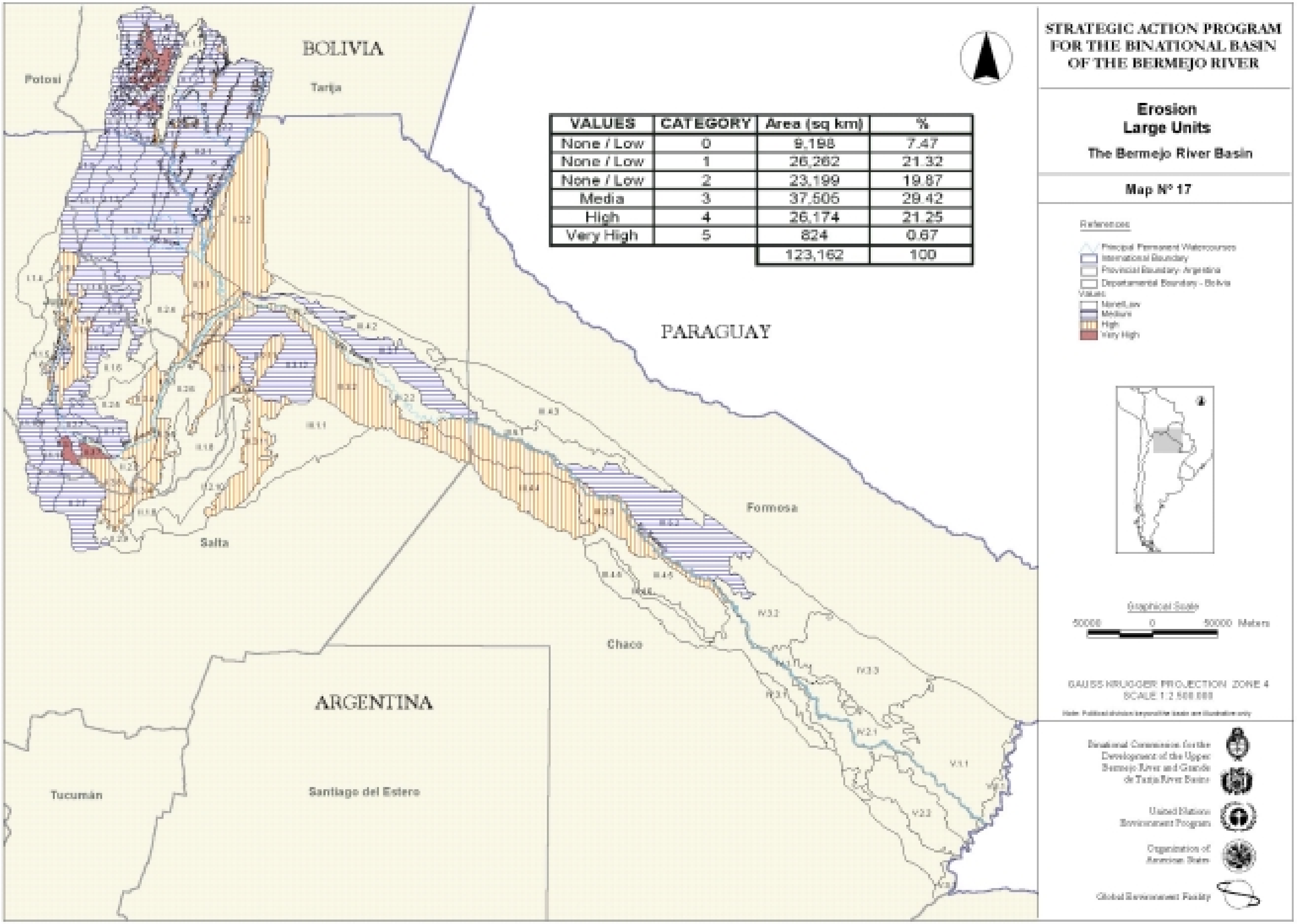
CATEGORY	% TOTAL AREA
Irrigated agriculture	3.2
Dry-land farming	11.6
Agro-sylvo-pastoral	1.7
Forestry and livestock	51.4
Arid and semiarid stockraising	22
Lowland stockraising	6.5
Pasture-land stockraising	1.7
Subhumid stockraising	1.5
Miscelaneous 1	0.5
	100


STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Land Planted to Agroindustrial Crops
Departmental Division - Argentina
Division by Sections - Bolivia
The Bermejo River Basin
Map Nº 14
References
International Boundary
Provincial Boundary - Argentina
Departamental Boundary - Bolivia
Area Planted to Comercial Crops (%)
None
Very Low: >0% <5%
Low: >5% <20%
Medium: >20%<50%
High: >50%
Source: National Agricultural Census1988.
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility
BOLIVIA
PARAGUAY
ARGENTINA
Potosi
Tarija
Salta
Jujuy
Formosa
Chaco
Tucumán
Santiago del Estero

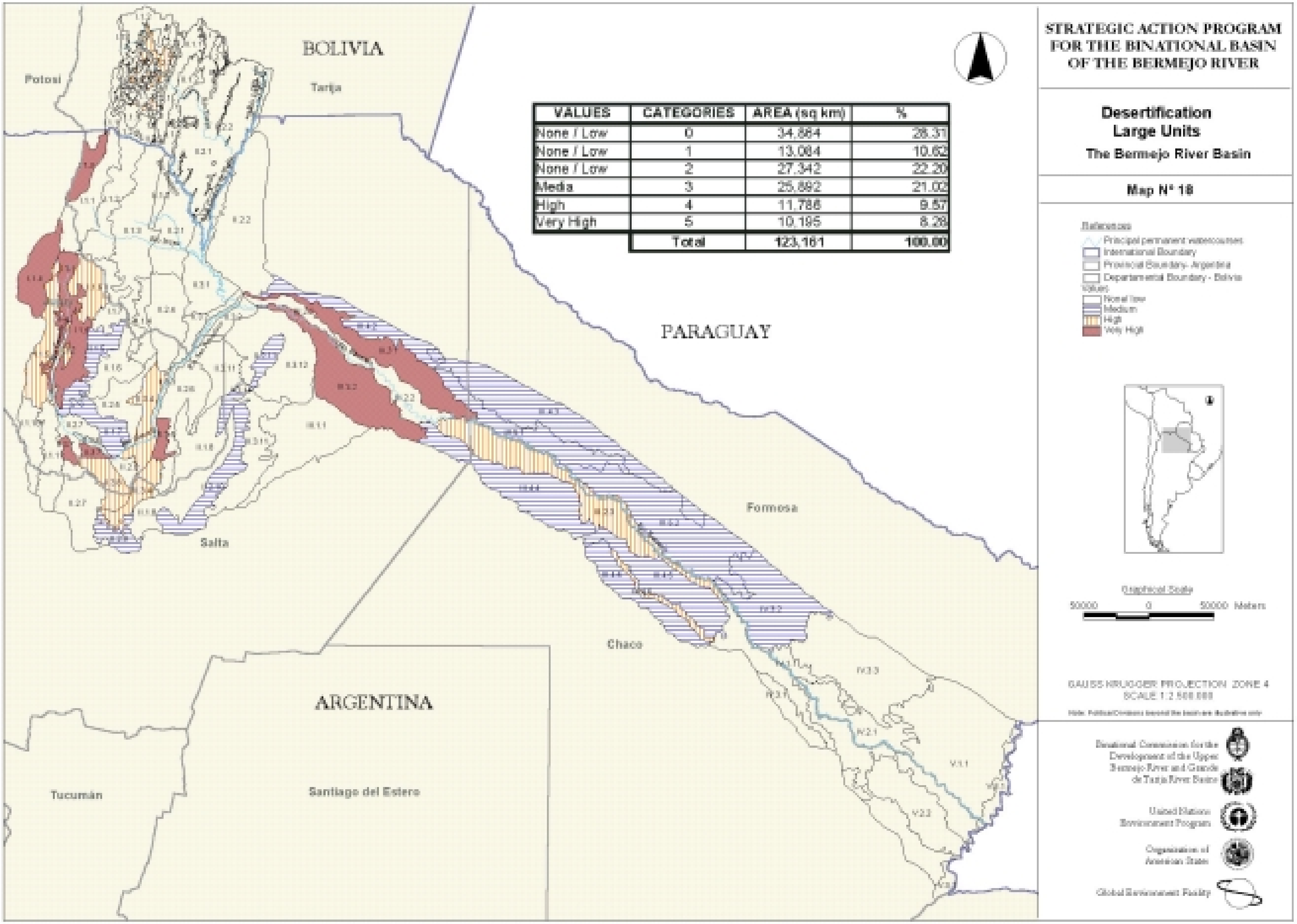

STRATEGIC ACTION PROGRAM
FOR THE BINATIONAL BASIN
OF THE BERMEJO RIVER
Industrial Employment
Creation
Departmental Division - Argentina
Division by Sections - Bolivia
The Bermejo River Basin
Map Nº 15
References:
International Boundary
Provincial Boundary - Argentina
Departamental Boundary - Bolivia
Industrial employment (%)
Source: National Economic Census 1985
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basin
United Nations Environment Program
Organization of American States
Global Environment Facility
BOLIVIA
Potosí
Tarija
PARAGUAY
Salta
Jujuy
Formosa
Chaco
ARGENTINA
Tucumán
Santiago del Estero



VALUES	CATEGORY	AREA (sq km)	%
None / Low	0	51,817	42.07
None / Low	1	41,952	34.06
None / Low	2	1,360	1.1
Media	3	11,662	9.47
High	4	6,997	5.68
Very High	5	9,374	7.61
		123,162	100



VALUES	CATEGORY	Area (sq km)	%
None / Low	0	9,198	7.47
None / Low	1	26,262	21.32
None / Low	2	23,199	19.87
Media	3	37,505	29.42
High	4	26,174	21.25
Very High	5	824	0.67
		123,162	100



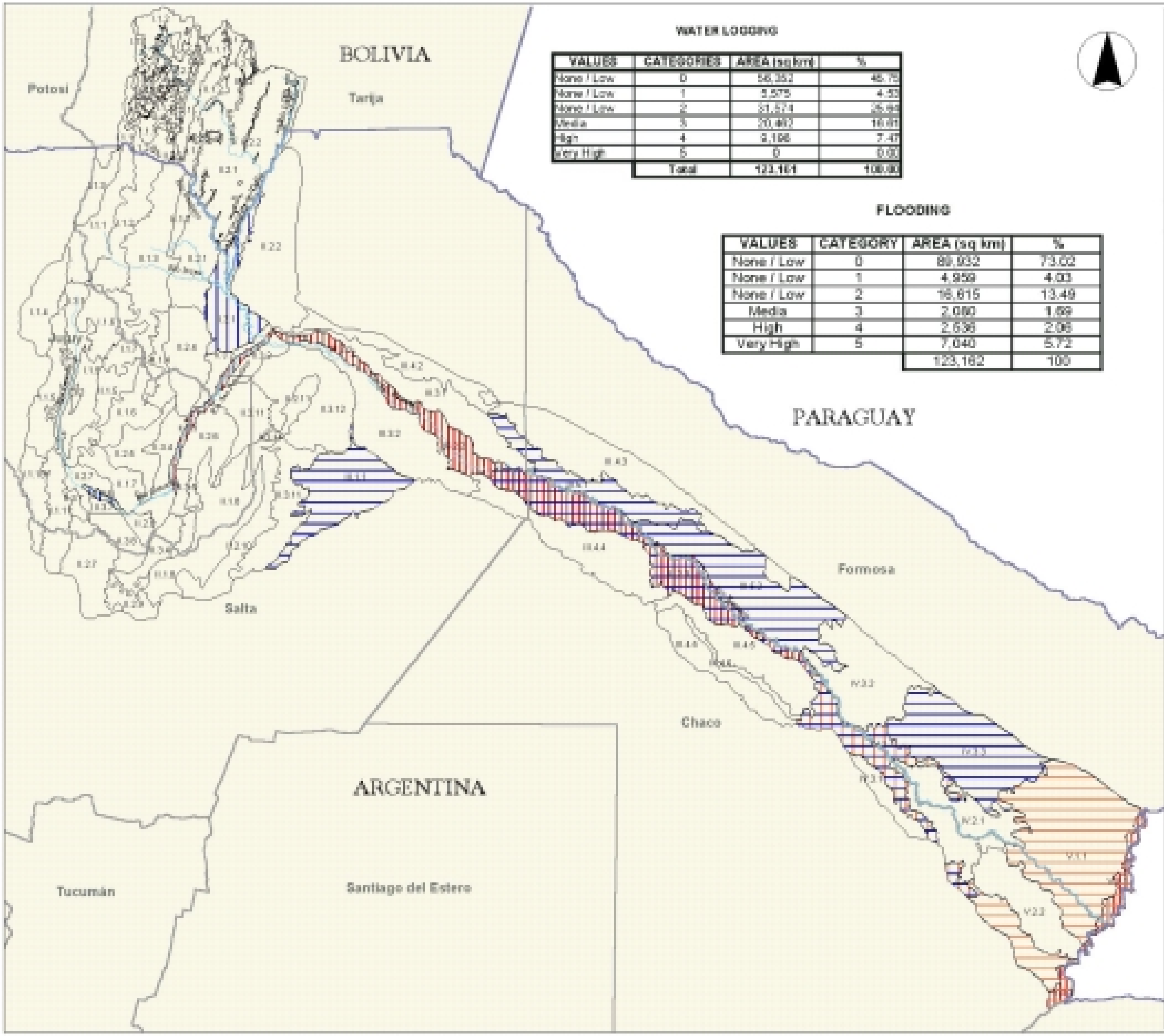
VALUES	CATEGORIES	AREA (sq km)	%
None / Low	0	34,864	28.31
None / Low	1	13,084	10.62
None / Low	2	27,342	22.20
Media	3	25,892	21.02
High	4	11,786	9.57
Very High	5	10,195	8.28
	Total	123,161	100.00

STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER

Flood - prone areas
Large Units

The Bermejo River Basin

Map Nº 19



WATER LOGGING

VALUES	CATEGORIES	AREA (sq km)	%
None / Low	0	56,352	45.75
None / Low	1	5,575	4.53
None / Low	2	31,574	25.63
Media	3	20,462	16.61
High	4	9,196	7.47
Very High	5	0	0.00
	Total	123,161	100.00

FLOODING

VALUES	CATEGORY	AREA (sq km)	%
None / Low	0	89,932	73.02
None / Low	1	4,959	4.03
None / Low	2	16,615	13.49
Media	3	2,080	1.69
High	4	2,536	2.06
Very High	5	7,040	5.72
		123,162	100

References

- Principal permanent watercourses
- International Boundary
- Provincial Boundary. Argentina
- Departamental Boundary - Bolivia

Values - Water Logging
- None/Low
- Media
- Hight
- Very Hight

Values - Flooding
- None/Low
- Media
- Hight
- Very Hight

Graphical Scale

50000 0 50000 Meters

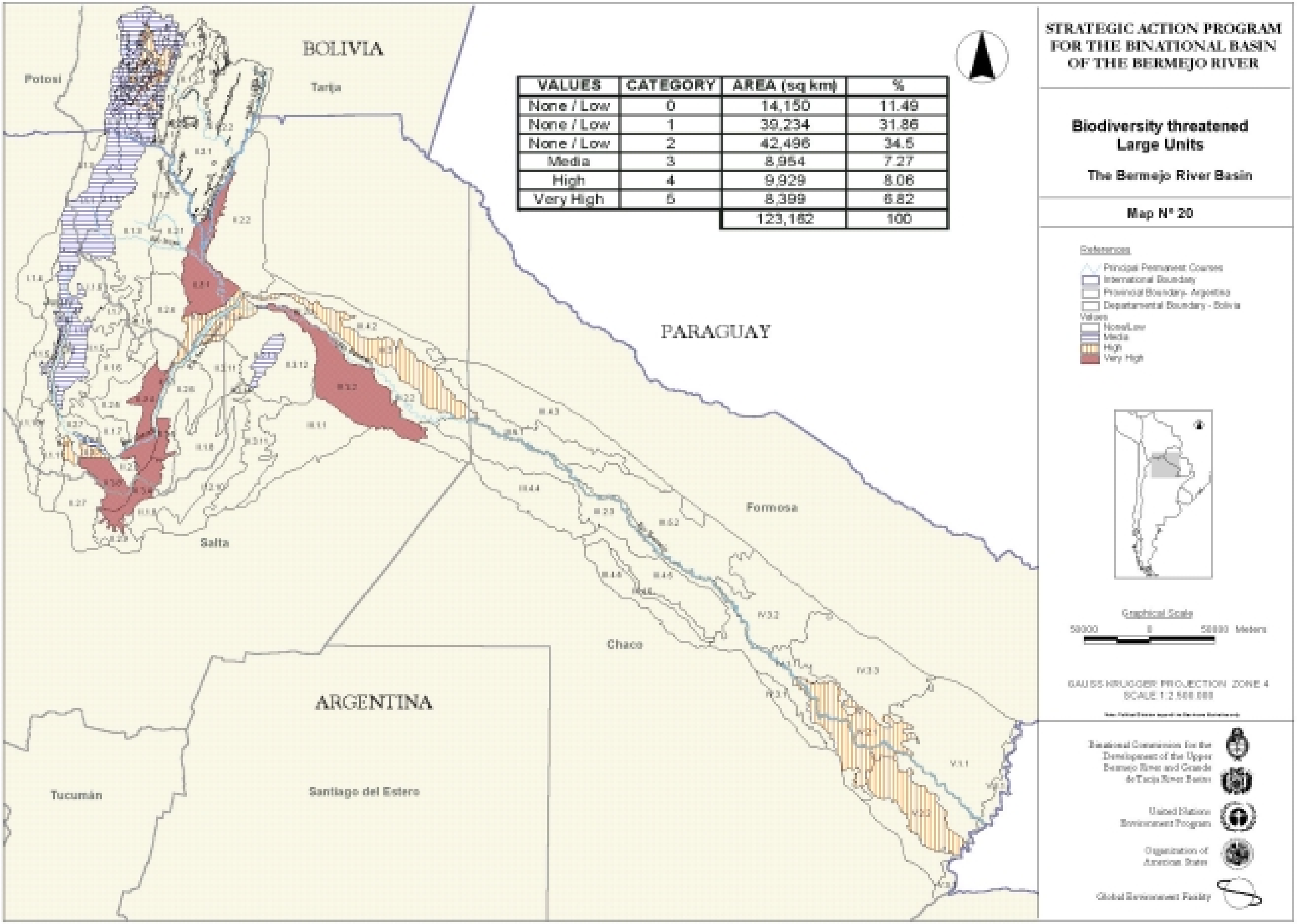
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000

Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins

United Nations Environment Program

Organization of American States

Global Environment Facility



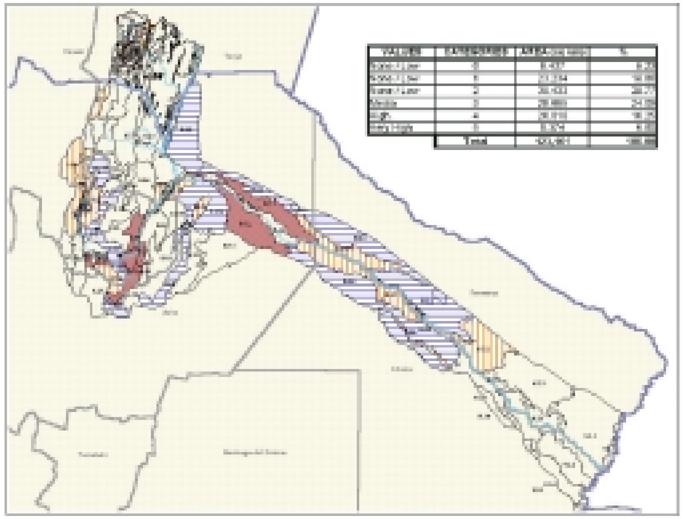
VALUES	CATEGORY	AREA (sq km)	%
None / Low	0	14,150	11.49
None / Low	1	39,234	31.86
None / Low	2	42,496	34.5
Media	3	8,954	7.27
High	4	9,929	8.06
Very High	5	8,399	6.82
		123,162	100

STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER

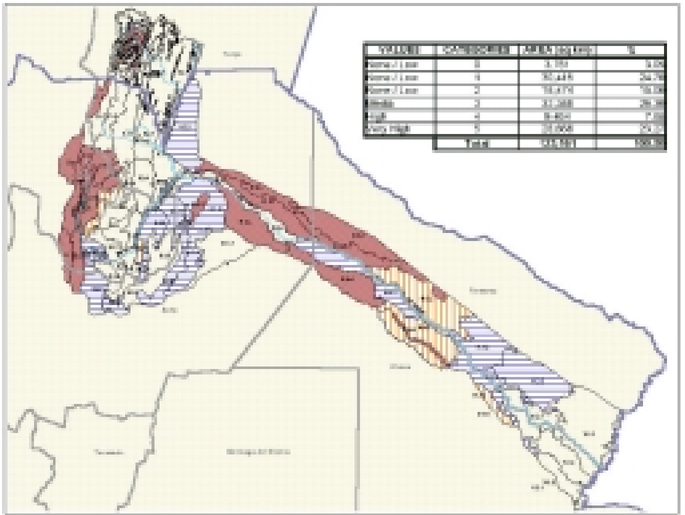
Environmental Indicators Zones Large Units

The Bermejo River Basin

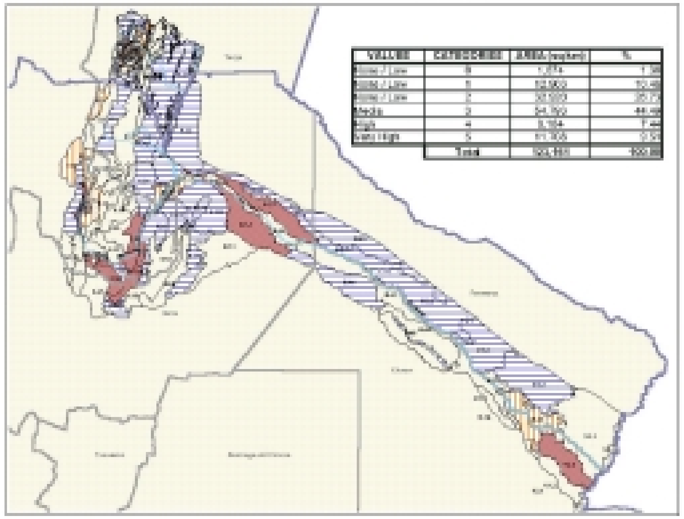
Map N° 21



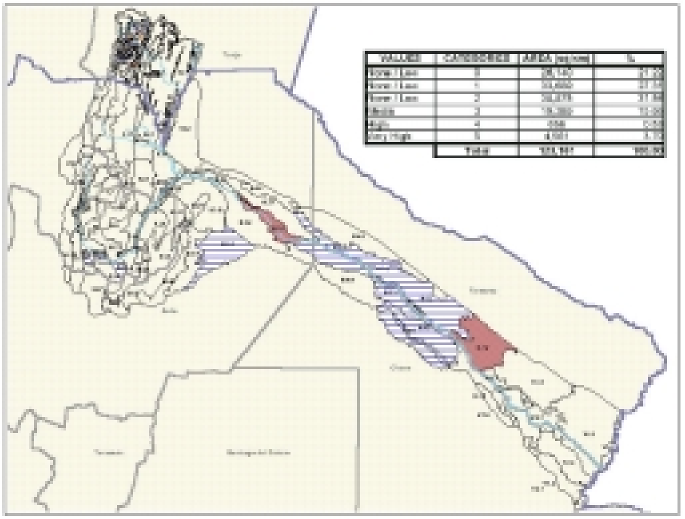
a) Loss of Livestock Carrying Capacity



b) Water Shortage during Dry Season



c) Vegetation Degradated from Overuse



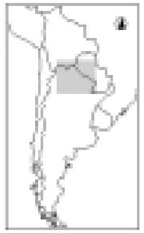
d) Invasion of Woody Species (Prosopis ruscifolia - vinal and others)

References

Principal Permanent Courses
International Boundary
Provincial Boundary, Argentina
Departamental Boundary - Bolivia

Values

None/Low
Media
High
Very High



Graphical Scale

50000 0 50000 Meters

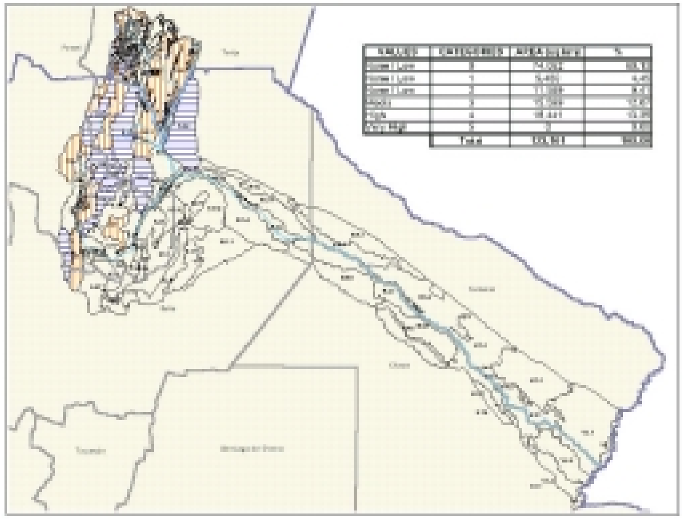
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000

Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins

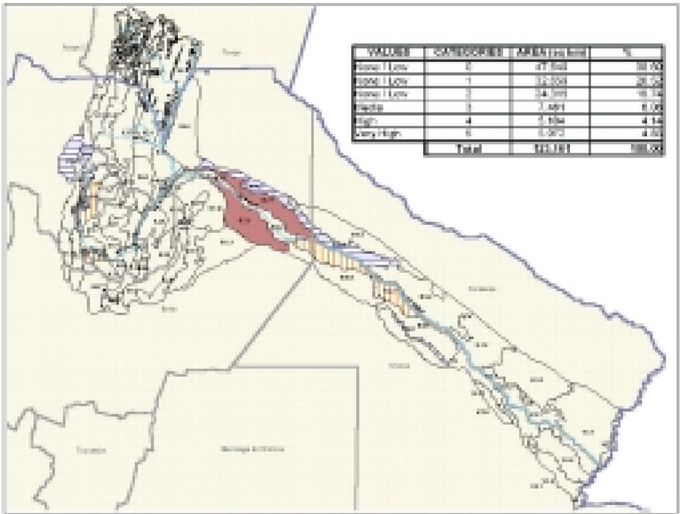
United Nations Environment Program

Organization of American States

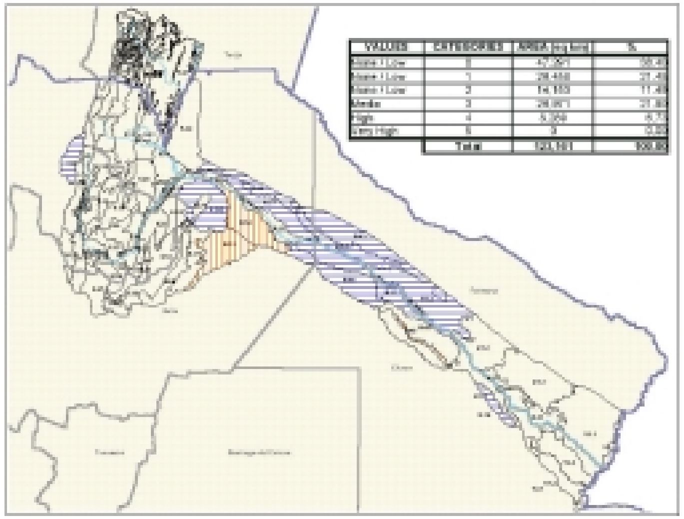
Global Environment Facility



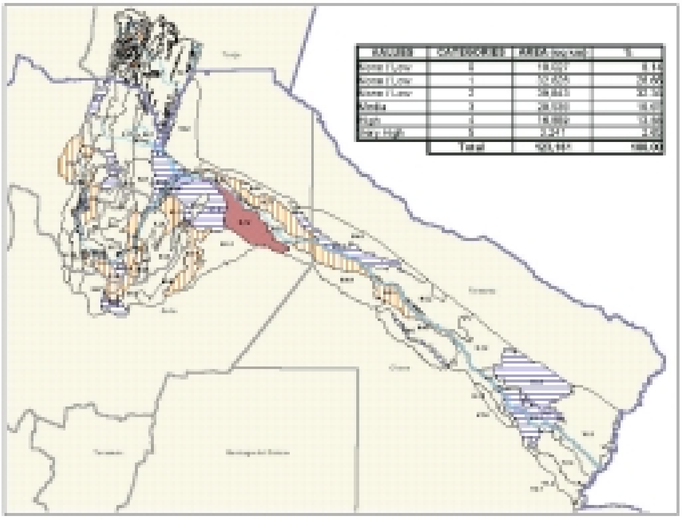
a) Mass Movements from Geomorphological Inestability



b) Peridomestic Barelands (loss of the vegtal cover from overuse)



c) Soil Salinization from mis use



d) Loss of soil fertility (biological properties)

STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER

Environmental Indicators Zones Large Units

The Bermejo River Basin

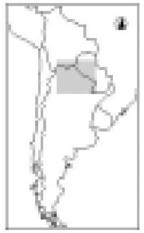
Map N° 22

References

- Principales permanent watercourses
- International Boundary
- Provincial Boundary- Argentina
- Departamental Boundary - Bolivia

Values:

- None/Low
- Media
- High
- Very high



Graphical Scale

50000 0 50000 Meters

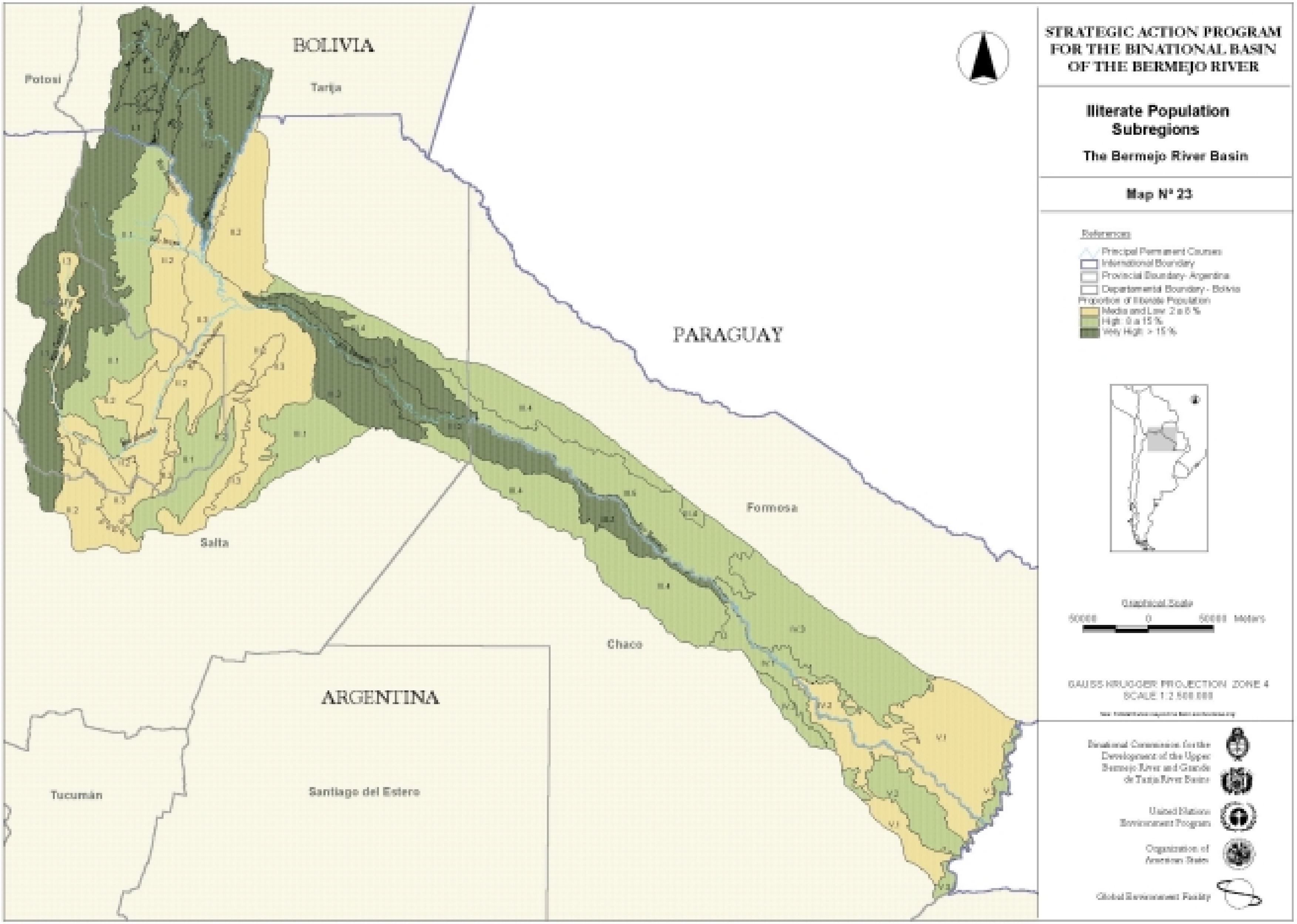
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000

Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins

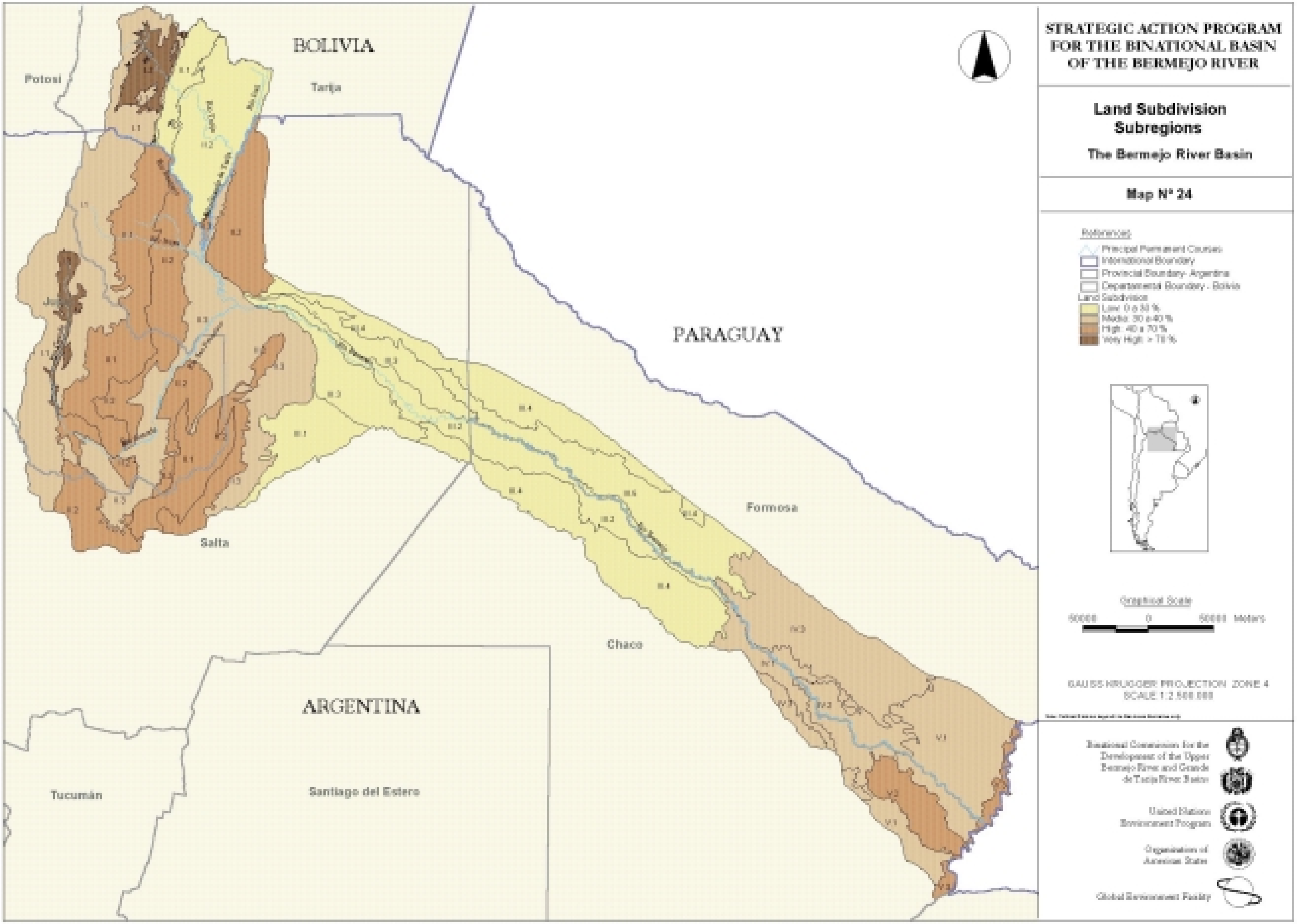
United Nations Environment Program

Organization of American States

Global Environment Facility



STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Illiterate Population Subregions
The Bermejo River Basin
Map N° 23
References
Principal Permanent Courses
International Boundary
Provincial Boundary- Argentina
Departamental Boundary - Bolivia
Proportion of Illiterate Population
Media and Low: 2 a 8 %
High: 8 a 15 %
Very High: > 15 %
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
Organization of American States
Global Environment Facility
BOLIVIA
Potosí
Tarija
PARAGUAY
Formosa
Salta
Chaco
ARGENTINA
Tucumán
Santiago del Estero



STRATEGIC ACTION PROGRAM FOR THE BINATIONAL BASIN OF THE BERMEJO RIVER
Land Subdivision Subregions
The Bermejo River Basin
Map N° 24
References
Principal Permanent Courses
International Boundary
Provincial Boundary- Argentina
Departamental Boundary - Bolivia
Land Subdivision
Low: 0 a 30 %
Media: 30 a 40 %
High: 40 a 70 %
Very High: > 70 %
Graphical Scale
50000 0 50000 Meters
GAUSS KRUGGER PROJECTION ZONE 4
SCALE 1:2.500.000
Binational Commission for the Development of the Upper Bermejo River and Grande de Tarija River Basins
United Nations Environment Program
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BOLIVIA
Potosí
Tarija
PARAGUAY
Formosa
Chaco
Salta
ARGENTINA
Tucumán
Santiago del Estero

6. LIST OF ACRONYMS

CSA	Common Strategic Action
DSA	Direct Strategic Action
ISA	Indirect Strategic Action
AGAS	General Water Administration, Salta, Arg.
NPA	Nature Protected Area
APA	Provincial Water Administration, Chaco, Arg.
APN	National Park Administration, Arg.
Arg/AR	Argentina Republic
Bol / BO.	Republic of Bolivia
CONAPIBE	National Commission of the Pilcomayo and Bermejo Rivers, Bol.
CONICET	National Council of Scientific and Technical Research, Arg.
COREBE	Bermejo River Regional Commission , Arg.
EAP	Explotaciones Agropecuarias
El.	Work Program Element
EVARSA	Resources Evaluation S.A. Arg.
FMAM	Global Environmental Facility (GEF)
FONPLATA	Financial Fund for La Plata River Basin Development
GEF	Global Environmental Facility
GTG PEA	Governmental Working Group for the Formulation of Bermejo SAP, Arg.
GU	Large Ecological Units (see Regional Ecology)
IDH	Index of Human Development
IGM.:	Army Geographical Institute, Arg.
INA.	Water and Environment National Institute, Arg.
INDEC	Statistics and Census National Institute, Arg.

INTA	Agricultural Technology National Institute, Arg.
LIEY	Laboratory of Yungas Ecological Research, Arg.
MERCOSUR	Southern Common Market
NBI	Basic unsatisfied needs
OEA	Organization of American States
ONG	Non governmental organization
PEA	Strategic Action Programme (SAP)
PBG	Gross Geographic Product
PNUMA	United Nations Environment Programme (UNEP)
PPP	Public Participation Program
PROMETA	Environment Protection , Tarija, Bol.
SCS-USA	Soil Conservation Service, USA
SRNyDS	Secretary of Nature Resources and Sustainable Development (now SPAyDS Secretary of Environmental Policy and Sustainable Development), Arg,
TDA	Trasboundary Environmental Diagnostic
UBA	University of Buenos Aires, Arg.
UCS	Catholic University of Salta
UDSMA	Unit of Environment and Sustainable Development
UICN	International Union for Nature Conservation (UICN)
UJMS	Juan Misael Saracho Autonomous National University, Bol.
UNNE.	Northeast National University, Arg.
UNJU	Jujuy National University, Arg.
UNSA	Salta National University, Arg.
UNT	Tucumán National University, Arg.
WWF	World Wildlife Found

ZONISIG Agro-Ecologic Zoning and Establishment of a Data Base and Geographic Information Systems Network Project, Bolivia

ANNEX I

WORK PROGRAM ELEMENTS

ANNEX I

WORK PROGRAM ELEMENTS

Work Program Element 1.1**: Transboundary Pollutant Movement, Binational.** The objective of the project is to determine the regional impact of the transport of sediments/pollutants generated in the basin into Paraguay-Paraná and La Plata rivers waterways and Delta.. The study comprises: a) elaboration of digitalized thematic cartography into a Geographic Information System environment; b) Mapping of erosion prone areas to estimate sediment production in the Upper Bermejo Basin; c) definition of quantitative flow and sediment transport scenarios; d) implementation and exploitation of a mathematical model of the river. In addition, possible measures to ensure environmental sustainability are analyzed.

Work Program Element 2.1: **Stream Classification, Bolivia**. This is a project to establish criteria and parameters of classification of water courses within the Upper Bermejo Basin and optimize use and quality control. Work to be done consists of sampling of water courses, laboratory analyses, processing and evaluation of data, classification of water courses, definition and regulation of water uses and preparation of guidelines for use and conservation of water resources.

Work Program Element 2.2: **Erosion Control-Santa Ana/Camacho, Bolivia.** This project consists of updating existing studies and experiences for control of erosion, land reclamation, and management of natural resources. The studies are: a) Analysis of soils, vegetation, cattle management, and agriculture, and a social-economic survey; b) Formulation of a plan for the management of natural resources and erosion control c) Identification of demonstration areas, and botanical species suitable to the area.

Work Program Element 2.3: **Land Tenure-Tarija Valley, Bolivia**. This study is to determine the use and ownership of eroded land within the Tarija Valley. Work required will consist of: a cadastral survey of the land; a census of owners of eroded land; legal characterization of property; and usage and conservation of land.

Work Program Element 2.4: **Range Management-Tarija Valley, Bolivia.** This is a project for zoning of natural grazing fields in accordance to their potential. It will establish sustainability criteria, limiting the number of cattle allowed in each grazing field. In order to do so, it is necessary to prepare an inventory of natural flora and fauna, evaluation of the potential for raising cattle in the area, detailed cartography indicating zoning and natural units of grazing fields, and establishment of strategies for the control of quantity of cattle grazing in the area.

Work Program Element 2.5: **Land Use in the Lower Bermejo River, Argentina.** The aims of this study are a) understand and evaluate the Bermejo River fluvio-sedimentologic dynamics and its water regimen, estimating its effects on the geomorphology of the valley, and the social-economic and ecological consequences; b) provide information and criteria for an environmental zoning of the areas affected by said dynamic, so as to identify management alternatives and elaborate recommendations. Digitalized thematical maps will be prepared, in order to characterize the natural resources baseline.

Work Program Element 2.6: **Management of Forage- Humid Chaco[1], Province of Formosa, Argentina**. This is a project of strategic value in the humid and sub-humid areas of the Chaco. In this area there are some two million hectares of land infested by *vinal*[2], affecting predominantly middle sized and small farmers. The objective is to determine the costs of utilizing practices for the control of vinal under farm conditions, and establishing the economic benefits to the farmer of the recuperation of productive levels in cattle ranching. The Experiment Station INTA-El Colorado has developed management procedures for *vinal* utilizing water from seasonal waterbodies. Use of those procedures is the only way to ensure protection of the habitat for numerous species of local flora, especially those of natural pastures. A small group of farmers will introduce those practices in their farms.

Work Program Element 3.1: **Transition Forest-Salta[3], Argentina.** This project aims to design ecotourism demonstrative approaches that involve Transition Forests areas in the Yungas, within the "El Rey" National Reserve Project area, in order to propose sustainable alternatives to cope with degrading practices carried out in the region. The implementation of this demonstrative project includes the supply of equipment and infrastructure, training of human resources and the initial public divulgation of the project. This project is carried out with the participation of the National Parks Administration, governmental institutions, provincial NGOs and local owners.

Work Program Element 3.2: **Tolomosa Watershed, Bolivia.** This is a demonstration project for land reclamation, control of sediments, reforestation and sustainable management of soils and water. The feasibility study for this project is concluded. Interventions at the "Quebrada de La Tablada" micro-watershed will be carried out through two components: engineering works for sediment control and agro-forestry and others sustainable practices. The execution of this project will allow the determination of the costs of the whole project and sediment abatement measures effectiveness to be taken at Jacinto reservoir.

Work Program Element 3.3: **Sustainable Development. Yungas,[4] Salta, Argentina.** This project, to be developed by a group of small farmers in an area in the vicinity of Los Toldos, will draw upon the experience of the Laboratory for Ecology Research in the Yungas (LIEY-University of Tucumán). The main objective of this project is to mitigate the antropic pressure on natural resources. It intends to integrate the farmers families into the regional market, generate local employment alternatives, improve the education level of the schools in the area, and search for sound sustainable management of the natural forest resources, within a multiple use criterion, that can be applicable to other communities of similar social-economic and ecological conditions. The GEF support will provide for the technical and economical assessment of the implemented practices.

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1 The Chaco region is an extensive area of plains located in the central part of tropical and sub-tropical South America, covering approximately one million square kilometers, in parts of Argentina, Paraguay and Bolivia.

2 Vinal (*Prosopis ruscifolia*), a woody invasive tree or shrub in the Chaco region, is a close relative to mesquite (*Prosopis juliflora*).

3 Transition forests are located in the plains, in the ecotone between Subandean_montane rain forests and dry forests of Chaco.

4 The Yungas ecosystems are montane cloudy forests located in the primary slopes of the Andes.

Work Program Element 3.4: **Removal of Constraints-Dry Chaco and Humid Chaco. Province of Chaco, Argentina**. The adoption of practices of sustainable use of natural resources are constrained by both the lack of land title and the poor quality of surface and groundwater during the dry season in the Dry Chaco and by floods in the Humid Chaco. The objective will be to promote public participation through demonstrative projects that will solve those constraints, determine the costs of their removal and the benefits of introducing adequate management practices.

Work Program Element 4.1: **Hydrometeorological Network, Binational.** This is a project for the design of a complete binational hydrometeorological network and the rehabilitation of the existing network in the Upper Bermejo River Basin, in order to obtain reliable and continued data needed for monitoring the basin.

Work Program Element 4.2: **Environmental Law, Binational.** In Bolivia this study will promote the establishment of a legal framework harmonizing laws for sustainable development in critical eroded areas, creating legal conditions for policies, actions and interventions by landowners and public and private institutions within the basin. Bolivian existing environmental laws and their causes and their applicability will be determined. In Argentina the objective is to analyze the present situation of the existing environmental institutional and organization setup, to propose a desirable and feasible model for environmental management and elaborate proposals to be considered in the formulation of the SAP. The SAP project will be one of the first activities in implementing the Treaty on Environment between Argentina and Bolivia. It will also be analyzed the situation of existing laws and treaties in relation with the Oran Agreement and the activities and competences of the Binational Commission.

Work Program Element 4.3: **Ecological Corridor-Baritú/Tariquía, Binational.** This study will focus on the optimization and conservation of flora and fauna through the formulation of joint policies in the territory between Baritú and Tariquía natural protected areas to preserve biodiversity conditions and the equilibrium of the ecosystem. Planned activities comprise an analysis of the legal and institutional framework concerning Baritú and Tariquía; an inventory and ecological complementation of both reserves; the formulation and analysis of alternatives for the installation of a biological corridor; and the evaluation of the physical, legal and biological feasibility of the corridor.

Work Program Element 5.1: **Transboundary Migration, Binational**. This is a study to determine the temporary and permanent transboundary migrations so as to establish the role of migrations in the use, conservation and sustainable development of natural resources within the Bermejo Basin. Work needed is compilation of statistical information and social-economic conditions of the transboundary migrations; social, economic, cultural and anthropological surveys, establishment of patterns of temporary and permanent migrations; and an analysis of the relation among migrations and the management and use of resources.

Work Program Element 5.2: **Environmental Education-Formosa, Argentina**. The purpose of this project is to promote and contribute to build up environmental awareness through forest cultivation in selected schools and communities in Eastern Formosa. Forests in this area are affected by a process of degradation due to poor management practices. The objective of this project will be to show the local population that costs of management practices are justified by the productive recuperation of native forests.

Work Program Element 6.1: **Formulation of the Strategic Action Program,** Binational. Formulation of a SAP is the main activity. It consists of the identification and harmonization of development initiatives in the Bermejo Basin, followed by an strategic integration and rationalization of those initiatives and the proposals for sustainable development in the region. It will include an environmental evaluation of the basin, emphasizing the analysis of transboundary problems, and a socioeconomic survey reviewing environmental practices and their relation with the education, health, income and organization of local population. Support to Government efforts at introducing environmental considerations into the laws and regulations at the national and regional levels is a part of SAP

Work Program Element 6.2 **Public Participation, Binational**. This is a program of seminars, courses, workshops and publications designed to engage the active participation of the many communities living in the Bermejo River Basin, in order to increase the awareness of inhabitants in relation to environmental concerns, avoid the disruption of the ecological balance and promote the protection of their habitats. Most of the SAP components will also incorporate specific activities of participation or public consultation.

ANNEX II

BASIC ENVIRONMENTAL DATA

ANNEX II

BASIC ENVIRONMENTAL DATA

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- **1.3 Climate**
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- **1.5 Water quality**
- **1.6 Transportation of sediment**
- **1.7 Soils**
- **1.8 Vegetation**
- **1.9 Wild animals**
- **1.10. Nature conservation**

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- **2.2 National and Sub-national (Provincial) Level**
- **2.3 Regional Level**
- **2.4 Binational Level**

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- **3.2 Economic aspects and production**
  - **3.2.1** Land use
  - **3.2.2** Subdivision of the land
  - **3.2.3** Soil use with agroindustrial crops
  - **3.2.4** Generation of industrial employment
  - **3.2.5** Industrial establishments and generation of industrial value added
- **3.3 Road infrastructure**
- **3.4 Transboundary migration**
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BASIC ENVIRONMENTAL DATA

The following data present an environmental profile of the basin, showing the major sectoral aspects of the natural environment, the socioeconomic setting, and the existing legal and institutional framework. The Work Elements developed by the SAP Project are presented in Annex I while the corresponding documents and final reports, produced between 1997 and 1999, are listed in Chapter 4 of the main text. The numerical refrence to said documents is placed among brackets along the texts.

1. THE NATURAL ENVIRONMENT

This binational basin is marked by active and intense hydrological, geomorphic, and ecological processes, with significant potential in terms of natural resources, variety of ecosystems and biodiversity. But it also has strong environmental limitations and risks, both bio-geophysical and social. This situation -- and the need to take energetic development measures to improve the quality of life of the people, in a context of the lack of policies and management and development instruments with a broad enough view of the basin to properly understand these problems – were the basis of GEF's decision to assist the governments in drawing up a SAP for the Bermejo River Basin, in the focal area of the GEF of International Waters.

There was a compilation and synthesis of environmental information on the basin, on the basis of an **Ecological Regionalization (31)**, which then became the framework for the analysis of a set of indicators of natural and socioeconomic conditions and related limitations. The territory was divided into hierarchically related spaces on the basis of differing environmental characteristics that were homogenous at each corresponding level. For this purpose we basically used the Subject Mapping (**Figure 9,** and the documents **1, 13, 37),** generated on the basis of interpretation of satellite images and other sources of information. It was possible to identify **5 Eco-regions, 17 Subregions, and 68 Large Ecological Units** (in addition to six around the basin). The following information describes the principal aspects of the environment in general, and specifically the water resources, in the context of the problems identified.

1.1. Hydrography

The River Bermejo Basin, shared by Argentina and Bolivia **(Figures 3 and 4)**, is an important area in the macro-region of the River Plate Basin. Its area is 123,162 square kilometers **(Table 1)** and its principal course is more than 1,300 kilometers long. According to its characteristics, it can be divided into the Upper Basin and the Lower Basin. Various aspects of the water resources have been analyzed in (**1, 2, 3, 4, 13, 14, 23)..**

In Bolivia, the Upper Bermejo Basin is found in the extreme southern part of the country, totally within the Department of Tarija. It covers an area of 11,896 square kilometers. The rest of the Upper Basin and all of the Lower Basin are in Argentina, in the extreme center-north of the country, occupying part of the provinces of Chaco, Formosa, Jujuy, and Salta, with an area of 111,266 square kilometers.

The Upper Basin (50,191 square kilometers) represents the active basin of the Bermejo river. It specifically encompasses the central and southern parts of the Department of Tarija in Bolivia, nearly all the province of Jujuy, and the northern and eastern parts of the province of Salta to the confluence of the San Francisco river and the Upper Bermejo river itself. In this part of the Basin 75.6% of the area is in Argentine territory and 24.4% is in Bolivian territory.

Table 1
TERRITORIAL DISTRIBUTION OF THE BASIN

JURISDICTION		AREA km^2	PROPORTION (%)
COUNTRY	**BOLIVIA**	**11,896**	**10**
Department	Tarija	11,.896	10
COUNTRY	**ARGENTINA**	**111,266**	**90**
Provinces	Chaco	19,47	16
	Formosa	26,445	21
	Jujuy	21,053	17
	Salta	44,521	36
TOTAL		**123,162**	**100**

The hydrographic network is composed of four main tributaries: the Tarija Grande river, the Upper Bermejo river, which after Juntas de San Antonio is called simply the Bermejo, the Pescado river, and the San Francisco river.

The Tarija river, situated entirely in Bolivia, originates in the Sama ridge, and near its source is called the Guadalquivir. After the confluence with the Camacho river, it is called the Tarija. From there it continues predominantly in a northwest-southeast and north-south direction to its junction with the Itaú river. The principal sources in the north are the Salinas and Chiquiaca rivers, and in the south the Pampa Grande river. From its confluence with the Itaú it is called the Tarija Grande river, and it forms the border between the two countries, until Juntas de San Antonio.

The Bermejo river also arises in Bolivia, in the vicinity of Padcaya. Initially it is known as the Orosas until in meets the Condado river, and then is called Bermejo where it begins to take a northwest-southeast direction to the confluence with the Tarija river. This last sector is a border and receives input from the Lipeo and Toldos rivers on the right bank (Argentina), and the Emborozú and Guandacay rivers on the left bank (Bolivia).

After Juntas de San Antonio, the Bermejo river, fully within Argentine territory, continues in a northwest-southeast direction and receives on its right bank the flow from the Pescado river and the Blanco or Zenta and Colorado rivers. It should be noted that the Pescado river basin includes, since 1865, the waters from the Iruya river basin, which was diverted at that time to prevent flooding in the city of San Ramón de la Nueva Orán, because that basin is a main source of sediment.

In the southern part of the region, the San Francisco river takes its name in the final section after the juncture with the Grande river, which has the longest trajectory in this sub-basin, completely within the province of Jujuy with sources in the ridges of Chani, Aguilar, and Santa Victoria and is initially known as the Quebrada de Humahuaca. Its tributaries on the left bank are longer than those on the right bank. The most important are the Calete, Yacoraite, Huasamayo, Volcán, Lozano, Yala, Reyes, and Perico. The inter-provincial Lavayén river is a tributary of the Grande river on its right bank from the south-southeast, fed by the Mojotoro river that flows entirely in the province of Salta

The Lower Basin (72,971 square kilometers), totally within Argentine territory, is marked on both sides by the winding course of the Bermejo river[1/] in the eastern part of the province of Salta. After crossing its boundary it becomes the border between Formosa and Chaco until it empties into the Paraguay river **(Figures 3 and 4).**

In the Lower Basin, it should be noted that from the place called Desemboque, the Bermejo river changes its name to Teuco, because from there toward the southern shore flows the old bed of the Bermejo. This is fed by others, diverting from the Quirquinchos and Zanja del Saladillo swamplands, which receive water from the important Dorado and del Valle rivers and an extensive network of ravines. There is an important group of rivers, brooks, and streams that eventually flow into the Bermejo river or are fed by its overflows. In the province of Formosa, we could note the Teuquito river on the northern shore, the Dobagán, Mbiguá, and Lindo brooks and the Salado, Saladillo and Negro runs. In the Chaco province, on the south shore, it feeds the Bermejito, Muerto, and Oro rivers, the Guaycurú, Guaycurú Chico, Cangui, Cangui Chico, and Zapirán brooks, and the Guaycurú, Salado, and Nogueira runs. In this whole region of intermittent courses and pools there has to be a great amount of mingling of the surface runoff in the floodable areas and underground drainage. **(Figure 4).**

1.2. Geology and Geomorphology

In Bolivia, the basin is divided into two geomorphic regions: the Eastern range of the Andes, and the Sub-Andean ridge, which continue in Argentina, where there is a third region, the Chaco Plain, with the largest area. In the Bolivian sector the eastern range is found in the water systems of Sama and Cóndor (3,000 to 4,600 meters), which border the central valley of Tarija, which has a river plain at the bottom. In Argentina, there is the Santa Victoria Sierra, which in the south is divided by the Quebrada de Humahuaca. It is a rugged, rocky range with maximum elevations of 6,200 meters. The sub-Andean ridge, which has the eastern Andes on the west and the Chaqueña plain on the east, runs in a north-south direction with an elevation of about 2,000 meters above sea level. In the Bolivian part of the basin, the drainage is greatly affected by the tectonics, with rivers in the sinkholes. In the Argentine sector the drainage system has a sharp west-to-east thrust. In the extreme southeast of the basin, the Santa Barbara Sierra (2,500 meters) borders the broad valley of the San Francisco river.

Initially, an ancient alluvial conoid formed from Juntas de San Francisco to the southeast, covering the Chaco Bajada to below the Barilari Line, in contact with the conoids of the Valle river and the Tartagal river, and on the north with the Pilcomayo. Later, the river must have advanced over its old sediment and formed the large conoids of the north and south of the present valley, which we have called the Conoid of Bermejo Salado and the Conoid of Bermejo

1. The constantly changing course of the river creates a whole set of situations that are difficult to interpret with traditional tools. The beds of the tributaries and frequent and imprecise overflows vary in space and time, not always at the same place because of the effect of the unusual adjacent topography. This includes deactivated beds, filed in with sediment, or intermittent streams with no outlet that end in pools and extensive surfaces for reception and transpiration through the existing vegetation.

FIGURE I
RATE OF PROPDUCTION OF SEDIMENTS BY EROSION IN THE UPPER BASIN

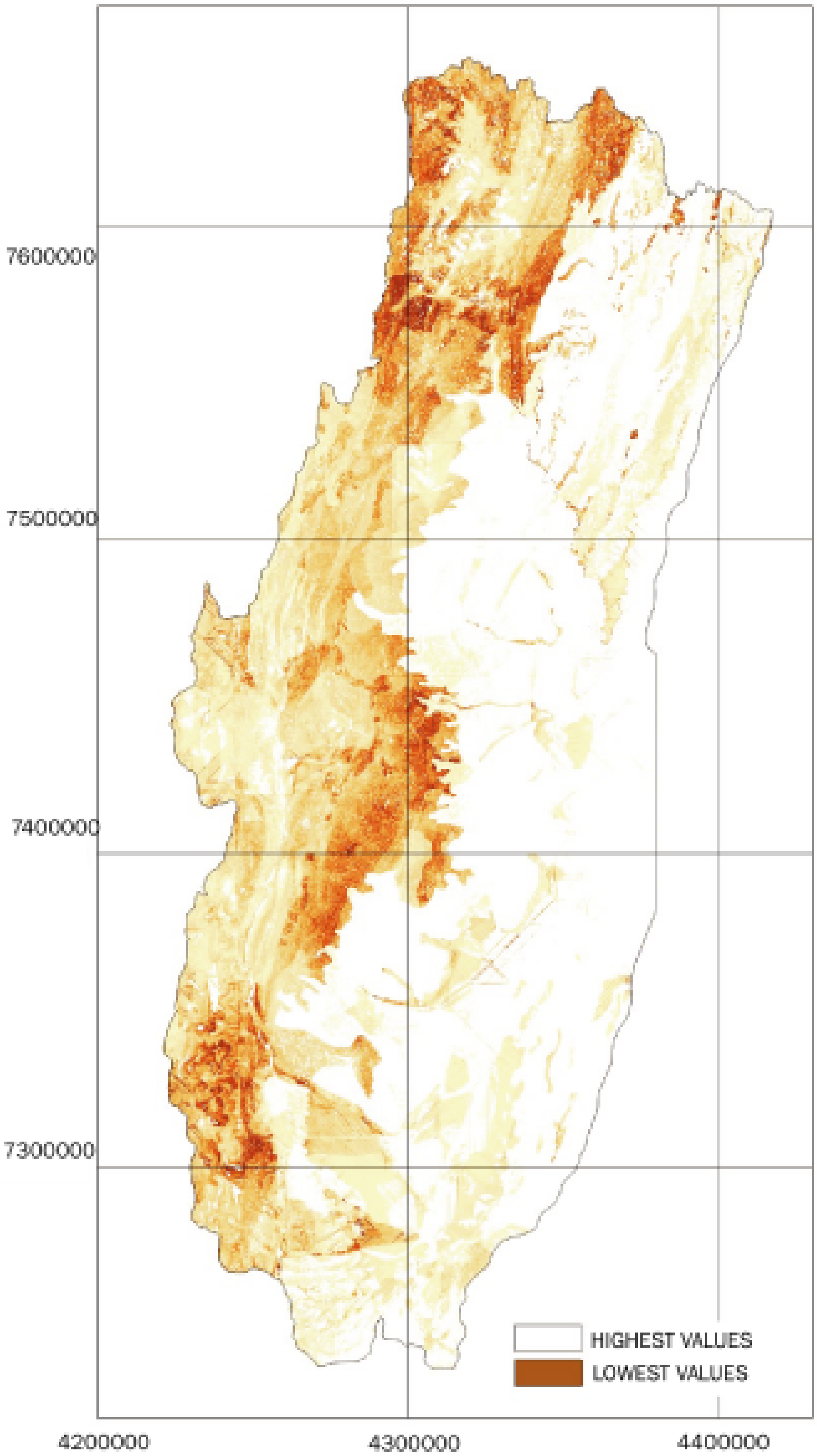
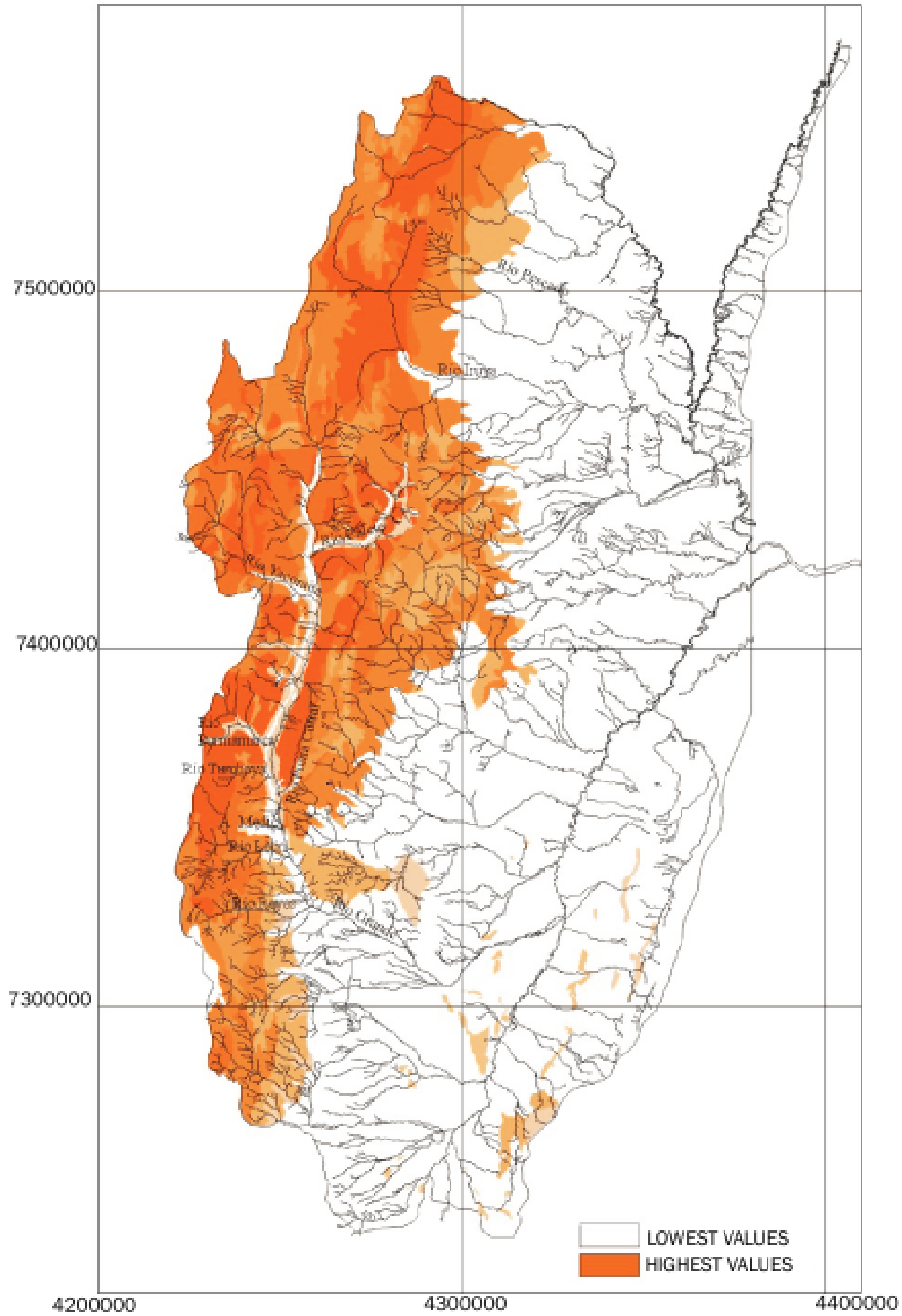


FIGURE II

AREAS MOST SUSCEPTIBLE TO GENERATION OF MASS MOVEMENT TO THE UPPER BASIN



Guaycurú. In this whole area it is easy to recognize the buildup that extends like fingers over the plain and is directly linked with the upper high cloudy forest.

The Eastern Andes and the Sub-Andean ridge contain sectors that are extremely active from the geomorphic point of view. The process of generation of sediment, which affects substantial areas, has been studied in all of the Upper Basin by **(2),** by means of a simulation model[2/] so **Figure 1** presents one of its findings, the *Rate of Sediment Production from Surface Erosion.* It should be noted that this study has comparable value in the overall Upper Basin environment. By contrast, **Figure II** presents in qualitative form the *Areas Prone to Generate Massive Land Movements for the Argentine Upper Basin* (for example, landslides and large movements of hills). This process is one of the major contributing factors to sedimentation in the basin, and constitutes a natural threat of environmental risk for local settlements, many of which are poor. Some sectors have such complex and intensive shifts that they are being given special study, as in the central valley of Tarija, the Iruya river basin, and Quebrada de Humahuaca.

Significant amounts of material accumulated in the Upper Basin are carried by the river system toward the Lower Basin, where the plains serve as the major recipient of medium and heavy material. Fine material is carried downstream, outside the basin. Various agents have sculpted the area (polygenic plain), but the primary ones are those associated with rock movement. This is evident in the complex matrix of geomorphic units that affect drainage, soils, and vegetation. In very recent eras, the Bermejo river underwent many shifts of position, covering an area that we call the plain of digression. Even today, the entire plain is very active from a geomorphic standpoint.

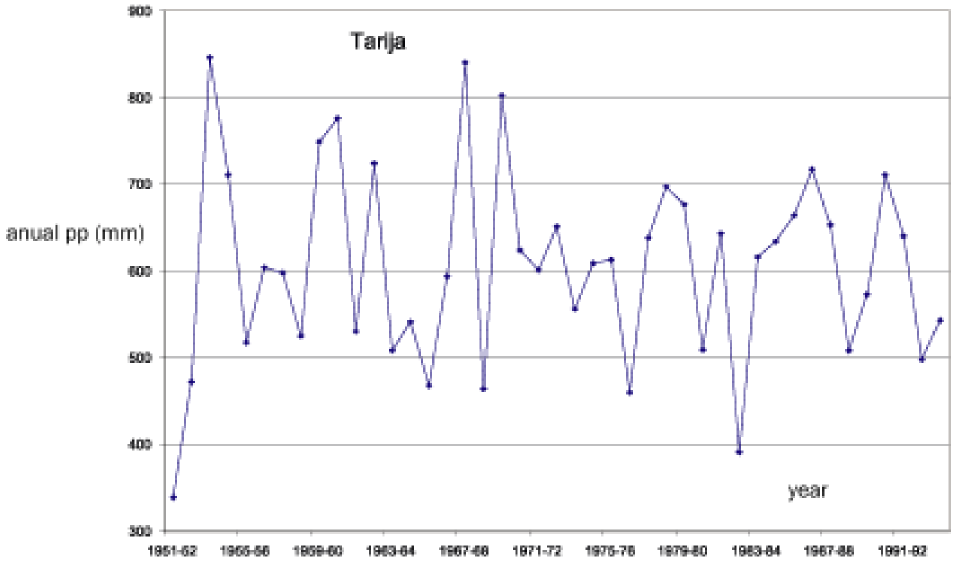
1.3. Climate

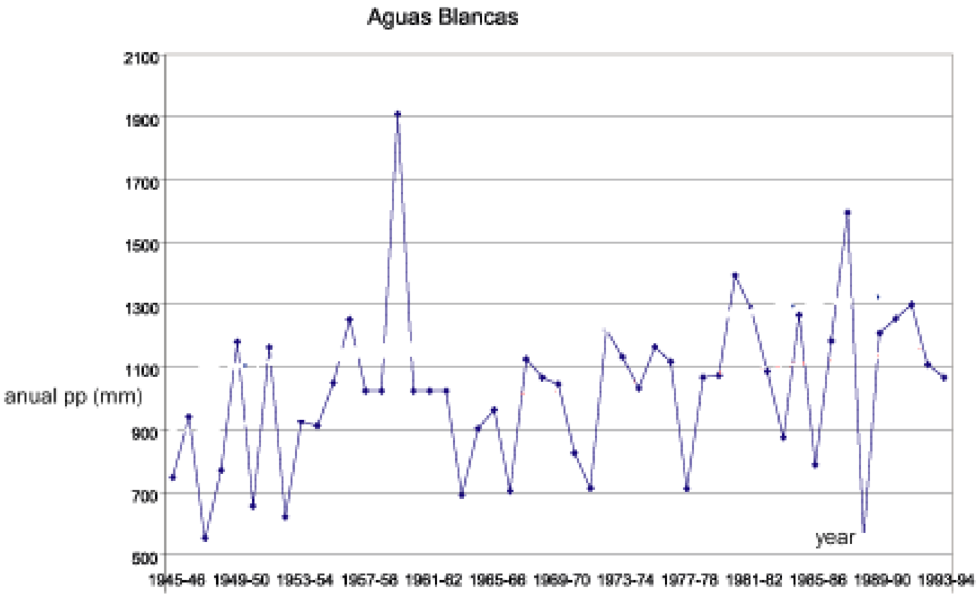
The Basin is located in a transition climate zone.[3/] This is especially evident in the Upper Basin, where in a short distance one encounters significant variations, from a cold semi-arid montane climate in the west, to a tropical humid climate in the east. The mountain mass is an important factor affecting circulation of air masses in the region. Maximum precipitation,(according to **(1**), is found in the sub-Andean Eco-region, with more than 2,200 millimeters per year, diminishing toward the west to 200 millimeters (Eastern Andes Eco-region) and toward the east to 600 millimeters in the center of the Semi-arid Chaco Eco-region, and increasing to 1,300 millimeters in the sector of the confluence with the Paraguay river, in the Humid Chaco Eco-region (**Figure 5**).

Elevation and longitude from the Upper Basin in the northwest to the Lower Basin in the southeast presents a heterogeneous climate pattern, with the following variations:

2. The results of the application of this simulation model have been properly compared. See a breakdown in **(2). Figure 1** shows spatially only the intensity of the rate of production of sediment from surface water erosion. There could be other erosive factors that are not reflected in the model.
3. The region as a whole is influenced by subtropical cyclones and by the interruptions caused by the formation of a low pressure center in the Andes mountain range.

FIGURE III
REGISTERS OF RAINFALL SATATIONS
IN THE SUBSIDIARY BASINS OF TARIJA AND BERMEJO RIVERS





- ***Cold Zone:*** located at elevations above 2,700 meters above sea level, where the following two climates are found cold: *semi-arid and cold sub-humid.*
- ***Temperate Zone:*** at elevations of between 1,500 and 2,700 meters above sea level, with climates that are *temperate arid, temperate semi-arid, temperate sub-humid, and temperate humid.*
- ***Warm Zone:*** covers the whole eastern area of the basin, the Sub-Andean zone and the Chaco Plain, where four climate types are found: *warm sub-humid, warm humid warm very humid, and warm semi-arid.*

It should be noted that there are large sections of the territory in the basin that are short of water. These are in the Eco-regions of the Eastern Andes (with dry spots as in the Valle Central de Tarija and especially the Quebrada de Humahuaca) and the semi-arid Chaco, as shown in **Figure 5** the average annual distribution of rainfall. This restriction in the environment is compounded by the growing shortfall and seasonality of rain from the Eco-region (from east to west), with a growing period of drought. This climatic condition results in limitations on use. The drought conditions, combined with torrential rains in the context of the unstable contours lead to the occurrence in the Upper Basin (especially in the Eastern Andes Eco-region) of natural threats such as mass movements of all types (landslides, mudslides, avalanches, etc.) as well as the processes of surface water erosion.[4/]

Another important aspect associated with climate is the great inter annual variation in rainfall, with extreme heavy rains and drought periods . This situation is reflected in **(35)** in the registers of the rainfall stations located in the sub-basins of the Tarija and Aguas Blancas rivers, shown in **Figure III,** with variations of between nearly 750 mm. (1988) and 2,100 mm (1959) for the same rainfall measuring station.

1.4. Hydrology

The hydrological regime of the rivers is controlled by rainfall, and as such presents clearly delineated seasonal variations, with a period of heavy flow in the rainy season, with up to 75% of the flooding between January and March (reaching 85% in the entire season), and another period of light flow in the dry season (April to September, when it drops to as low as 11%).

Flow data for the Bolivian sector or that shared by both countries, measured in the respective gauging stations, are shown in **Figure IV.**

As for the **Bolivian sector of the Upper Basin,** during the period in question the average flow of the Bermejo river, at Aguas Blancas, was 92 cubic meters per second, while the average flow of the Tarija Grande river, at Algarrobito-San Telmo, was 127 cubic meters per second. The specific slowest flow was recorded in the basin of the Santa Ana river in the Central Valley of Tarija, with 2.8 liters per second (square kilometer), and the heaviest was found in the Emborozú sector with 27.5 liters per second (square kilometer).

4. Castro, H, Arzeno, M, 1999. Environmental risk in the Quebrada de Humahuaca: components, perceptions, and responses. Institute of Geography, University of Buenos Aires.

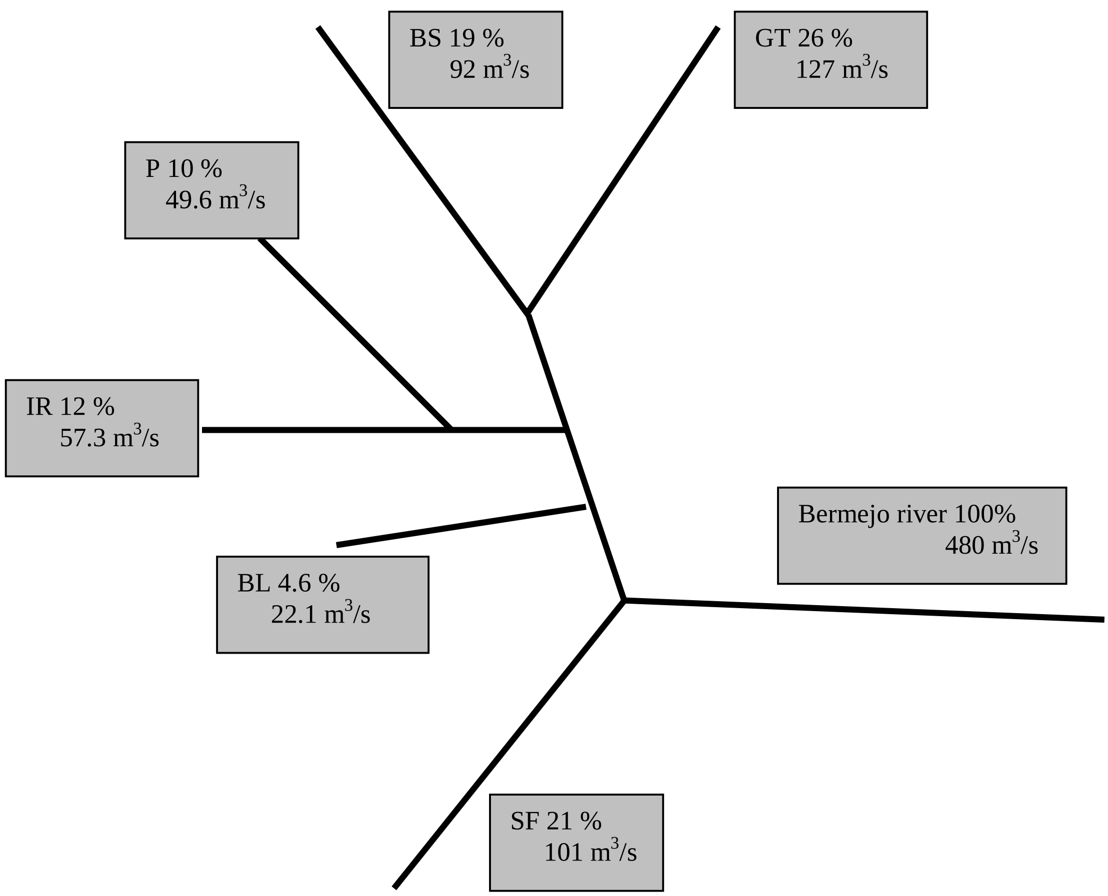
On the basis of available information, and correlating the specific flows with the average rainfall, the availability of water for every sub-basin, and for characteristic sections of the main rivers, was calculated.

Minimum flows in the Tarija valley rivers are completely used in irrigation and drinking water, so the minimum flows of the Tarija Grande river registered before the confluence with the Bermejo (Juntas de San Antonio) basically comes from the subbasins of the Sub-Andean region. This arrangement changed after 1988, with operation of the dam of San Jacinto, which increased natural minimum flows on the order of 10 to 20%.

As for the **Argentine sector of the Upper Basin,** on the basis of available data (EVARSA, Hydrological Statistics, Volume I, 1994, MeyOySP, 1994) the average annual flow of the Bermejo before Junta de San Antonio is 92 cubic meters per second, with a specific value of 18.2 liters per second (square kilometer), while the data for the Tarija Grande river before its confluence with the Bermejo is 127 cubic meters, with a specific flow of 12.4 liters per second (square kilometer), and the average annual flow at Junta de San Antonio is 219 1 cubic meters per second, of which 56% is from the Grande Tarija river and 44% from the Upper Bermejo. (**Figure IV**).

FIGURE IVa

LIQUID AND SOLID FLOWS IN THE UPPER BERMEJO BASIN
LIQUID FLOWS:



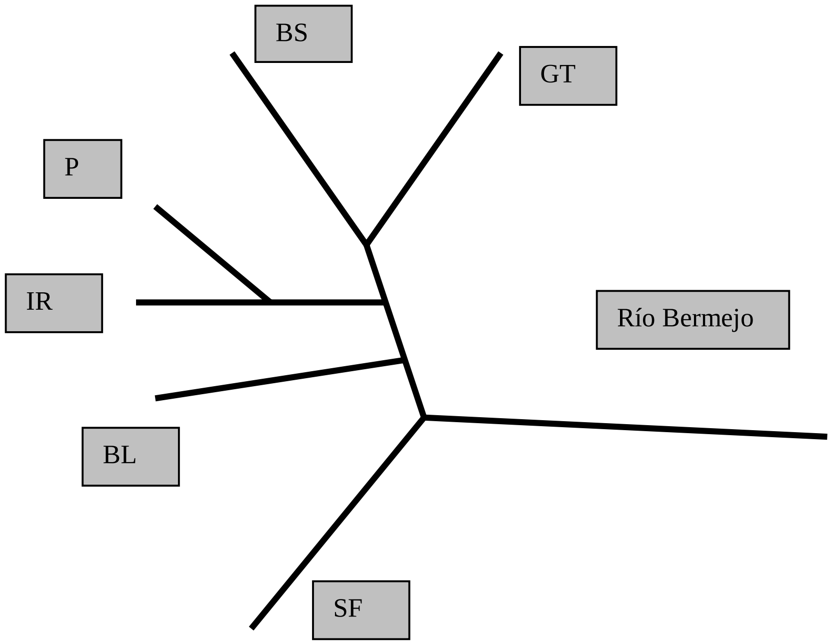
Legend:

GT:	Tarija Grande river.
BS:	Upper Bermejo river.
P:	Pescado river.
R:	Iruya river.
BL:	Blanco river.
SF:	San Francisco river.

Source: EVARSA (1994) and others

Figure IVb

LIQUID AND SOLID FLOWS IN THE UPPER BERMEJO BASIN
SOLID FLOWS:



FLOWS	GT	BS	P	IR	BL	SF	Bermejo
Solid flow (10^6 tn)	12.96	8.64	5.76	36.72	7.92	18	90
Solid flow (%)	14.4	9.6	6.4	40.8	8.8	20	100
Specific solid flow (tn/km^2.year)	1,239	1,781	3,388	12,447	1,571	698	1,772
Watershed Surface (km^2)	10,460	4,850	1,700	2,950	1,571	25,800	50,800

Legend:
GT: Tarija Grande river. BS: Upper Bermejo river. P: Pescado river. IR: Iruya river. BL: Blanco river. SF: San Francisco river. Bermejo: water below Juntas de San Francisco

Source: EVARSA (1994) and others

After the confluence of the Pescado and Blanco rivers, the module of the river reaches 347 cubic meters per second. With the input from the Grande-San Francisco system, whose module is 101 cubic meters per second and specific flow is 3.91 liters per second (square kilometer), the Bermejo river attains 448 cubic meters per second, which is the contribution of the water from the Upper Basin to the Lower Basin.

In the **Lower Basin,** evaluations of the monthly flow in El Colorado, with a module of 386 cubic meters per second and a specific flow of 5.88 liters per second (square kilometer) mean the hydrogram shows a displacement of the cresting wave for the months of February to April, and the low point from the months of June to December. An analysis of the data shows that the area contributing the greatest specific flow is the sub-Andean sector (in the Upper Basin of the Bermejo river the specific flow in the Balapuca station is twice that at the Alarache station (40 kilometers upstream), which is in the sector with the highest rainfall in the entire basin.

In Bolivia, current use of the water of the Bermejo and Tarija Grande basins is limited to irrigation of cultivated areas, human consumption, and for livestock. The estimate of current demand (based on the irrigated area and the total of the present population) is approximately 110 hm^3/year, which is smaller than 2% of the volume available in the basins. However, considering the natural minimum flows (in the month of September), current use is nearly 100% of the available flow of the rivers in the entire inter-Andean region, especially in the sector of the central valley of Tarija, which is where the highest population concentration is found, and the largest area of irrigated crops. In the central valley of Tarija there is only one dam for regulating the flow, the San Jacinto dam, located on the course of the Tolomosa river, which has a useful storage capacity of 48.7 hm^3 with a basin of 432 square kilometers. This is a multiple use dam (generation of electric power, irrigation, and drinking water for the city of Tarija).

In the Argentine sector of the basin, the main use of the water resources of the Bermejo system is for the development of low irrigation crops (cotton, soybeans, rice) and the supply of water for human consumption and livestock. In Jujuy the Las Maderas and La Ciénaga reservoirs, together with Los ;Molinos diversion damon the Grande river, supply irrigation water for the Pericos valley system, as well as potable water and electric power generation. The flooding that drains the piedmont areas of the Upper Basin in Salta and Jujuy are used to support local irrigation networks. In the section of the Lower Basin water is diverted for irrigation and drinking water, as is the case of the Laguna Yema system, in Formosa, or important private irrigation systems, like the rice project currently under development in Chaco (much of it on the flood plain of the Paraguay river).

Document **(35)** has studied the impact of the so-called climate change in the surface hydrology of the basin on the basis of currently accepted premises. The estimates made indicate different effects of the El Niño phenomenon on the Upper Basin and the eastern edge of the Lower Basin (sectors under the influence of the Paraguay river—River Plate basin). The phenomenon of El Niño—Southern Oscillation (ENSO) is one of the major variables in atmospheric circulation and affects the main components of the water cycle, which are responsible for unusual floods and droughts.

In the Upper Basin, the data from Aguas Blancas in the study on monthly levels show that the occurrence of cold episodes in the Pacific Ocean (La Niña) produce average monthly flows slightly higher than the average for the month of March, and the hot episodes (El Niño) produce lower than average flows.

In the final stretch of the Bermejo for the Lower Basin and the area of influence of the Paraguay river—River Plate, the effects of the extreme events of El Niño and La Niña are the opposite of those in the Upper Basin. In fact, water flow data show higher volumes for the months of El Niño and lower volumes for the cold events (La Niña).

This same study has examined the sensitivity of the water resources in the principal sub-basins to the effects of the global climate changes on the rainfall and temperature in the region of the basin. The various scenarios studied show a tendency toward increasing temperature and evaporation as a consequence of the increase in carbon dioxide in the global atmosphere, which would result over the long term in a reduction of flows. The San Francisco basin appears to be the most sensitive to the effects of climate change.

1.5. Water quality

The large scale of these basins and the diversity of environmental and use conditions result in widely differing water quality.

One of the variables is the hydrological system. During high flows in the wet season, a decisive factor is turbidity, which is high and presents similar characteristics in all the rivers. In the intermediate stages the quality is a factor of turbidity and the concentration of fecal coliforms, which are much lower than in the dry season. During the dry season, the conditions become more critical. Generally the water of the rivers in the basin has medium to low content of salts and low indexes of sodium absorption, so the water is good for irrigation.

In Bolivia, for classification by suitability for consumption we have employed the criteria established by the regulations of the Environmental Law No. 1333, and for classification by suitability for irrigation we have used the Agriculture Manual of the Soil Conservation Service of the United States.

The principal sections with low water quality (suitability D, not suitable for human consumption with conventional treatment) are found in the following rivers: Guadalquivir (between Tomatitas and the junction with the Camacho), Camacho (between Chaguaya and its junction with the Guadalquivir), Salinas (in the Entre Rios-La Cueva section), Tarija Grande (from the confluence with Quebrada 9 to the junction with the Bermejo), Bermejo (in the section Aguas Blancas-gauging station to the junction with the Tarija Grande). The control points suggest similar conditions of unsuitability (suitability D) for the quality of water in the following sites: Guadalquivir river in the El Tejar zone and Camacho river in the El Mollar zone. The evaluation of the quality in terms of suitability for irrigation shows that in Bolivia, of 20 sites sampled, 17 have medium salinity (no restrictions), two were highly saline or very saline, and only one was of low salinity.

As a reference, (**Table Nº 2**), 28, out of 41, control sites surveyed in the Bolivian sector, exhibited some degree of pollution (mainly bacteriological or due to organic matter). The greatest organic pollution, obviously, is found in the sections of the rivers where there are population centers, due to the dumping of semi-treated or raw waste water, and of waste water from the sugar and alcohol industries.

In the Argentine sector of the basin, the data obtained from the control points indicate that of 14 sites sampled, six have some sort of restrictions on use, in all cases because of bacteriological contamination (total and fecal coliforms), to which often must be added excessive concentrations of iron or sulfates.

The latest census data available (1988)[5] indicate that in the Argentine basin, only 6% of the area of farmland is used for crops, such as tobacco, beans, sugar cane, citrus, corn, and sorghum, pastures, vineyards, timber, fruit, and cotton, which could potentially contribute with runoff from pollutants associated with pesticides and/or inappropriate use of farming techniques, as well as erosion that occurs naturally in the zone, reaching the Grande, Lavayén, and San Francisco rivers and finally the waters of the Bermejo river. As shown in the map of soil use (**Figure 13**), crops with the largest area are sugar cane, tobacco, and soybeans, which are found primarily in the piedmont of the sub-Andean Eco-region. Overfarming or use of improper techniques for the agrosystems can ruin the soil and contaminate the environs, affecting even the river courses in the basin.

Available data for the basin in both countries, presented together in **Tables 2 and 3** at the end of this **Annex** summarize the classification of water control by monitoring stations.

1.6. Transportation of sediment

The study of cross-border transportation of sediment has been one of the points of interest of the TDA in both countries (**2 and 14**). This is reflected in the generation of the model of production of sediment by surface erosion in the Upper Basin (Bolivian and Argentine), and the morphological model of the principal water courses in the Upper Basin and the Lower Bermejo.

The amount of sediment transported in the Upper Basin was estimated on the basis of measurement of 24,000,000 tons per year up to Juntas de San Antonio, with roughly 15,500,000 tons per year corresponding to the Tarija Grande river and 8,500,000 tons per year to the Bermejo river. Stated in terms of surface units of the basins, that is 1,400 tons per square kilometer/year and 1,700 tons per square kilometer/year respectively. In the area of the basin that was studied, surface erosion is the main producer of sediment. In the central valley of Tarija, the amount of sediment that enters San Jacinto reservoir has been estimated at 1,697 cubic meters/square kilometer/year.

These amounts have been reasonably replicated in the sediment production model, which indicate that the amount of sediment generated just by surface erosion and transported to the border area of the Upper Basin (Juntas de San Francisco) is about 18,500,000 cubic meters per year (corresponding to 49,000,000 tons per year). The 64% has its origin in Argentinean territory and remaining 36% in Bolivian territory, according **(2)**.

In the Argentine sector of the Upper Basin, in addition to the production model indicated, we made a map of the areas of greater susceptibility to the processes of slippage, sliding, and rapid mass movement (**Figures I and II**). The slope (**Figure V**) is one of the determining factors. The Iruya, Pescado and Grande river of Jujuy are the sub-basins with the greatest propensity to generate sediment.

Results of the production model indicate that the Argentine sector of the Upper Bermejo Basin produces and transports to the edge of the basin 31,400,000 tons per year of sediment from

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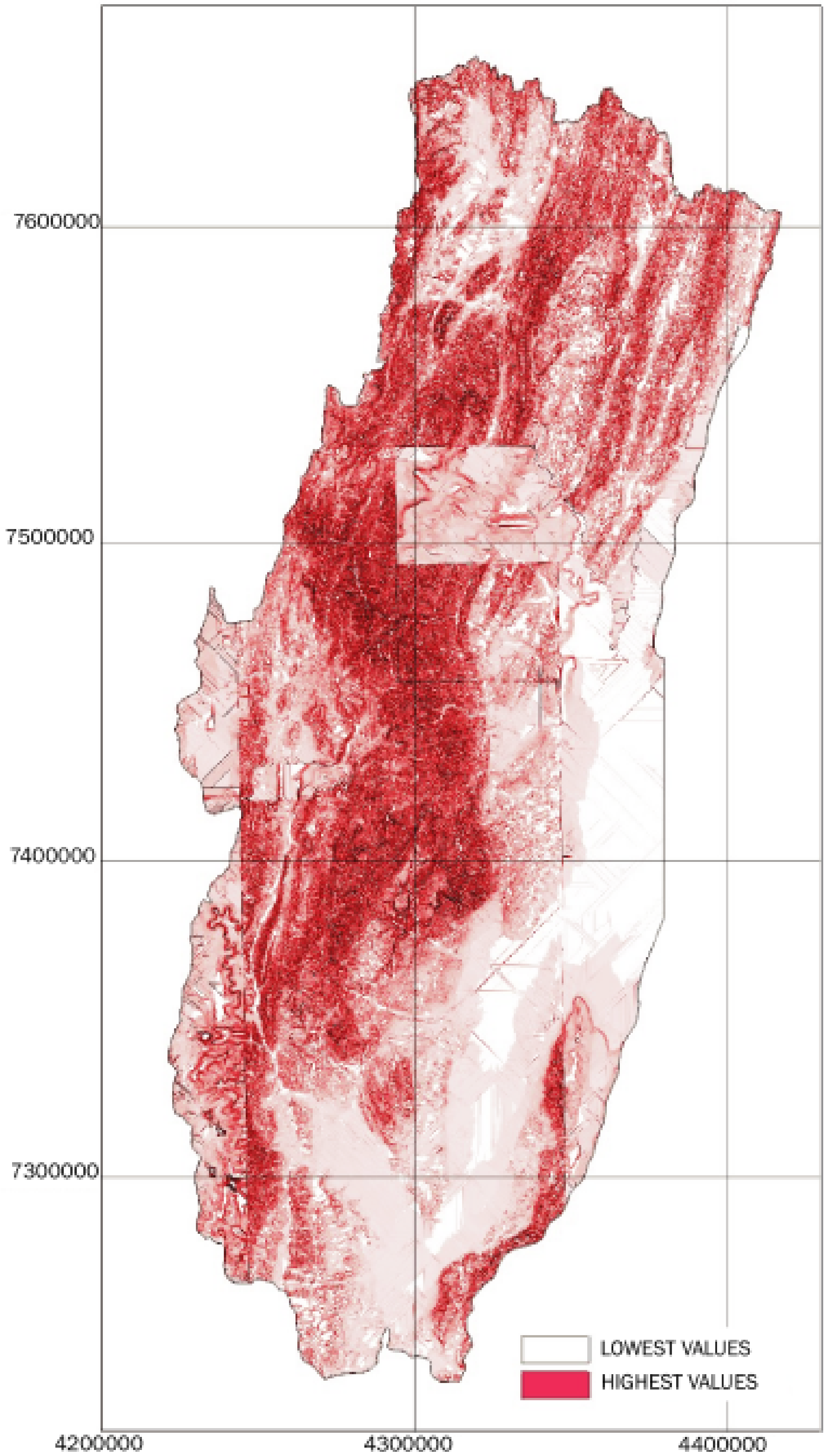
5. With regard to the currency of census data, Argentina is nearing the end of the inter-censal period. Therefore the only information available at the departmental level is partially out of date. On the other hand, the data from the provincial level are much fresher.

FIGURE V

MAP OF THE SLOPES OF THE UPPER BASIN



surface erosion, which added to the amount produced in Bolivia by the same source gives a total of about 49,400,000 tons per year (the rest of the sediment transported is caused by mass erosion).

The gauging stations for suspended solids that are most typical of the Argentine sector of the Upper Basin, and the average annual amount and maximum monthly amount carried are shown in **Table 4.**

The geographical identification in the spatial distribution of the rate of production of sediment in the basin is shown in **Figure 1**, as a result of the application of the abovementioned mathematical models.

The morphological models done for the Upper Bermejo river show the present situation of the channel is relatively stable, with a probable tendency for erosion. In the section down water to Juntas de San Francisco there is the opposite condition, with a tendency to movement based on the heavy input of solids from the tributaries, the Tarija Grande, Iruya-Pescado, and Blanco rivers, in the initial and central stretch, and the Santa Maria-Colorado and San Francisco rivers in the final stretch.

As for the scenarios analyzed to evaluate the impact of the accumulation of solids in the rest of the system, it is significant that there is little influence from the major reduction in the buildup of sands in the basin that produces the most sediment, in the morphology of the section of the Upper Bermejo river downstream, and the contribution of sand toward the Middle and Lower basins of the Bermejo river.

Table 4
SOLIDS SUSPENDED IN THE BERMEJO RIVER

Name of river/Gauging Station	Total annual avg. suspended Solids, thousands of tons	Monthly max. suspended solids, thousands of tons
Bermejo / Alarache	5,023	2,268
Bermejo / Balapuca	8,062	4,163
Bermejo / Aguas Blancas	8,346	14,337
Iruya / San José	13,127	5,953
Iruya / El Angosto	35,.341	12,.265
Pescado / Pto Romero	5,312	3,186
Bermejo / Zanja del Tigre-Pozo Sarmiento	70,.508	34,138
San Francisco / Caimancito	18,901	10,219

As for mud and clay, given the characteristics of the rivers of the network it is clear that the transport of these elements is done as “washing load” in the entire Upper Bermejo river. In these conditions the concentration of mud and clay is determined by the amount of these materials put into the current, and not by its capacity to transport them.

This indicates that decreases in the amount of fine sediment carried will be reflected almost without alteration at the exit from the upper basin, at Junta de San Francisco. Although this is true in theory, in practice the situation is more complicated. There are other factors, such as morphological changes, reincorporating fine sediment in the flood plains and banks, which means there is indeed recovery of fine material.

About 80% of the material in suspension carried to the lower Bermejo at Junta de San Francisco comes from the Upper Bermejo sub-basin, and the other 20% comes from the San Francisco sub-basin. If we take into account the series of solid gauging stations at Pozo Sarmiento-Zanja del Tigre (Bermejo) and Caimancito (San Francisco), we see that the former has an average suspension of 70,508,100 tons per year (3,047 tons/km^2 year), and the latter has 18,901,200 tons per year (720 tons/km^2 year), which gives a total of 89,409,300 tons per year (1,811 tons/km^2 year). This amount reaches 120 million tons per year when the ratio of solid/liquid flow is applied to that of average monthly flow.

The morphological model has also been applied to the Lower Bermejo river, from Junta de San Francisco to Route 11, in the vicinity of the communities of L.V. Mansilla (Formosa), and Colonia Vélez (Chaco).

It has been established that the system in its present conditions appears to be in balance from the viewpoint of solids transport. The scenarios for change in the solid input to the Lower Bermejo at Junta de San Francisco that were studied were reductions in the addition of sand. The result was that, as in the case of the Upper Basin, the sand level is rapidly recovered.

With regard to the impact of the reduction of fine particles in the Upper Basin, the possibility of recuperation of mud is greater in the Lower Bermejo, because of the nature of its bed and banks. However, the balances of the transportation of solids in suspension in the system could be indicating slight significance for recovery of bottom mud and banks.

Finally we studied the influence of the variation in sediment load of the Bermejo river on the Paraguay-Paraná-Delta-River Plate system. This led to interesting conclusions. In the first place, the amount contributed by the Upper Bermejo and San Francisco was in practice the same as that of the Lower Bermejo at El Colorado.

Analysis of the Paraguay-Paraná portion for the period studied (1969-89) revealed that the former provides 94% of the total and the latter the remaining 6%. In the percentage corresponding to the Paraguay river, 87% of the total corresponds to the Bermejo, whose share has increased in recent years.

It should be noted that the time of data collection affects the amount of sediment reported, which varies between 90,000,000 tons per year (for the entire period registered) and almost 123,000,000 tons per year (for the period 1969-89). The average can be considered about 100,000,000 tons per year, which is mainly the fine portion (basically mud and clay) of the Bermejo river that is added to the Paraguay-Paraná river systems.

The National Water and Environment Institute (**2 and 14**) and other specialists (**3**) analyzed the incidence of sediment from the Bermejo in the configuration of the Delta of the Paraná and River Plate. The studies indicate that the contribution of sand from the Bermejo to the Paraguay-Paraná rivers is not significant. The same is not true of the mud and clay that make up 90% of the fine particles transported to the Paraná, which silt mainly in the River Plate. An analysis of the sedimentation in the River Plate estuary reveals that the major area of river morphology is the Upper River Plate, contiguous to the delta. The studies indicate that the annual amount of fine material (only mud and clay) dredged in the navigation canals of the River Plate are equivalent to 23% of the total amount from the Bermejo river.

A general conclusion that can be drawn from the studies done (**2**) is that it has not been possible to identify measures for management in the Upper Bermejo Basin that significantly affect the amount of sediment generated. From this point of view, it can be said that the zones that produce the most sediment in the Upper Bermejo Basin are not significantly affected by human action at present.

This is not to say that specific problems of local scope related to the process of sediment production at any point in the basin cannot be solved by the application of structural and/or non-structural measures that are feasible from all points of view and work toward specific local objectives. In this regard, we recommend greater study of the technical and economic possibilities of structural interventions in the drainage network of the basins that flow into the Bermejo river, as well as possible techniques for reduction of widespread erosion.

1.7. Soils

Topography, origin, climate, and river sculpting–among other factors shaping the soil–have been important to varying degrees in the different sectors of the basin. In general terms and on a regional scale, the Upper Basin is the source basin of sediment. This has generated a rich variety of soils, and has been reflected also in their potential for use (**Figure 6**). To this variable one must add the diversity of present and past uses, which has left a mosaic of conditions from the point of view of conservation.

Examination of **Table 5** shows the absence (at the scale of work used) of Class I soils, which are the most arable (without restrictions for their use), and indicates the preponderance of Class VI soils, which have serious limitations and are generally not suited for traditional crops.

By capacity for use, only about 27.3% of the total area of the basin has soils of classes II, III, and IV, which encompass those apt for farming, but with some limitations for this use. Those most suited, classes II and III, total only 11.1%.

Table 5
CAPACITY FOR USE OF THE SOILS OF THE BASIN

CLASSES	AREA IN KM	% TOTAL AREA
II	10,102	8.2
III	3,584	2.9
IV	12,966	1.5
Mosaic III	6,975	5.7
V	7,679	6.2
VI	52,326	42.5
VII	20,558	16.7
VIII	7,971	6.5
Flooding area	999	0.8
	123,162	100.0

Of this total of soils suited for farming, only 1.5% is in Bolivia and the other 98.5% is in Argentina. The class covering the largest area in the basin of 52,326 square kilometers (42.5%) is class VI, not suited for cultivation, but useful for extensive livestock raising, forests, and wildlife.

In Bolivia, soils suited for agriculture (86.7 square kilometers) have limitations because of erosion and infertility, because their fertility is low to very low. 82.4% of the soils in the Bolivian sector of the Upper Basin have problems because of erosion. This is a significant percentage that suggests the need to deal with the problem in planning for sustainable soil use.

In Argentine territory in the Upper Basin the soils are more suitable for farming (class II and III) in the flood plains, as in those of the Grande, Ledesma, and San Francisco rivers, but together they make up less than 7% of the basin.

In the Lower Basin, soils with greatest farming potential (classes II and III) are found in the extreme eastern portion, associated with past changes in the position of the rivers, covering something more than 10% of the total area.

In summary, the soils have serious limitations in terms of potential development of agricultural activities, with many of them affected by varying degrees of current or potential erosion. This is clearly evident in the studies done. (**Figure 6** and the results of **1 and 14**).

1.8. Vegetation

The diversity of environments, climates, and relief is evident in the prolix biomass and forms of vegetation **(Figure 7).** The dominant types in the basin, with more than 47% of the area (58,186 square kilometers) are arboreal, including xerophilous, sub-humid, or humid forests, evergreen, semi-deciduous, or deciduous, and a variety of patterns with dominant forest. It should be clarified that there is a broad degree of forest cover, from high to medium. Next in importance is the mountain forest with 16.6%, and then the biomass with natural dominance of the shrub strata with more than 10% (more than 12,000 square kilometers), including scrub vegetation, shrubs, thickets, deciduous, and mixed growth forests. Cultivated forests occupy 6.1% of the area. **Table 6**, which follows, lists the types and areas the degree of existing changes.

Table 6
TYPES OF VEGETATION IN THE BASIN

LEGEND	AREA km^2	% TOT. AREA
Mainly shrubs	8,941	7.3
Mainly shrubs and scrub	510	0.4
Mainly floodable growth	752	0.6
Mainly high forest	27,806	22.6
Mainly low forest	2,730	2.2
Mainly low mountain forest	1,132	0.9
Mainly inter-Andean forest	66	0.1
Mainly mountain forest	5,262	4.3
Mainly herbaceous steppe	1,833	1.5
Mainly riparian steppe	1,721	1.4
Mainly deciduous thicket	1,964	1.6
Mainly mountain thicket	174	0.1

Mainly sedge	5,990	4.9
Mainly palms	396	0.3
Mainly high pasture	4,038	3.3
Mainly pasture	1,682	1.4
Mainly bald	4,307	3.5
Mainly mountain forest	20,438	16.6
Mainly cultivated forest systems	7,508	6.1
Mixed shrubs	3,350	2.7
Mixed shrubs / herbaceous	1,123	0.9
Mixed forests	14,026	11.4
Mixed high and low forest, pasture	4,463	3.6
Mixed high forest / agrosystems	618	0.5
Mixed floodable forest	493	0.4
Mixed palms	247	0.2
Mixed bald	206	0.2
Mixed sedge	1,386	1.1
	123,162	100.0

The distribution **(Figure 7)** of these types of vegetation, which with varying composition of species are found in the different Eco-regions, is shown in **Table 7.**

Table 7
ECO-REGIONS AND DOMINANT TYPES OF VEGETATION

ECO-REGION	DOMINANT TYPES OF VEGETATION
Eastern Andes	Shrubs, scrub, herbaceous steppes, riparian steppes, deciduous thicket, mountain thicket, high pasture, balds, agroforest systems, mixed forests.
SubAndean	Mountain jungle, high forest, inter-Andean forest, low mountain forest, low forest, sub-mountain sedge, high pasture, balds, agroforest systems, mixed forests.
Semiarid Chaco	High forest, low forest, floodable forest, palms, shrubs, pasture, sedge, balds, agroforest systems, mixed forests.
Subhumid Chaco	High forest, low forest, floodable forest, floodable low growth, palms, pastures, sedge, agroforest systems, mixed forests. .
Humid Chaco	High forest, low forest, floodable forest, floodable low growth, palms, sedge, agroforest systems, mixed forests. ..

In the Sub-Andean Eco-region the Yungas cloudy forest have a group of highly fragile habitats (internally threatened and endangered by humans) in the Upper Basin, represented by the transition jungles, mountain jungles, mountain forests, and high pastures. In Bolivia, according to the Tree Conservation Data Base (1999) the species faced with extinction in this zone are the oak (*Amburana cearensis)* and the cedar *(Cedrela fissilis)*, and 18 others are listed as threatened. (UICN, 1994).

Chébez and Haene, 1994[6/] list the following species (with various arboreal and herbaceous habitats) as being endangered for conservation in Argentina. Endangered: Quebracho Colorado santiagueño *(Schinopsis balansae),* Calaguala *(Anthurium paraguayense),* Paratodo *(Tabebuia caraiba),* Lapacho amarillo *(Tabebuia lapacho),* Soroche *(Pseudobombax argentinum), Tartagalia roseorum,* a high mountain cactus *(Weingartia neumanniana),* a shrubby plant (helecho) *(Nephelea incana),* Tabaquillo *(Cochlospermun tetraporum),* Sacha guinda *(Mutingia calabura),* and two iridaceous species, making in all at least a dozen species. More than 20 other species are threatened.

1.9. Wild fauna

In the whole basin biodiversity, abundance, and distribution of fauna varies according to the specific ecological conditions and the degree of intervention in the natural habitats. In general, there have been few studies of the fauna, except for some hallmark species such as certain migratory birds and the large mammals (cameloids).

The species listed as **in danger of extinction** are the vicuña *(Hippocamelus antisensis),* anteater *(Myrmecophaga tridactila),* swamp deer *(Odocoiles dichotomus),* tapir *(Tapirus terrestris),* jaguar *(Leo onca),* river otter *(Lontra longicaudis),* among the mammals; the harpy eagle *(Harpia harpija),* royal crested eagle *(Spizaetus tyrannus),* yellow thrush *(Xanthopsar flavus)* among the birds; and the pug-nosed alligator *(Caiman latirostris)* and black alligator *(Caiman yacare)* among the reptiles. Threatened species include the cart armadillo *(Priodontes giganteus)*, giant otter *(Pteronura brasiliensis)* and the green parrot *(Ara militaris),* (UICN, 1994

6. Chébez, J.C. and Haene, E. Plants. In Chébez, J.C. 1994. *Los que se van.* Albatros publishers.

and 1999, Preliasco et al., 1999[7]. This long list, which does not include many species in the **threatened** category, demonstrates that there is still strong human pressure on natural habitats and measures for their control are not working. The principal risk factors are alterations to the habitat, especially by deforestation (clear-cutting or selective) and the ever-encroaching agricultural lands. In some cases of species with economic value, legal or illegal hunting has been an important factor in the pressure. **Table 8** shows the number of species of reptiles, birds, and mammals in different categories of conservation. Note that the sub-Andean, Sub-humid Chaco, and humid Chaco Eco-regions are those at relatively greater risk. Mammals are the category at greatest risk.

Table 8
SPECIES OF WILD FAUNA AT RISK FOR CONSERVATION , BY ECO-REGION[8]

SITUATION	**ECO-REGION**			
ARGENTINA[9]	Eastern Andes	Sub-Andean	Semi-arid Chaco	Sub-humid and humid Chaco
Threatened	5	11	10	12
Endangered	1	7	4	9
Critically endangered		1	1	2
BOLIVIA[10]	Eastern Andes	Sub-Andean		
Threatened	3	10		
Endangered		2		
Critically endangered				

Fauna in the mountain jungle habitats and humid areas appear to be at greater risk as a group, although there are some endangered species in other habitats and Eco-regions.

1.10. Nature Conservancy

Conservation of the natural heritage is analyzed from complementary points of view: the protected natural areas, and the humid areas of importance for conservation and biodiversity. Both countries have different legal frameworks **(24;25; Table 10** at the end of this **Annex),** specially applied in the area encompassed by the natural protected areas **(Figure 8). Table 9** at the end of this **Annex** has the full information.

In the entire basin, some category of conservation system is in force in 6,489 square kilometers, which is more than 5% of the area. In Argentina, 2,445 square kilometers of the area of the provinces of Chaco, Formosa, Jujuy and Salta is within the jurisdiction of a protected natural

7. Preliasco, S.; Toledo, M.J; Benzaquen, L.; Domnanovich, A.; De Lucca, G.; Guzmán, G.; Huwiler,C 1999 *Caso Cuenca del Bermejo.* In Survey of the Territory and Conservation of the Natural Environment, PROPUR-UBA (University of Buenos Aires).
8. Due to the procedure used to develop this table, there is overlapping of species as the same category appears in various Eco-regions of the basin.
9. Source: Preliasco et al., op. cit These data are preliminary and should merely be used as a guideline.
10. Ibid.

area, and in Bolivia the area is 3,148 square kilometers, which amounts to 26.5% of the territory. There are a total of 21 protected natural areas within the basin, with a variety of conservation objectives. Their degree of control is generally unsatisfactory. Although it is true that the number of these areas in the entire basin and the area in the Bolivian sector are important indicators, protection of biodiversity and the natural heritage is by no means assured, given the facts that these areas are not truly representative in terms of geographical diversity, habitats and migration routes have been disrupted, there is often occupation with non-compatible uses, and monitoring and control are weak.

Another issue, especially in the Lower Basin, is the existence of several large **wetlands**[11/] (more than 75,000 hectares within the basin, according to **Figures 7 and 8**), although none is listed in the Ramsar Convention[12/]. They include permanent and temporary lagoons, estuaries, pools, rivers, and streams with permanent or temporary flow (Dugan, 1992). The significance of the wetlands such as the Bañados del Quirquincho, Laguna Yema, Lagunas de Yala, Ayarde, Montevideo, Vieja, Cañadas Grande, Teuquito and Condal is great in the dynamic of the Bermejo Basin. They provide ecological services such as the capture of sediment and water purification. They also act as water flow regulators and provide a habitat for many endangered species. In addition, permanent and temporary wetlands offer water for human consumption and livestock. These eco-systems are at high risk because of the growing trend for use of the water resources and increasing human settlement in the basin.

2. LEGAL AND INSTITUTIONAL FRAMEWORK

The political and administrative structure differs in the two countries **(Figure 10).** In Argentina there is a system of federal government, based on a confederation of states called provinces. These are organized into departments, which in turn are subdivided into municipalities. The municipality is the decentralized, autonomous entity at the base of the national institutional pyramid.

Bolivia, from a political and administrative standpoint, is a country with a centralized system of government structured into departments, with provinces divided into sections. These in turn are divided into municipalities, which are subdivided into cantons.

2.1. Political and institutional framework

The Bermejo Basin project has a complex institutional framework because the project is binational and Argentina has a federal structure.

The following plans have been identified:

> Binational: The Binational Commission for the Development of the Upper Basin of the Bermejo river and the Tarija Grande river.

11. Source: Humid ecosystems of Argentina, Wetlands International. Publication 49, 1999.
12. The Wetlands Convention, known as the Ramsar Convention, was first signed by 18 countries in 1971. It has been ratified by more than 114 countries, and covers nearly 1000 wetlands of international importance. Its purpose is to promote conservation and rational use of wetlands.

Regional: Argentina – Regional Commission for the Bermejo river[13/] (COREBE)
Regional: Bolivia – National Commission for the Pilcomayo and Bermejo Rivers (CONAPIBE)
Provincial plans in Argentina: Provinces of Chaco, Formosa, Jujuy and Salta.
Departmental plan in Bolivia: Tarija Department

The strengths and weaknesses of this political and institutional framework are analyzed based on the results of the studies **4 and 25).**

The legal framework of both countries is presented in simplified form in **Table 10,** at the end of this **Annex.** The conclusions reached in study **(24)** suggest that the following issues merit high priority for the legal and institutional framework in Argentina:

Sub-national (Provincial) and National level

a. Legislation is uneven, incomplete, or lacking on the subject of protection of shared natural resources (in many cases those that move through different jurisdictions), such as water (insufficient in terms of quality), air, wild fauna (terrestrial and and aquatic), wild flora, forest resources, nature protected areas (asymmetrical standards, without general standards to constitute a provincial system), waste (incomplete) and total environment (asymmetrical standards). In general the soil resource is considered to be adequately regulated, although the regulations may not be effectively applied).
b. Regulations of existing laws are incomplete, lacking, or asymmetrical, which greatly weakens them (for example, environment, regulations for commercial or sport hunting and fishing).
c. Lack of standards for management instruments, or lack of regulations means they are not applied (this applies to all the provinces of the basin, except for some rules issued for the province of Formosa).
d. Need for close interagency coordination on environmental management.
e. At the local level the regimes in force in the four provinces are adequate and tend to guarantee proper dovetailing of provincial policies and local needs.
f. Lack of provisions for environmental protection, which means the public has no real access to courts for protection of various interests (except Formosa).
g. There are asymmetries and in general serious weaknesses in the mechanisms for public participation such as petitions, referendums, hearings (provided for in the provincial constitutions, but not adequately regulated).

Similar studies in Bolivia offer the following findings:

a. Legal provisions include general standards defining the importance of maintaining the quality of the environment and conserving the natural heritage through sustained use and the preservation of natural resources for the benefit of present and future generations.

13. An Argentine federal agency with representatives from the federal government, the provinces of Chaco, Formosa, Jujuy and Salta that border the basin, and the provinces of Santa Fe and Santiago del Estero.

b. The environmental legislation is found dispersed in various legal codes, regulatory decrees, sector resolutions, and other legal instruments, which makes it difficult to know them and it is complicated to apply them.

c. Although the natural resources are interrelated, each one is covered by separate laws and regulations, independently of the other.

d. The absence of common or overall guidelines in terms of the objectives pursued and the great dispersion of the guidelines give rise to a lack of coherence among the various standards.

e. Many of the provisions have been effectively rescinded by the simple passing of years, although they are still on the books. This is the case with the approval of potential settlement areas, which dates from 1905 and continues to be used as a reference point. The Water Act has not been updated since 1906.

f. There are many fields still not covered by legislation, which leaves many legal gaps.

g. One of the main reasons that the Bolivian legal provisions are so dispersed and incoherent is the lack of proper implementation, which means that many of the rules and actions are only on paper.

2.3. Regional level

In Argentina the Regional Commission for the Bermejo River (COREBE), establish by federal agreement in 1982, is tasked with the rational and equitable use of the shared resource for the development of the region. This agency is the forum for developing policies and management strategies among the provinces involved. All its actions arise from decisions of its Governing Council (composed of the governors of the provinces of Chaco, Formosa, Jujuy, Salta, Santa Fe, and Santiago del Estero, and by the competent national agency), and are executed by its Board of Directors (made up of representatives of the members of the Governing Council). The COREBE is made up of six provinces, four of which have territory in the Bermejo River Basin. Argentina's provinces have original jurisdiction over their natural resources and are therefore essential participants in the national decision-making processes that affect the resources.

In Bolivia, the National Commission of the Pilcomayo and Bermejo Rivers (CONAPIBE) has the following functions: to establish policies and strategies to be applied in negotiations with Argentina and Paraguay for the use of the Pilcomayo and Bermejo river basins; to coordinate the use of the Bolivian basins of the Pilcomayo and Bermejo rivers, under the supervision of the National Commission; and to act as national counterpart agency in the studies and projects undertaken with a view to multilateral use.

2.4. Binational level

The Orán Agreement, signed by the governments of Argentina and Bolivia in 1995, establishes the principles of collaboration and cooperation between the states, and the rational and equitable use of the cross-border natural resources.[14/] In Article I, it provides that the Binational Commission for the Development of the Upper Basin of the Bermejo River and Tarija Grande

14. United Nations Economic and Social Council Committee on Natural Resources, Second Session 22 February-4 March 1994, "Review of Progress on Water Related Issues: Consideration of New Instruments for Global Action" (E/C.7/1994/5).

River has the objective of “establishing a permanent legal-technical mechanism responsible for the management of the Upper Basin of the Bermejo river and the Tarija Grande river to promote the sustainable development of its area of influence, optimize the use of its natural resources, generate employment, attract investment, and permit the rational and equitable management of the water resources (cf. paragraph a). Paragraph b of Article I of the Agreement explains that within the overall objective indicated the parties pursue the best use of the water resources to satisfy needs for domestic use, production of electric power, irrigation, flood control, commercial fishing, industrial and recreational uses, and other uses.

The competence of the Binational Commission covers only actions expressly agreed upon by both countries in the territory of the Upper Basin of the Bermejo and Tarija Grande Rivers. It functions through the Executive Secretariats established by the COREBE in Argentina and the CONAPIBE, through its national technical office, in Bolivia.

In practice, the Binational Commission has not still effectively incorporated in its decision-making process, the principal institutional actors of the basin (the provinces in Argentina and the prefecture and municipalities of Tarija in Bolivia). Nor has it established formal mechanisms for participation of the other social actors involved.

COREBE has thus far, in all its actions, not been able to develop as a functioning agency equipped to ensure the integral management of the shared water resources. Nor has its relationship with the Argentine delegation on the Binational Commission been an effective channel for provincial participation in the decision-making process in the areas within that Commission’s competence.

Given Bolivia’s political organization, decisions there on the use of natural resources are within the purview of the national government, and are technically channeled through the Bolivian delegation on the Binational Commission by CONAPIBE , through its Technical Office.

A series of recommendations for strengthening and making uniform the legal and institutional framework for the environmental management of the Bermejo River Basin has been presented in **(24 and 25)**, and in the conclusions and results of this cross-border environmental survey.

3. SOCIOECONOMIC ASPECTS

Socioeconomic aspects of the basin have been analyzed from various points of view in the following studies: **6; 8; 10; 12, 16; 17; 18; 19; 20; 27; 28; 29; 30; 32; 3336; 37 and 38).**

3.1. Social aspects

Total population in the basin is 1,063,285 inhabitants, distributed unevenly, including densely populated areas and relatively uninhabited spaces. The total population in the Argentine sector is 874,980, according to the 1991 census, and in the Bolivian sector it is 188,305, according to the 1992 census (**Table 11**). This population in the basin represents in both cases 2.9% of the total population of Argentina and Bolivia.

There are 54 settlements in the basin (**Figure 10**) with more than 2,000 inhabitants, (including the capital of Jujuy province, with more than 180,000 inhabitants). The hydrographic boundaries of the basin exclude several nearby settlements, of which the largest are these urban areas: greater Resistencia (292,350 inhabitants), Formosa (148,074 inhabitants), and greater Salta (370,904), which are the respective capitals of the provinces of Chaco, Formosa, and Salta.

A complete picture of the total population density in the basin is presented in **Table 11**, which shows an uneven demographic distribution, ranging from 97 persons per square kilometer in Manuel Belgrano Department (Jujuy, Argentina) or 72 persons per square kilometer in Bermejo Municipality (Bolivia) to as low as only one person per square kilometer in several cases in both countries, in an area of more than 15,000 square kilometers.

The population with **Unmet Basic Needs (UBN)** is that living in households that have at least one of the poverty indicators[15/]. At the level of the Basin (**Figure 12**) the population with Unmet Basic Needs is 464,667 (1991), which is about 41.7% of the total. In the Argentine sector this is 37% percent of the total, which is almost double the national average of 19.9% in 1991. In the Bolivian sector 64.1% of the total population has Unmet Basic Needs.

The illiterate population is about 80,000, which is 9.9% of the total population in the region. In the Bolivian sector 18.5% of the people cannot read and write (34,836 persons over 15 years of age), and in Argentina the figure is about 37% (48,449 persons over 10 years of age), as shown in **Figure 21.**

The population lacking health coverage varies in the Argentine provinces. Between 43% and 53% of the people have access to public health services. The health service indicator in the department of Tarija, Bolivia, is 37%. This indicator shows critical socioeconomic conditions in large sectors of the population, and is particularly acute in certain sectors of Argentina and Bolivia.

Analysis of the principal social variables (**10; 12; 28; 31; 33; 37 and 39**) shows extremely precarious living conditions in a large portion of the Basin, affecting a great number of the people. Social policies carried out in the form of many national or provincial programs only serve to ameliorate in part the conditions of poverty. In many cases they only provide food for the neediest. This induces many people to migrate. Socioeconomic changes in recent decades have worsened the situation of large sectors of the population, making them more vulnerable to the natural threats of landslides, floods, droughts, and other climatic disasters.

3.2. Economic aspects and production

3.2.1. Land use

The categories of land use and their principal location in the Basin are shown in the following table:

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15. a) More than three persons per room (critical overcrowding); b) housing of inadequate construction; c) no flush toilets; d) some child of school age who is not attending school; e) the family has four or more members per employed family member and the head of the household has a low educational level.

Table 12
LAND USE IN THE BERMEJO BASIN

CATEGORY	BASIN	% TOTAL AREA
Irrigated farming	Upper and Lower	3.2
Dry farming	Upper and Lower	11.6
Farming/pasture	Upper (Bolivia)	17
Forestry/livestock	Upper and Lower	51.4
Dry and semi-arid livestock	Upper and Lower	22.0
Lowland livestock	Lower	6.5
Livestock in pasture	Lower	1.7
Sub-humid livestock	Lower-Upper (Bolivia)	1.5
Miscellaneous	Lower	0.5
		100.0

The predominant land use category in the Basin is forest/livestock (51.4%), which is found in clearly defined sectors in **Figure 13**, in the Upper Basin and all through the stretch in the provinces of Formosa and Chaco in Argentina. This land use category frequently covers up conditions of non-use or under use of natural resources. In order of importance this is followed by arid and semi-arid livestock, which occupies 22% of the surface classified in the Basin. As shown in **Figure 13,** this use is found predominantly in the Upper Basin, and a band included in the provinces of Salta, Chaco, and Formosa in Argentina.

TABLE 11
POPULATION CHARACTERISTICS OF THE BASIN: ESTIMATED DATA

POLITICAL/ ADMINISTRATIVE DIVISION IN THE BASIN		POPULATION CHARACTERISTICS OF THE BASIN			POPULATION DISTRIBUTION IN THE BASIN		UNMET BASIC NEEDS (UBN) IN THE BASIN		ILLITERACY IN THE BASIN
		Total Population of Basin (Persons)	Total surface area of Basin km^2	Population Density P/km^2	Total Rural Population (persons)	Total Rural Population Density P/km^2	Total Population with UBN	Rural Population with UBN	Ratio to school-age population
ARGENTINA		874,980 (83%)	111,266 90%	8	216,977 24.8 %	1.9	37% of total population	65.6% of rural population	48,449* illiterate 7.5%
PROVINCE	**CHACO**	87,708	19,247	5	37,583	1.9	53%	66%	17.9%
	FORMOSA	111,330	26,445	4	42,474	1.6	37%	60%	8.0%
	JUJUY	472,653	21,053	24	71,397	3.4	34%	59%	6.3%
	SALTA	203,289	44,521	5	65,523	1.5	35%	70%	6.5%
BOLIVIA		188,305 (17%)	11,896 10%	15.8	74,967 39.8%	6.3	64.1% of total population	90.2% of rural population	18.5%**
DEPARTMENT	**TARIJA**	188,305	11,896	15.8	74,967	6.3	64.1%	90.2%	34,836 illiterate
BINATIONAL BASIN		1,063,285 100%	123,162 100%	8.6	291,944 27.5%	2.4	41.7 % of total population	73.5% of rural population	9.9%

References: * % of illiterate population, in Argentina, older than 10 years
** % of illiterate population, in Bolivia, older than 15 years

Finally, there is 11.6% in dry farming, which is distributed somewhat more widely, as shown in **Figure 13.** This data should be linked with the information from mapping the vegetation, which showed only for the Argentine Upper Basin 6.2% of the area under cultivation.

In the Bolivian area of the Basin, forest/livestock is the predominant land use, affecting 50% of the total land area that is productively used. This is followed by farming/pasture (17%) and with less importance for arid and semi-arid livestock (14%). For the Argentine sector, in the Upper Basin forest/livestock is the predominant use with 60% of the used area. This is followed, but with much less incidence, by arid and semi-arid livestock. In the Lower Basin, the percentages vary in accordance with the size of the area, but the trend is the same as in the Upper Basin. Forest/livestock continues to be the dominant use, followed by dry farming (17%) and arid and semi-arid livestock (16%).

3.2.2 Subdivision of the land

This variable[16/] shows the degree of subdivision of land use in each jurisdiction. The standard used is farms (EAP) of up to 25 hectares, a size that indicates small operations in Argentina, although a different measure is used in Bolivia[17/], according to the context. An overview of the data of this indicator in the Basin is presented in **Figure 24.** The greatest subdivision of the land is found in the Upper Basin. In the rest of the basin the situation is relatively homogeneous, with low and medium levels of subdivision. In the final stretch of the Lower Basin there is high subdivision.

3.2.3. Land use with agroindustrial crops[18/]

This indicator shows in **Table 13** the degree of land use devoted to the most easily marketed and traditionally most profitable crops, called industrial crops: cotton, tobacco, sugarcane, etc. At the level of the Basin, **Figure 14** shows an uneven pattern. The Eco-regions of the Eastern Andes and the west of the Semi-arid Chaco show a lesser contrast of this land use. By contrast, the Sub-Andean Eco-region in the provinces of Jujuy, Salta (both in Argentina) and Bermejo (in Bolivia), together with a majority of the Eco-regions of the Sub-humid and Humid Chaco, have the heaviest concentration of agroindustrial crops.

3.2.4.Generation of industrial employment[19/]

16. Ratio of the number of farms less than 25 hectares in each department to the total number of farms in the same unit.
17. This indicator reflects subdivision of land in farms too small to be considered the minimum needed for each crop. These situations are generally associated with occupation by poor families, because they are less efficient or productive.
18. Percentage of total farm area planted with industrial crops at the departmental or section level.

19. This variable indicates at the departmental level in Argentina and sectional level in Bolivia the ratio between the number of jobs generated by the industrial sector and the total number of jobs generated by all industrial, commercial, and service sectors.

Figure 15 presents the data on this variable at the level of the Basin. The highest levels of the Basin are found in the Municipality of Cercado (Bolivia) and the departments of Palpalá (Jujuy), Pirané (Formosa), and General Donovan (Chaco) in Argentina, where the generation of industrial jobs exceeds 50% of the total number of jobs generated in all sectors. The situation of virtually no job generation prevails in the Upper Basin and only in two departments in the rest of the Basin.

Table N° 13
SUBDIVISION OF LAND IN FARMS OF UP TO 25 HECTARES
AND AREA PLANTED WITH INDUSTRIAL CROPS

POLITICAL/ADMINISTRATIVEA REA OF THE BASIN		Farms up to 25 hectares.		Area planted with Industrial crops	
		TOTAL	%	TOTAL hectares	%
ARGENTINA			42		31
PROVINCE	CHACO	1,656	30	52,259	57
	FORMOSA	2,333	36	37,064	46
	JUJUY	2,320	67	65,284	50
	SALTA	875	45	27,438	11
BOLIVIA					
DEPARTMENT	TARIJA	13,088	100	14,860	100

** In these provinces, for the information in the Economic Census Formosa and Capital departments were not included in the Basin because their provincial capitals are outside it.

*** The Economic Census has not included the Department of Iruya in Salta Province.

3.2.5. Industrial establishments and generation of industrial value added

These variables are indicators of the importance of the Basin's industrial activity: the value of the industrial production, the number of industrial establishments, and the number of industrial jobs (**Figure 15**). They are shown in **Table 14.**

3.3. Road infrastructure

In the Bolivian sector of the Basin, the transportation infrastructure is generally weak. The roads are hard to use in the rainy season–both primary and secondary roads. The most

20. Percentage of total farm area planted with industrial crops at the departmental or section level.

21. This variable indicates at the departmental level in Argentina and sectional level in Bolivia the ratio between the number of jobs generated by the industrial sector and the total number of jobs generated by all industrial, commercial, and service sectors.

developed communities and settlements are found along the principal highways: Tarija-Bermejo, Tarija-Entre Rios, and Tarija-San Lorenzo. Total length of the roads is 984 kilometers, of which 184 kilometers are paved, 544 kilometers are gravel, and 256 kilometers are dirt. In the Argentine sector, the road network has good connections in the north-south direction between cities such as Salta and Jujuy, or between Chaco and Formosa. However, there is poor linkage between the Upper and Lower Basin. The total road network is 5,072 kilometers, of which 2,940 are paved, 796 gravel, and 1,328 dirt.

TABLE 14
GENERATION OF INDUSTRIAL VALUE ADDED, DENSITY OF INDUSTRIAL ESTABLISHMENTS, AND GENERATION OF INDUSTRIAL SECTOR JOBS

POLITICAL/ ADMINISTRATIVE DIVISION IN THE BASIN		GENERATION OF INDUSTRIAL VALUE ADDED Thousands of US$		NUMBER OF INDUSTRIAL ESTABLISHMENTS		INDUSTRIAL JOBS GENERATED	
		TOTAL	%	TOTAL	%	TOTAL	%
ARGENTINA							
PROVINCE	CHACO**	34,340	57	168	29	1.105	29
	FORMOSA**	12,263	34	440	37	1.640	37
	JUJUY	477,579	59	711	27	8.797	27
	SALTA** ***	82,492	57	215	27	2.226	27
BOLIVIA							
DEPT.	TARIJA	14,100	100	523	100	7807	100

**In these provinces, for the information in the Economic Censes Formosa and Capital departmen were not included
in the Basin because their provincial capitals are outside it.
***The Economic Census has not included the Department Of Iruya in Salta Province

As an indicator of the poor transportation connections between the two banks of the Bermejo, there are only five highway bridges and two railroad bridges along the river's 1,300-kilometer length.

3.4. Transboundary migration

In Bolivia, according to the study on trans-border migration by the Binational Commission for the Bermejo River (1999), of the entire population surveyed (characteristics of the population by origin, activity, etc.), 42% have gone to Argentina at some time or other. Causes of migration are work for 69.9%, family reasons for 8.4%, study for 6.8%, and other causes for 2.7%.

It is true that in Tarija Department there are net rates of immigration (for the 1987-1992 five-year period it was 0.64%), a large percentage of its people have emigrated to the interior or abroad for generations, primarily skilled laborers. This represents a loss of valuable human resources, and the displacement of contingents of farm workers temporarily or permanently to Santa Cruz and Bermejo. However, in recent years the area has become a net inflow of immigrants, coming mainly from the departments of Chuquisaca and Potosí, along with migration from the rural areas to the urban centers. This has resulted in the erection of slums around the cities that lack basic urban services because the cities do not have resources to meet the needs of such a large number of immigrants.

The main causes of this migration are the small farms, spent soil, erosion, lack of water, drought, etc. In this case, Bermejo is a magnet for internal migrants who take part in the sugarcane harvest, and a way station for cross-border migrants. There are more during the fallow period in the central valley and the sugar harvest, especially in the farms that depend on seasonal rains.

A key factor in the migration picture is the network of immigrants, composed of personal links between migrants, former migrants, and non-migrants of the areas of origin and destination, through bonds of kinship, friendship, and common home town. These networks are one of the factors that increase the possibility of international movement because they reduce the costs and risks of the transfer and increase the net inflow expected from migration.

In Argentina (**28**) immigration in the past decade has been primarily from border countries. Bolivians make up the greatest number, growing in absolute and relative terms, in comparison with the other neighboring nations. Most of them are women and young people. Net inter-census migration of people born in Bolivia, between 1980 and 1990 was just over 35,000 people. Many of them went to Jujuy and Salta, the traditional magnets, although more than previously went to the city and province of Buenos Aires, Mendoza, and new locations in Patagonia. It should be noted that while Jujuy and Salta received immigrants from the border areas, part of their native or immigrant population was lost because of domestic migratory currents, primarily directed to the large cities.

In 1991 the population coming from Argentina's neighbors that settled in the Upper Basin of the Bermejo River was 5.5%, which is much higher than that which settled in Jujuy and Salta together (3.9%) and in the country as a whole (2.6%). Most Bolivians were totally assimilated years ago. They do a variety of jobs, including retail, farming, odd jobs (for example, construction). However, some of the recent immigrants in the magnet cities probably do not find better working conditions and quality of life, and are a drain on the public services and welfare. Many of them end up in poverty in the urban slums.

In summary, the net migration of Bolivians has not been a significant factor in population growth in Jujuy and Salta. According to population projections for these two provinces to the year 2010, they will experience growing levels of net immigration. Although it is true that Jujuy and Salta receive immigrants from across the border, these pale in comparison to the domestic migration to the big cities. On the basis of available data, it appears that low productivity of the land and lack of income in Bolivia condition the phenomenon of immigration, with the resulting impact on the society from which they come. However, the impacts at the destination (Argentina) on the natural resources and infrastructure are imperceptible in the Basin in comparison with the pressure of the local community and the internal migratory movements in Argentina.

3.5. The Basin and its region

Study **(32)** has identified the following characteristics in the linkages between the Bermejo Basin and the overall region (**Figure VI**):

- There are several projects related to the integration of *two-ocean corridors and cross-border power networks,* which include the improvement and/or construction of road-and-rail networks, gas pipelines, oil pipelines, etc., which have an impact on the environment and also on the affected communities. These can be potentially destructive.
- Comments of the workshop participants and analysis of the documents reveal a lack of vision and understanding of the role of local and regional actors in the Basin.
- The process of regional and local planning– inadequate in Bolivia and virtually absent in Argentina – makes it impossible to operate at the various levels to address the real needs of society as a whole.
- The current trend of economic restructuring in the territory of Latin America has altered the traditional patterns of intra- and inter-regional competition.

In the case of Bolivia, the socioeconomic link of the Department of Tarija with the countries of the greater region of MERCOSUR is minimal at present, although it has the potential to be very important. This country shares 70% of its border with three of the MERCOSUR members (Argentina, Brazil, and Paraguay), and within the country are important joint ventures for the international projection of the economy, such as the natural gas pipeline to Brazil and the two-ocean corridors. Intra-basin economic integration with the interior of the country occurs along two main routes: one links the consumer centers of Tarija-Bermejo with Potosí and the northern part of the country and the other with Argentina to the south. It is to be expected that the regions with “physical contact” with the large projects mentioned[22/] may under great changes before the projects are finished. Expansion of the gas integration networks, which respond to the law of comparative advantage, could also bring about important changes, both in the flows and new territorial rivalry. In the case of the natural gas pipeline between Bolivia and Brazil, for example, the potential demand of the Brazilian market acts as a magnet for complementary economic relations between the countries and intra-regional competition in the interior of Bolivia (between Tarija and Santa Cruz de la Sierra).

Analysis of the borders in the Basin region has been done in depth in **(32).** The region now has new forms of organization in the border areas (as a result of infrastructure projects or new production sites). The border areas and in general all areas that receive new settlements can become involved in a process of inclusion, while the remaining areas feel the reverse pull. The Argentine-Bolivian twin cities like Aguas Blancas-Bermejo constitute the most active border area in terms of both trade and agricultural and livestock production.

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22. Large projects such as the rail corridors lining the Atlantic and Pacific, the road corridors (central, south, north, linking Bolivia or Argentina with Chile, Brazil, and Paraguay), the waterways (Paraná-Paraguay and Paraná-Tieté), the completion of routes, the opening of border crossings (Jama, Sico, Socompa), etc.

FIGURA VI
THE BASIN AND ITS REGION

Expansion of border production in a new “settlement process” can only be accomplished if the state adopts policies conducive to settlement of the land. This is currently left up to market forces, which could lead to more gaps and asymmetries in both the land occupation and the social conditions. Since this is predominantly an area with borders of various types–between countries inside and outside MERCOSUR and between provinces (in Argentina) or departments (in Bolivia) as well as production and settlement borders–the factors of integration operate unevenly and there are constant legal and administrative disputes.

The search for a regional legal and administrative framework for the Basin has been a concern of both countries, which have set up public agencies such as the above-mentioned Binational Commission, COREBE in Argentina, the National Commission for the Pilcomayo and Bermejo Rivers in Bolivia, FONPLATA, border commissions, Pilcomayo River Commissions (Argentina, Bolivia, and Paraguay), the Regional Commission for Foreign Trade in Northeast Argentina, coastal CRECENEA, the Council for Development and Integration in the South (CODESUL), etc. There are also other private and nongovernmental agencies with various objectives in the same area. The study **(32)** shows that the weaknesses in the present administrative and institutional structure have spawned a plethora of mini-programs for assistance, supported by lay and religious groups, governmental or nongovernmental, often resulting in a situation of dependence on social assistance.

The emergence of new actors makes it necessary to forge new alliances or give rise to fresh conflicts that demand action and solution. To cope with these situations it would be advisable to consider developing principles of ranking by importance (also intraregionally), cohesion, and identity to reduce the undesired effects of economic restructuring, and to promote equitable sharing of the benefits of the large projects and those for shifts to productive operations.

3.6. Conclusions

Although there are significant differences within the area, broad sectors of the Basin have unstable economies (**32**) that are made more so by the adjustment process, recessions, and crises that have been occurring, especially in Argentina. Although it is true that in many cases production has increased, agricultural operations have expanded, and exports have increased in the decade of the 90’s, this has not translated into improved well-being for the people. The economy is growing but resources are not being more evenly distributed, in the Argentine framework of increasing budgetary deficits, which are starving the provinces. The high degree of social vulnerability identified in the Basin and its environs makes it necessary to promote the strengthening of the institutional framework and the organization of various sectors of the civil society.

4. ECOLOGICAL REGIONALIZATION

4.1. Background and methodology

The study **31** presented an appeal for integration and synthesis of environmental data on the basis of an “ecological regionalization” of the Basin. This was later the basis for analysis of a set of indicators of natural and socioeconomic factors, and the related restrictions and conflicts. To contribute to ecological regionalization the Basin was divided into hierarchically related areas, taking into account the nature of the environment and similar characteristics at each level of the breakdown. For this purpose the primary tool was the thematic mapping (**1; 6 and 13)** developed from the interpretation of satellite images and other sources such as aerial photographs, existing maps, field verification, and others. We identified and established boundaries for Eco-regions, Subregions, Major Ecological Units, and Landscape Units, on the basis of the following criteria:

Eco-regions (Figure 9 and Table 15)

Five Eco-regions[23/] were defined on the basis of their physical characteristics. These have their distinctive climate, similar geology, chronology, and tectonic situation. In the Upper Basin the climate characteristics complement the variables of the boundary identification, whereas in the Lower Basin (formed by the same geological process) these are the deciding factors.

Subregions (Figure 9 and Table 15)

The Eco-regions were divided into 17 sub-regions, on the basis of their distinctive morphology. In the Upper Basin, the central criteria was the location of the mountains, and the Lower Basin the river courses were the determining factor.

Major (Ecological) Units (Figure 9 and Table 15)

The Subregions were divided into major units, which are composed of landscape units that have similar functional characteristics (such as an alluvial fan). Their boundaries were drawn on the basis of data provided on soil and vegetation. They are based on the final reports and the database of the subject areas on soil, vegetation, climate, topography, geology, geomorphology, and hydrology.

Landscape Units

We identified topographical units, which were then combined with elements of common vegetation at that particular scale.

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23. The eco-regions identified for the Basin coincide with those listed by Dinerstein et al. 1995: *A conservation Assessment of the Terrestrial Ecoregions of Latin America and the Caribbean*, WWF- World Bank). *Humid Chaco* includes the eco-regions of humid and sub-humid Chaco and the eastern half of the semi-arid Chaco. *Chaco savannas*, coincides with the western half of the semi-arid Chaco. The sub-Andean eco-region corresponds to *Andean Yungas*. The eastern Andes eco-region includes a vast area of Central Andean Puna with smaller sections of the Bolivian Montaine Dry Forest and Central Andean Wet Puna.

Table 15

CLASSIFICATION OF ECO-REGIONS, SUBREGIONS, AND LARGE ECOLOGICAL UNITS

ECO-REGION	SUBREGIONS	LARGE UNITS	AREA km^2	
I - EASTERN ANDES	I.1 Mountain	I.1.1	2,457	
		I.1.2	3,212	
		I.1.3	631	
		I.1.4	1,273	
		I.1.5	1,347	
		I.1.6	983	
		I.1.7	806	
		I.1.8	213	
		I.1.9	961	
		I.1.10	868	
		I.1.11	1,231	13983
	I.2 Central Valley of Tarija	I.2.1	594	
		I.2.2	293	
		I.2.3	658	
		I.2.4	122	1667
	I.3 Quebrada of Humahuaca	I.3.1	672	
		I.3.2	308	979
				16,629
II - SUB-ANDEAN	II.1 Mountain	II.1.1	858	
		II.1.2	1,273	
		II.1.3	3,019	
		II.1.4	627	
		II.1.5	1,015	
		II.1.6	1,023	
		II.1.7	873	
		II.1.8	3,223	11,912
	II.2 Sub-mountain	II.2.1	6,828	
		II.2.2	4,460	
		II.2.3	253	
		II.2.4	1,739	
		II.2.5	1,111	
		II.2.6	1,685	
		II.2.7	2,270	
		II.2.8	313	
		II.2.9	619	
		II.2.10	1,885	
		II.2.11	444	21,608
	II.3. Piedmont	II.3.1	1,971	
		II.3.2	1,081	
		II.3.3	482	

Table 15

CLASSIFICATION OF ECO-REGIONS, SUBREGIONS, AND LARGE ECOLOGICAL UNITS

ECO-REGION	SUBREGIONS	LARGE UNITS	AREA km^2	
		II.3.4	1,930	
		II.3.5	307	
		II.3.6	109	
		II.3.7	165	
		II.3.8	828	
		II.3.11	3,186	
		II.3.12	3,193	13,252
				46,772
	III.1 Overflow not caused by the Bermejo	III.1.1	3,081	
	III.2 Current flood plain of the Bermejo	III.2.1	498	
		III.2.2	1,259	
		III.2.3	3,765	5,521
	III.3 Current overflows and paleo-beds of the Bermejo	III.3.1	2,731	
		III.3.2	3,241	5972
III - SEMI-ARID CHACO	III.4 Paleo-beds of the Bermejo	III.4.2	1,560	
		III.4.3	3,964	
		III.4.4	3,117	
		III.4.5	2,456	
		III.4.6	1,967	13,063
	III.5 Feeders on the left bank of the Bermejo	III.5.1	1,990	
		III.5.2	4,667	6,656
				34,293
IV - SUB-HUMID CHACO	IV.1 Overflows of the Bermejo	IV.1.1	2,413	2,413
	IV.2 Silt buildup in the Dobagán - De Oro system	IV.2.1	3001	3001
	IV.3 Gullies, depressions, and lagoons	IV.3.1	712	
		IV.3.2	3,303	
		IV.3.3	4,548	8,562
				13,997
V - HUMID CHACO	V.1 Inlets and ravines with poorly developed gullies	V.1.1	6,790	
		V.1.2	1,372	8,162
	V.2 Major gullies and blocked inter-river links	V.2.2	2,292	2,292
	V.3 Flood plain of the Paraguay River	V.3.1	1,036	1,036
				11,491

Table 15

CLASSIFICATION OF ECO-REGIONS, SUBREGIONS, AND LARGE ECOLOGICAL UNITS

ECO-REGION	SUBREGIONS	LARGE UNITS	AREA km^2
TOTAL BASIN			123,162

4.2.Ecological and socioeconomic characteristics

Figure 9 shows the boundaries of the Eco-regions, Subregions, and major units, which are more completely described in **Annex III.**

The Eco-regions are described here, taking **31** as the basis for the environment and **31** for the socioeconomic aspects.

Eco-region I: "Eastern Andes"

This occupies the far western portion of the area studied, which is the watershed dividing the basins of the Juramento river to the south and the Pilcomayo to the north. It includes the ridges of Sama, Santa Victoria, Aguilar and Chañi. Structurally, the region has elements of the Andean uplift, responsible for its high elevation. The structures are predominantly faults and folds, with a clear north-to-south pattern.

In the Montane Subregion, most of the landscape consists of high mountains and ridges. In the northwest of the Argentine sector, hardly entering Bolivian territory, is an area of high plateaus where the relief is less abrupt. The creases are moderate to pronounced in all of the units. Elevations vary from 2,700 meters in the valleys to 4,600 to 6,200 meters on the higher summits. These characteristics explain the existence of areas with cold sub-humid climate to cold semi-arid climate. In the sub-humid areas there are high pastures, including narrow strips of herbaceous steppe on the high peaks in the western section. In the high dry elevations the bushy steppes predominate.

In the central valley of Tarija (Bolivia), the elevation varies from 1,700 to 2,700 meters above sea level. There are low slopes, hills, piedmont, and river plains. The topography varies from rugged in the hills to moderately rugged in the piedmont and rolling with some flat sectors in the flood plain. Creasing varies from moderate to intense, the latter occurring principally in the badlands of the flood plain. The climate is temperate with variations of sub-humid, semi-arid, and arid. The vegetation is scrub, and the most prevalent species is Xerofita churqui (*Acacia caven).* The soils are medium to heavy, thin, with many stones and rocky outcroppings in the hills and piedmont. The river flood plain has deep soil, predominantly mud and clay.

The Quebrada de Humahuaca in Argentina is in the large inclined plain called the "eastern edge of Puna." Its topography is complex and dissected, with evidence of active regressive erosion. North of the Yacoraite there are remnants of quaternary deposits, deeply dissected by gullies with large-scale movement of land.

In economic terms, this is the least progressive and least developed in the Upper Basin in the Argentine sector. The indicators show a “very high” subdivision of the land, with “very low” use of the soil, and “low” generation of jobs. Population density is “low,” with the exception of the Quebrada de Humahuaca Subregion, where there are “medium” densities.

In the Bolivian sector, the economic characteristics of this Eco-region are marked by the development of the agricultural and livestock sector, which contributes 72.2% of the Gross Domestic Product of the Basin. This is the most dynamic region in Tarija Department.

The socioeconomic indicators show that the subdivision of land and its utilization vary from “medium” to “very high.” In this area there are 88.4% of the industrial establishments, which results in high generation of jobs, influenced by the city of Tarija, the departmental capital. As for the human development indicators, the population with unmet basic needs is “very high,” with the exception of the Municipality of Cercado.

Eco-region II “Sub-Andean Rangess”

The montane area has high ranges, with a very humid hot climate, while the upper slopes become temperate humid and sub-humid. The soils are shallow and rocky, of average fertility. They are heavily forested with little farming, and the population density is low. Continuing with the sub-mountain landscape, there are high narrow valleys. The climate is hot, sub-humid to very humid. The predominant vegetation is mountain jungle and mountain forest. At the higher elevations, there are high pastures. There is little farming, and the population density is low. The piedmont has typical characteristics of hot and sub-humid climate and deep soil. The land is primarily used for agriculture, so there is higher population density.

The Argentine portion of the economic indicators offers different characteristics: the “montane” Subregion is the least developed, with low soil use, high subdivision of land, and low level of employment. In its interior there are some areas influenced by the higher level of development found in the “sub-mountain” and “piedmont” regions.

The social indicators show serious poverty in the “montane” and “sub-montane” Subregions, but the situation improves somewhat in the “piedmont” Subregion, which includes the San Francisco river valley, the zone with the greatest fruit culture and agroindustry.

In the Bolivian sector, this Eco-region generates 27.8% of the Gross Domestic Product of the Basin area. Land use is low in the montane and submontane Subregions, and high in the “piedmont.” As for the poverty indicators, the population with unmet basic needs is “high,” except for the Municipality of Bermejo, which is “medium.”

Eco-region III “Semi-Arid Chaco”

This is the largest of the Eco-regions. Its climate is semi-arid, with a water deficit of more than 400 mm. (in most of the area, more than 600 mm.). Annual rainfall in most of the Subregion is between 600 and 700 mm. Owing to the high annual shortfall of rain, it is not suited for dry farming. It is intercepted by a network of gullies and riverbeds.

In economic terms this Eco-region has a very low level of economic development, in fact, the lowest of any in the Lower Bermejo Basin. Although there is not much subdivision of land (the farms are medium to large), land use is low or very low, and the generation of jobs is low except in the city of Embarcación. This Eco-region contains three of the four departments in the Lower Basin that were identified as those with least economic development: Rivadavia (Salta), Bermejo and Matacos (Formosa).

This Eco-region has the lowest population density in the Lower Basin, with very low levels of inhabitants per square kilometer. The social indicators show the most extreme poverty in this sector of the Basin, with “very high” ranking in all of the variables and Subregions.

Eco-region IV “Sub-Humid Chaco”

This has a sub-humid to dry climate, with a water deficit of 100 to 200 mm. and annual rainfall on the order of 900 to 1,100 mm. Climatically the region is suited for dry farming, and the principal crop is cotton. The main farming area is in the Lower Basin. There is an intricate network of rivers with natural dams that form a large number of lagoons and pools.

This Eco-region has low economic development, and land subdivision is of medium level, but land use is low and so is job generation, except for the department of Pirané in Formosa. Population density varies in this Eco-region, from “very low” in the Subregion “oveflows of the Bermejo” to “medium” in the other two Subregions, which have a number of large communities.

The social indicators reflect high to very high unmet needs, with the exception of the Dobogán-De Oro system Subregion, where there are major urban centers amid a well-developed farm zone.

Eco-region V “Humid Chaco”

The climate is sub-humid to humid, with almost no water shortage, with annual rainfall of between 1,100 and 1,300 mm. The dominant characteristic is low and floodable areas (gullies and ravines), riverbeds and deep valleys with major farming areas. At the end there is strong influence from the Paraguay river.

This Eco-region generally has low to medium economic development, but it is the most economically active of any of the Eco-regions in the Lower Bermejo Basin. Nevertheless, it is not an evenly developed Eco-region, because there are extreme cases in the province of Chaco: The General Donovan department (Chaco), which is comparatively the most developed in the province, and Primero de Mayo, which has the least development of any of the Chaco departments in the Basin.

Population density varies in this Eco-region, from low to medium. The social indicators are at a medium level for unmet needs, in a zone with greater economic development than the rest of the Lower Basin, and with large urban settlements.

4.3. Environmental zoning

In the pattern developed for “ecological regionalization” we evaluated the principal conflicts in the Basin on the basis of the following indicators: deforestation for agricultural purposes, soil degradation from over-use, loss of biological properties of the soils, illegal timber-cutting, domestic clearing, erosion, salinity, loss of capacity, desertification, flooding and risk of flooding, loss of biodiversity, and mass land movements.

The **Table of Annex IV** presents for each M**ajor Unit** the values assigned to the indicator for each variable. To evaluate the magnitude of each variable we took into account the intensity as well as the geographical spread, to classify them according to five levels of severity.

The analysis of the socioeconomic aspects of the Basin in terms of the physical limits identified in the “ecological regionalization” was done at the **Subregional** level. This qualitative assessment is based on the quantitative analysis done in the sectoral study of the following indicators: subdivision of land, functioning of agricultural and livestock establishments, generation of industrial jobs, population density, population with unmet basic needs, population with housing deficit, population without health coverage, and illiterate population. **Figures 23 and 24** present, by way of example, indicators of illiteracy and land subdivision for each of the Subregions of the Basin.

ANNEX III

DETERMINATION OF ECOLOGICAL REGIONS

ANNEX III

DETERMINATION OF ECOLOGICAL REGIONS

METHODOLOGY

The purpose of determining ecological regions within the Bermejo River basin was to define territorial units in different degrees of detail. The objectives were as follows: a) to provide a framework for a general description of the area under study for subsequent use in developing an Environmental Zoning scheme; b) to define units with sufficient internal consistency so that any observations or results derived from the various experiments performed in a portion of the unit can be extrapolated to apply to the entire unit; and, c) to determine the limits applicable to extrapolation and generalization of characteristics of similar cartographic units with regard to isolated features (e.g., the production of thematic maps).

In the determination of Ecological Regions, hierarchical criteria are used to ensure that the boundaries or limits are compatible with each other. In other words, if an Eco-region is divided using a specific criterion, the external boundaries of the higher level or larger area will contain within them the boundaries of the lower level or smaller area units. Likewise, in an agglomerative process, the union of units at a lower level will result in a larger unit with boundaries coincident with the boundaries of the higher level division. According to these criteria, an entire Basin is divided into Eco-regions, Subregions, and Large Ecological Units. In addition, to meet the needs of the sedimentological models, areas were delineated to the level of Landscape Units in the Argentine portion of the upper reaches of the Basin.

THE BASIN

To describe the Eco-regions, a genetical technique based on bibliographical and cartographic analysis was used. For the final determination of the boundaries, however, agglomerative criteria were used, since they made it possible to reproduce the boundaries of the smaller units. In general, to engage in a regionalization exercise, methodological procedures begin with the most stable (physical) elements, and end with the least stable, or biotic elements. In other words, the exercise begins with climatological elements as a general framework, followed by the relief, the soils, and the vegetation. In view of the marked differences between the Upper Basin and the Lower Basin, adjustments based on relevant factors for each sector were made.

Eco-regions were defined on the basis of physiographic criteria. These included morphostructural unity, similar chronology and tectonic style, and determining climate characteristics. While relief defines boundaries and characterizes the region in the

Upper Basin, the climate is used as the dividing criterion in the Lower Basin, which is formed by a single morphostructural unit.

Subregions were defined by using an agglomerative process, which made it possible to determine Large Units with similar characteristics and recurrent patterns. This would suggest the existence of higher ranking controls in the scale of analysis adopted.

The Eco-regions are composed of a varying number of Subregions, which can be distinguished on the basis of their morphological characteristics. In the Upper Basin, the main criterion was based on mountain morphology, while, in the Lower Basin, consideration was given primarily to fluvial morphology.

Large Units (LU) or Large Ecological Units (*Grandes Unidades*, GU) were identified using visually-interpreted satellite images (at a scale of 1:250,000), while the boundaries were drawn on the basis of the configuration of the Landscape Units defined for the Upper Basin, and on the basis of thematic cartography for the Lower Basin. Large Units are divisions of the Subregions, and they in turn are made up of Landscape Units, which respond to similar functional characteristics (for instance, an alluvial fan). To define their boundaries, account was taken of the information provided by the thematic layers of soils and vegetation, and to describe them, the information appearing in the final reports and the data base for the thematic layers was used, as was data on climate, physiography, geology, geomorphology, and hydrology and land use.

Landscape Units (*Unidades de Paisaje*) were defined in the Argentine portion of the Upper Basin. The thematic maps prepared by provincial teams were subdivided to meet the needs of the sedimentological models to be applied. This generated the breakdown to the level of Landscape Units. The Landscape Units defined for the Upper Basin represent homogeneous areas insofar as the recurrent configuration of their elements is concerned. Boundaries were drawn on the basis of physiography and vegetation, using the information taken from the thematic mapping and interpretation of 1:250,000 scale satellite images. This information is not presented in the Transboundary Diagnostic Analysis (TDA).

DESCRIPTION OF THE ECO-REGIONS, SUBREGIONS, AND LARGE UNITS

Eco-region I. "Eastern Andes"

This Eco-region occupies the entire western boundary of the area under study, defined by the watershed of the Juramento River to the South and the watershed of the Pilcomayo River to the North. It includes the Santa Victoria, Aguilar, and Chañi mountain chains. It is important to note that in both Bolivia and Argentina, there are areas that should, strictly speaking, be described as belonging to the High Andean Eco-region. However, specialists in both countries believe that it is not appropriate to create a new Eco-regional division because of the fact that there is little territorial expression. Structurally, the Eco-region is characterized by Andean orogenic elements, responsible for its very high elevation. The predominant structures are folds and faults, with a clear North-South orientation.

Subregion I.1. "Montane"

This Subregion is dominated by a landscape of high mountains and mountain ranges, characterized by a steep to very steep relief, with rocky outcrops and a stony surface. In the northeastern part of the Argentine area, virtually without crossing into Bolivia territory, there is an area of high plains, where the relief is more greater. The dissection is moderate to strong in all the units. The elevation varies from 2,700 meters in the valleys to 4,500 meters at the highest summits. Due to these characteristics, the climate ranges from subhumid cold to semi-arid cold.

In the subhumid areas, there are high pasturelands, including narrow strips of High Andean Steppes in the western section. At the high, arid altitudes, the shrub-covered steppes of Puna and Prepuna predominate. The vegetation consists primarily of grasses, especially growing in clumps. The shrubs are generally nondeciduous, and are either scattered or grouped together in the form of small islands. In the areas with rocky outcrops, which cover 40 percent of the surface, the soils have a low cationic exchange capacities and a low content of organic material. In contrast, the soils of the valley floor, where there are possibilities of (organic matter) accumulation, exhibit improved soil conditions. This fact, together with availability of water, generates conditions for introducing small farm units. However, population density is low.

- LU. I.1.1. Very abrupt relief, with crests clearly lined up in a N-S direction. It experiences the last effects of humid air currents. This unit has a cold, arid to semi-arid climate, with hilly, mountainous pastures, high Andean pastures, and Puna brushwood.
- LU. I.1.2. Steep relief, with east-facing slopes, which form a symmetrical dentritic system, with alternating waterways originating in the high basins. This orientation is favorable to moisture-bearing air currents. This explains the temperate, subhumid climate, which supports a mosaic of mountain forests and highland pastures.
- LU. I.1.3. Relief with abundant colluvial deposits which smooth the typical high plateau landscape. The flat areas formed allow for some agricultural use, despite the high elevation. The unit is located on the eastern slope of the Santa Victoria mountain range, where the climate is cold, varying from semi-arid to arid. High Andean and high mountain pasturelands predominate, with abundant bare ground.
- LU. I.1.4. A mixture of colluvial deposits and other unsorted material, transported by torrents (fanglomerates), which generates a relief that is

regionally gentle but sharply dissected by gullies. Puna scrub and pastureland, high Andean pastures, and abundant bare ground.

- LU. I.1.5. Very steep relief with high crests lined up in a N-S direction, where the beginnings of the tributaries of the *Quebrada de Humahuaca* are located, as are the Yacoraite and Purmamarca rivers. A pure arid climate, influenced by the interception caused by the Alta de Tilcara mountains. The unit presents a sequence of Prepuna thistles and cacti, Puna scrub, and high Andean pastureland, with abundant bare ground.
- LU. I.1.6. It's formed by the high summits of the uplands of Zenta and Hornocal, which channels the drainage to the Calete River, the only basin of any size which drains to the West (towards the Humahuaca ravine, to the South of the homonym locality). At the base of the slopes, Prepuna scrub is found, followed by Puna and high Andean scrub along the periphery of the summits. The climate is cold and arid, but allows for farming on terraces.
- LU. I.1.7. High summits, with a vigorous relief and chaotic drainage, without any predominant direction. A very cold and dry climate, with highland pastures or Puna scrub and undergrowth in the lower part and high Andean pastures along the periphery of the summits.
- LU. I.1.8. This comprises the western flank of the *Quebrada de Humahuaca*; in the upper parts, deeply dissected anticlines appear, with their flanks equally dissected. A temperate, semi-arid climate, with thistles and bushes.
- LU. I.1.9. Steep relief with a marked N-S line-up. The eastern side receives the remains of the humid air currents up to high altitudes, where the climate is cold and semi-arid, with high Andean pastureland vegetation. The western side, in contrast, is arid, with a cold-temperate climate, and is covered with Puna to Prepuna scrub.
- LU. I.1.10. This unit lies in the extreme southwestern part of the High Basin, where the highest peaks are found, with a clear N-S orientation, covered with snow (Nevado de Chañi) and barren of vegetation. Very steep relief, cold and dry climate. The lower sides contain high Andean pastures.
- LU. I.1.11. This forms the eastern flank of the mountain range, with very steep relief. The flanks present a sharp dissection to the East, which is superimposed on the structural N-S orientation. The flanks are exposed to the influx of humid winds from the East; hence at the base the upper stages of the mountain forests, and at higher elevations, there is a strong predominance of highland pastures.

Subregion I.2. "Central Valley of Tarija"

This landscape is characterized by low mountain ranges, alternating with hills and valleys. The mountains reach elevations of 2,700 meters, with a steep relief where 30 to 40 percent gradients are found. In the hills and valleys, located at around 1,700 meters, moderate to pronounced dissection is evident. In the areas of fluvio-lacustrine deposits ("bad lands") with gently to moderately undulating relief, dissection is pronounced to very pronounced.

The general climate is temperate, with hydric variations ranging from subhumid to semi-arid, and even arid. Under these conditions, the dominant vegetation is deciduous scrub, mostly replacement, with scattered grasses and scattered nondeciduous and deciduous bushes, in response to the intensive antropic intervention, which is turn is the result of a high population density. The soils of the hills have a medium to rough texture, and are thin with rocky outcrops. The pediments are extremely rocky, the soils are deep, and drainage is rapid. In contrast, in the flat areas with sedimentary soils, the texture is argillaceous and silty, with an alkaline pH, high sodicity, and a low content of organic material.

- LU. I.2.1. Hilly land that emerges in a discontinuous manner, with gradients ranging from 30 to 60 percent. The result of a tectonically influenced denudation process, the parent material is mostly siltstone, lutite, and sandstone. Dissection is moderate in the high hills and more extreme in the medium and low hills. The altitudes vary between 2,100 and 2,600 m. The dominant vegetation is scrub of varying density and coverage, with *Acacia caven* being the species most commonly found.
- LU. I.2.2. Piedmont landscape, with a complex of alluvial fans and dejection cones, it is the product of denudation of the contiguous slopes. The parent rock is sandstone and lutite, the material is semiconsolidated stones and pebbles, sands, silts, and clays. Underneath these conglomerates is a layer of sediments of fluvial/lacustrine origin. The vegetation is deciduous scrub and mostly grasses in the herbaceous stratum.
- LU. I.2.3. Fluvial/lacustrine Plain. Valley landscape, with fluvial/lacustrine deposits. The relief varies from deep ravines, gullies and buttes (bad-lands), ranging from undulating land with varying degrees of dissection with broad crests, to the remainders of fluvial/lacustrine plains. The original material is semi-consolidated, and is made up of cobbles, pebbles, sands, silts, and clays produced by sedimentation of the former lake. The dominant vegetation is high scrub areas of *Acacia caven* of varying density and coverage to the West and South of the plain and low scrub of *Prosopis alpataco* in the arid climate zone.
- LU. I.2.4. Recent alluvial roofs. Valley landscape, with small recent depositional surfaces along the water courses, and with considerable development of agriculture. The original material is not consolidated and is made up of pebbles, sands, silts, and clays deposited by the rivers. In the areas not under cultivation, the vegetation consists of trees and scrub, generally replacement.

Subregion I.3. "Quebrada de Humahuaca"

This Subregion includes the great inclined plane at the eastern boundary of the Puna. It has a highly complex and dissected relief, with features showing active retrocedent erosion. This erosion has not yet reached the entire glacial surface of the Quebrada, and so to the North of the Yacoraite River, remnants of quaternary deposits can be observed. They are deeply cut by stream beds, where there are intensive mass removal processes.

- LU. I.3.1. This is the upper portion of the *Quebrada de Humahuaca*. It has large lateral valleys, with a strong development of coalescent alluvial cones, which are sharply dissected. It is a very narrow tectonic trench or trough, with a cold, arid temperate climate. From Yacoraite to the North, thistles and bushes with *churqui* (P*rosopis ferox*) predominate.
- LU. I.3.2. This is the lower part of the *Quebrada de Humahuaca*, from Volcán to Yacoraite. It is a narrow tectonic trough or rift valley, with a "V" profile. The principal riverbed is torrential, with a constant flow. The climate is temperate, with arid riparian vegetation. It has alluvial cones, with thistle-bush cover. There are small lateral tributaries or side streams.

Eco-region II. "Sub-Andean"

The mountain chains belonging to the Sub-Andean range present fold structures where there are abundant dipping anticlines and synclines whose axes follow a North-South direction. In the Bolivian portion of the Basin, the drainage network is very closely related to tectonics, with rivers located in synclinal depressions. In the Argentine portion of the Basin, the drainage network shows a sharp dissection in a West-East direction.

Subregion II.1. "Montane"

This Subregion is characterized by highlands at medium to high elevations (around 2,500 m, but with higher peaks), and with a steep to extremely steep relief, deeply dissected in parts. In the lower portions, located at about 1,500 meters, a warm, very humid climate prevails, whereas on the higher slopes, the climate becomes humid to subhumid temperate, depending on the orientation of the slopes or on how open they are to inflows of air masses.

The soils in general are acid, relatively shallow, and rocky, with good levels of organic material and average conditions of fertility. They are mainly used for intensive forestry, with little agriculture, and the population density is low.

- LU. II.1.1. Consisting of high slopes and crests of the eco-regional watershed and adjacent slopes of the eastern side, the relief is generally very scarplike and predominant. From a lithological standpoint, compact rocks formed of sandstone, siltstone, and lutite are found. Rocky outcrops cover about 15 percent of the surface. Water erosion is moderate to strong. The dominant vegetation is high coarse grasses, bushes with microfoliate plants, and *queñoa (Prosopìs ferox)* forests forming small, scattered patches.

- LU. II.1.2. Range chains with a marked, well-defined North-South folding pattern, such as the Cerros de los Cinco Pinachos, for instance. In Bolivia, these folds determine the direction of the drainage network, but from the Bermejo River to the South, in Argentine territory, the folds are dissected by large river channels which run in an east-west direction. Mountain forests predominate.
- LU. II.1.3. This is vigorous mountainous country, not aligned in a North-South direction and deeply dissected. It has no major watercourses. The slopes are occupied by the upper reaches of the montane cloudy forest and by mountain woods, alternating with highland pastures.
- LU. II.1.4. The unit consists of a dense network of mountain ranges without any apparent alignment, except along the eastern boundary, where they are in a clear North-South direction. The land is completely covered by dense mountain rainforests.
- LU. II.1.5. Sandstone predominates in a vigorous mountainous landscape with a strong fluvial dissection in an East-West direction, which is superimposed on the general North-South alignment.
- LU. II.1.6. Steep relief. This area presents a complex mixture of mountain forests and highland Chaco, where the effect of slope exposure is very marked. In the Valle Grande, behind the Calilegua range, this effect is particularly marked, with a predominance of highland Chaco.
- LU. II.1.7. This is the area of the Zapla range, which has a Northwest-Southeast alignment. The eastern slopes have a more gentle relief, with subhumid piedmont forests predominant. In the area near the summits, there is a mosaic of piedmont forests, mountain rainforests or cloudy forests mountain wood or forests and highland pastures.
- LU. II.1.8. This area is made up of the González and the Cresta del Gallo ranges, with summits of 3,200 meters and extremely steep relief. The climate is cold and subhumid, which makes for a predominance of pastureland

Subregion II.2. “Sub-Montane”

This Subregion has a landscape consisting of low mountain ranges and hills, with narrow valleys, and elevations between 600 and 1500 meters. The mountain ranges are rocky and have steep relief. The hills have a strongly undulating to moderately steep relief. The dissection, largely conditioned by the lithological characteristics, varies between moderate and very pronounced. The climate is hot, and graduates from subhumid to very humid. The predominant vegetation is mountain rainforest, while mountain woods are confined to narrow strips. In the higher elevations, highland pastures are present. The eastern portion of the Subregion, and particularly the lower foothills, is dominated by an ecotone zone, where transitional cloudy forest is found in the upper stratum, and Chaco forests in the lower stratum. The Lomas de Olmedo is a special case, with a dry-subhumid to semi-arid climate and clearly Chaco style elements of vegetation.

The soils of the hills are highly variable, but are generally rocky, with a medium to rough texture, and slightly acidic, with a moderate content of organic material, and they are moderately to highly fertile. In the valleys, the soils are deep, with medium to fine texture, slight acidity, and average fertility. Agricultural activity is scant, hence the population density is low.

- LU. II.2.1. Pronounced Sub-Andean folding in a marked North-South direction. The area is crossed by major torrential rivers, such as the Pescado and Iruya, and the Upper Bermejo along the northern boundary. The same lithological unity continues into Bolivia, but without the large rivers crossing it. The climate is hot and humid. Rainforests predominate, some of which are protected in the National Parks of Tariquía in Bolivia and Baritú in Argentina.
- LU. II.2.2. The ranges of San Antonio to the West and Tartagal to the East frame the Seco River, which runs between them in a North-South direction. The relief is highly dissected. The climate is hot and humid. There are piedmont rainforests at the base and mountain woods on the sides.
- LU. II.2.3. Low mountain ranges; low mountainous country with hogback ridges with irregular crests, and short, relatively shallow valleys with steep slopes which are moderately to sharply dissected. The original material is not highly compacted, and is formed from medium to rough sandstones interspersed with thin layers of clay stones. Sparse submountain woods, that are mostly evergreen, seasonally green or transitional.
- LU. II.2.4. These are intensely dissected sierras with Tertiary sandstones. Because of the lithological characteristics and the relief, the rivers flow through narrow ravines, and they stand out for not having any rocks, but only sandy material in their valleys. The climate is hot and humid. Dense rainforests predominate.
- LU. II.2.5. This area is made up of a series of low mountains located at the eastern foot of the Calilegua Sierra, where intensely dissected sandstones predominate. There are large rivers. The climate is hot and humid, and this is related to the predominance of dense forests.
- LU. II.2.6. A submontane region, dissected by numerous episodic riverbeds (there are no major waterways). It is located on the lower eastern flanks of the Sierra de Santa Bárbara. In general, the climate is dry, especially in the lower foothills, which gives rise to a predominance of highland Chaco.
- LU. II.2.7. This is formed by the Castillejo Sierras, at the eastern boundary of the Lerma Valley, the Gallinato Mountain Range (the cornice road), and the low sierras of Palpalá and Jujuy, in which evidence of the North-South alignment is heavily blurred because of the intense dissection caused by the major rivers and minor torrents. The climate is temperate subhumid, with

alternating mountain woods and pastures.

- LU. II.2.8. Slump of the Zapla Sierra, with low, hilly country which is relatively dry, with only episodic river beds, but no major ones. Highland Chaco is the predominant vegetation.
- LU. II.2.9. Gentle hills, with elements of highland Chaco and intermountain stretches of land. Subhumid climate.
- LU. II.2.10. Formed by the eastern slopes of the González and Cresta del Gallo mountain ranges. The relief is highly dissected, and gives rise to the Dorado and Valle Rivers in the area of the Finca El Rey National Park. The climate is hot and relatively dry at the base, where there are elements of highland and transition Chaco, with pediment forests and mountains on the slopes.
- LU. II.2.11 This area is made up of the rocky outcrops of the Lomas de Olmedo, with a semi-arid climate and Chaco vegetation. There are no level areas.

Subregion II.3. "Piedmont area"

This country features fluvial valleys and piedmonts, with colluvial/alluvial deposits and alluvial terraces and a flat to undulating relief, at altitudes of less than 600 meters, which descend to less than 200 meters in the areas that penetrate the Chaco Plain. The climate is hot, with humidity ranging from humid-subhumid to dry-subhumid, with semi-arid parts, such as in the piedmont of the Lomas de Olmedo.

The soils are deep, with medium to fine texture, good drainage, slight acidity, and with moderate to good content in nutrients and organic materials. Because of these characteristics, together with the flat to slightly undulating topography, this land is mostly used for agriculture, and so the population density is high. The exceptions are the areas subject to river overflows, such as the San Francisco Valley, or areas with climate restrictions, such as the above-mentioned piedmont of the Lomas de Olmedo.

- LU. II.3.1. This unit runs from the edge of the Grande de Tarija River valley to the proximity of the confluence of the San Francisco and the Bermejo. The hot, humid climate was conducive to development of a piedmont rainforest, which has now mostly been cleared for agricultural purposes, especially sugarcane. A low hill of round cobbles is also found in this unit.
- LU. II.3.2. This unit extends from edge to edge of the lower part of the San Francisco River valley. The unit presents virtually no dissection by waterways. Large cleared areas.
- LU. II.3.3. This is the alluvial valley of the San Francisco River, where silty and sandy materials predominate, in contrast to the Grande and Lavayén Rivers, with their rocky materials. It is characterized by woods of alders and willows.
- LU. II.3.4. Locally known as *El Ramal*, this is primarily an agricultural area, mostly cane fields, and largely irrigated. There are virtually no fences,

because there is little animal husbandry. Frost is rare.

- LU. II.3.5. This unit is located on the right bank of the Lavayén River and in the area where it meets the Grande River. Its morphological characteristics are similar to LU. II.3.9., but its climate is milder, with more water and less danger of frost.
- LU. II.3.6. This is the area where the City of Jujuy is located and where the farmed terraces extend on both sides of the Grande River, with a temperate, subhumid climate.
- LU. II.3.7. This is the area known locally as *La Almona*, a cone of very heavy soils which is deeply dissected, with pastures predominant. South of Palpalá, between the Grande y Perico Rivers, there is a similar area, but with a greater bush cover.
- LU. II.3.8. This unit is essentially made up of alluvial fans. It is known locally as the Siancas Valley (cone of the Mojotoro River) and the Perico Valley. Irrigated farming is practiced here, but because of the climate, mostly tobacco is grown instead of cane. It is crossed by major rivers, including the Grande, Perico, Alisos, and Mojotoro.
- LU. II.3.9. This is a piedmont without alluvial fans, with predominating clean sand textures. Rainfed agriculture and livestock raising are prevalent. The markedly continental climate is relatively dry, and there is danger of frost. This unit is not included within the current boundaries of the basin.
- LU. II.3.10. Formed by the piedmonts of the Tartagal Sierra, where the convergence of good soils and climate have led to intensive land clearing, covering more than 90 percent along Route 34 and 50 percent of the entire unit. San José Lake, with its saline, floodable soils, is included. It is part of the western subhumid Chaco, locally referred to as *Umbral al Chaco*. This unit is outside the area originally defined as the Upper Basin.
- LU. II.3.11. This comprises the piedmonts of the Maíz Gordo and Centinela Sierras, with its axis at Las Lajitas, where the entire surface is fully cleared. This decreases to the East, and especially in the northern part of the unit. It is also part of the Western Subhumid Chaco, locally known as Umbral al Chaco.
- LU. II.3.12. This unit comprises the pediments of the Lomas de Olmedo. Although its water contributions are insignificant, they have the peculiar characteristic of going as far as the San Francisco, Bermejo, Bermejito, and Dorado Rivers. There are cleared areas in the northern sector and along the road to La Unión. There are many seismic prospecting trails. The vegetation is clearly Chaco.

Eco-región III “Semi-Arid Chaco”

This is the largest strip of land. The climate is megathermal semi-arid, with a water index of –20 to –40, a water deficit of more than 400 mm (for the most part, over 600 mm). Annual rainfall throughout most of the Subregion ranges from 600 to 700 mm. Because of the marked annual shortage of rain, it is not suitable for rainfed farming.

Subregion III.1. “Overflows not formed by the Bermejo”

This subregion is formed by the oveflow deposits of the Dorado and Del Valle Rivers, and by the right portion of the alluvial fan of the Itiyuro River. In the uncleared areas, one can observe a dense grid of geophysical prospection trails.

- LU. III.1.1. This is the area of the oveflows of the Del Valle and Dorado Rivers, known as *Bañados del Quirquincho*. The dominant growth consists of saline brushwood, with diffuse drainage, except in the northernmost portion of the unit, where the streambeds which form a link between these rivers and the Bermejito River are found.
- LU. III.1.2. This is the right-hand portion of the alluvial fan formed by the Itiyuro River. The unit is outside the area originally marked off for this study (refer to the discussion on the relevance of the Bermejo or Pilcomayo River Basins). There is a large clearing in the area of the Itiyuro oveflow. In the southernmost part, various lakes have been formed by intercepting oveflows, generated by the paleoformation of LU. III.4.1.

Subregion III.2. “Current Floodplain of Bermejo-Teuco”

This Subregion is made up of various units directly affected by the swelling of the current of the Bermejo-Teuco River, from the Juntas de San Francisco, up to 40 km to the West of the Teuco-Bermejito confluence.

- LU. III.2.1. This is the first part of the Bermejo River to enter the plain. The course of the distributary can be seen during low tide periods and on the first flood plain. Alder forests are found on the lateral deposits. There is no farming.
- LU. III.2.2. Consistent with the expansion to the South of the slopes of the Bermejo, the river’s floodplain spreads and forms a vast surface of sedimentary deposits, inhabited by alders.
- LU. III.2.3. This is one of the largest units (250 km in a straight line). It can be divided into two from an operational standpoint, in the area near El Sauzalito, but the characteristics remain similar. This is the major area of water accumulation of Chaco Province. In the vicinity of El Sauzalito, the waters are confined between a large paleoridge of the LU. fragment of the paleoridge of the LU. III.4.4. and a fragment of the paleoridge of the Formosan Dobagán River which remained in Chaco territory as a result of the migration of the Bermejo. Because of the configuration of this unit, there is a possibility of harnessing the hydraulic power. The land has no clearings.

Subregion III.3. “Actual overflows and paleochannels of the Bermejo River”

This unit is identified with the ancient formation of the Bermejo River, with channels or beds which are episodically reactivated by flooding. The excess water is recaptured by the Teuco River (Bermejo), by means of two collector streams.

- LU. III.3.1. This is the left-hand portion of the actual distributary area of the Bermejo River (in that it has a number of arms into which some of the overflow is channeled). It has a large central strip of peridomestic arid plains, generated by the presence of livestock stations, which in turn are linked to the presence of watering places, provided by numerous ancient meander rings. There is no saline water coming from other GUs. In the rest of this unit, there are very few woods, and shrubs and savannahs prevail. To the South of Solá, diffuse drainage is concentrated in two separate waterways. The one furthest to the East has features similar to those of the Dobagán. All of the excess water, from local rains or overflow, is diverted by these two waterways back to the Bermejo River. There is no cleared land.
- LU. III.3.2. This unit is the same as the previous LU.insofar as modeling by recent overflow of the Bermejo River is concerned, in this case on the right-hand bank. There are major differences, however, the most important one being the inflow of saline water received along the entire length of its right bank (which does not occur in LU. III.3.1.). A second difference is the presence of large “islands” formed by paleoridges with extensive woods and paleochannels filled with pastures, to the southeast of La Unión, for instance. These ridges play a key role in preventing the overflow waters from entering the Bermejo River. The third difference lies in the destination of the waters, which do not return to the Bermejo River after a short distance, but continue to be channeled through the Bermejito River. There are also many peridomestic arid plains, linked with the meander rings (locally called “*madrejones*”) and the livestock stations. There is no agriculture.

Subregion III.4. “Paleochannels of the left bank of the Bermejo River”

This region comprises a series of units which were originally modeled by the Bermejo River, but are disconnected from the current network (LUs III.4.1. and IV.4.3.), or are only affected by major flooding (LU. III.4.2.).

- LU. III.4.1. This is a totally disactivated paleogrid, which marks the northernmost part of the distributaries of the Bermejo River system. The disactivation refers to the fact that it does not directly receive the overflow of the Bermejo River. However, the relief forms influence the local runoff, either by intercepting the runoff along the boundary with LU.III.1.4., or through the rainfall. From the standpoint of runoff, this LU. feeds the Pilcomayo River basin. There is very little clearing, only in the westernmost part, near Route

81. This LU.is outside the area of this study.

- LU. III.4.2. This unit is formed by the Bermejo River, but it only receives water from it sporadically, during major floods, which affect some drainage lines. Shrubs and savannahs predominate. There are no clearings.
- LU. III.4.3. From the locality of Los Blancos, there begins a paleolandscape dominated by large ridges covered with red and white break-ax bushes and wide pasture-filled paleochannels, which alternate with extensive low areas in which *palosanto* and carob trees [*vinal*] prevail. There are extremely isolated clearings along the boundary with LU.III.4.1.
- LU. III.4.4. The westernmost part of the unit is the point where the Teuquito and Teuco rivers are closest together (12.5 km in a straight line, 25 km along one of the watercourses). Although there is no evidence that it is a current spill point for the water of the Teuco River, it is a possibility for future hydraulic works to bring fresh water into the Bermejito River. To the North of Comandancia Frías, we find the start of a large "island" formed by paleoridges and filled-up paleochannels which prevent fresh water (overflow of the Teuco River) from entering the Bermejito River. This accentuates the salinity of these waters. This "island" forms the boundary with LU. IV.2.3. and prevents the floodwaters from advancing. In the interior of the island, there is a large depression bordered by two paleoridges, which has an outlet near Sauzalito. There are no clearings.
- LU. III.4.5. This LU.is structured upon a large dead river with ridges and filled-up paleochannels. It contains various paleoridges which are oriented in such a way that they prevent the overflow from entering and hence prevent the inflow of the replenishment fresh water. These ridges channel the overflow back to the Bermejo River, instead. There are no clearings.
- LU. III.4.6. The western boundary of this unit is the point where the Bermejito River begins to move away from the southern border of the Basin, which is also where the Guaycurú River originates. The Guaycurú River starts out as an ill-defined streambed, without lakes or large depressions, and almost without plains (except for 5 or 6 points above the bed), and develops a well-defined waterway 20 km further to the East. Not only does it not receive inflows of fresh water from the Bermejo, but because of its location along the southern boundary of the Basin, it receives small but new saline inflows from it. Savannahs and shrubs predominate.

Subregion III.5. "Effluents of the left bank of the Bermejo"

To the South of Ingeniero Juárez- Chiriguanos, there is a series of spill points on the left bank, where the waters cannot return to the Bermejo River. Instead, they are intercepted by the ridge of the Dobagán River, giving rise to the fluvial grid of Central and Eastern Formosa.

- LU. III.5.1. This unit is structured on the Teuquito River stream bed, and captures possible surplus flow draining from LU.III.3.1, but mainly from a spill point of the Teuco River. It is very homogeneous from a physiognomic standpoint, with a predominance of savannahs and shrubs, and without any obvious marks of intense fluvial modeling. The Teuquito River rambles along as a slightly incised waterway, without the formation of ridges, up to Laguna Yema. The surplus water from the Laguna is channeled by a pronounced course, through LU.III.5.2.
- LU. III.5.2. The unit begins between the Teuco and the Teuquito rivers as an area of alluvial oveflows, from which the fluvial network of Formosa is organized, with the peculiarity that the water that flows in does not return to the Bermejo River. The Dobagán River (the southern boundary of this GU), prevents the Bermejo River overflow from entering, while at the same time it prevents the formation of discharge points for itself. A recent exception is at kilometer 503, to the south of Estanislao del Campo, where a highly developed meander broke through the ridge of the Dobagán River, and created a water inflow point. Formosa Province has earthworks at this location. The LU.has an intricate network of paleocourses with ridges and paleochannels which are often filled. They form an imbricated design, which causes fragmentation of the landscape, but with a predominance of wooded areas and many small depressions with a heavy growth of shrubs. There are a very few clearings covering small areas.

Ecoregión IV. “Subhumid Chaco“ or “Central Chaco“

This Eco-region has a subhumid, dry, megathermal to mesothermal climate, with a water index of -20 to 0, a water deficit of 100 to 200 mm, and rainfall of the order of 900 to 1,100 mm per year. The climate makes it suitable for rainfed farming, and the major crop is cotton.

Subregion IV.1. “Overflow from the Bermejo”

This Subregion runs along both sides of the river, from 40 km to the West of the end of the Teuco-Bermejito interfluve. To the North of Pampa del Indio, it divides into two arms: the northern portion forms the Estero Bellaco; and, the southern part, which is more highly developed, is channeled by the Guaycurú River.

- LU. IV.1.1. From the junction of the Teuco and the Bermejito rivers, the Bermejo River forms a large, highly floodable plain, 50 km long by 10/15 km wide. It is relatively well contained to the South by the ridge of the Guaycurú River (review landscape units 99-100 and 101), until that ridge is surpassed several kilometers to the North of Pampa del Indio. From that point on, it serves as the primary point for floodwaters for more than 100 km. To the

North, the Dobagán River ridge contains the overflow up to a point located slightly to the East of Route 95, where it is largely destroyed (for a 35 km segment), thereby creating an arm to the North of this overflow, which forms the Estero Bellaco. The major sedimentary deposit of LU. IV.2.1. is the one that forces the division of these two arms. Because of severe flooding, there is no agriculture.

Subregion IV.2. "Fluvial deposits of the Dobagán-De Oro system"

This Subregion consists of a large deposit of an apparent delta nature located along both banks of the present course of the Bermejo River, which crosses it with a recently deposited layer. Accordingly, it has the largest area devoted to agriculture in the Lower Basin.

- LU. IV.2.1. This unit consists of the large agricultural area of Northern Chaco and Southern Formosa, structured upon a large sedimentary deposit of deltaic character, apparently formed by the Dobagán River, whose early course, prior to the present course of the Bermejo River, continues in Chaco Province by the name of Oro River, with a similar course, powerful ridges, and similar forests. The Bermejo River loses its large floodplain, which is obviously not agricultural, and begins to run through a narrow channel, following a clearly recently-formed course, without ridges, and with agricultural development up to the very edges of the channel.

Subregion IV.3. "Ridges, depressions, and lakes"

This is a highly fragmented Subregion, formed on the basis of an intricate network of fluvial units which generate natural dam areas, where a large number of lakes are formed. The southern part is structured on the ridges of the Nogueira Riacho (stream), the southernmost, and probably the oldest distributary of the Bermejo River. The northern part is highly fragmented by the presence of an intricate network of fluvial units which generate natural dam areas, where a large number of lakes is formed.

- LU. IV.3.1. This is the area where the Nogueira River begins, that is where the series of the southernmost derivations of the Bermejo River is found. It originates on the right-hand bank of the Bermejito River, as a continuous fluvial course, despite the fact that it is cut transversally by the course of the Guaycurú River, which suggests that it is a more recent fluvial episode, or in other words not as old as the Nogueira. It has powerful ridges and interfluves formed by connected lakes and depressions. In the central area, the woods present a compact mass, with large lakes. In the East, the disarticulation of the fluvial network begins, with a marked interdigitation, including a greater number of depressions and lakes.
- LU. IV.3.2. This unit is formed upon a base made up of a grid of

paleochannels, many of them filled up, which in crossings and curves generate (or reinforce) a large number of depressions, almost all of them without a permanent water fill and covered with brush, especially carob trees. These inter-ridge environments which dominate the landscape are much larger than in LU.III.5.2., and present a gentle topographic gradient. There are very few permanent water bodies. The agriculture is incorporated into the landscape, with small parcels which occupy for the most part the lands with herbaceous physiognomies (high border of the depressions), and which to a lesser extent generate clearings in the network of ridges. At 503 km, a major meander of recent development created a break in the ridge of the Saladillo River, allowing the waters of the Bermejo River to flow in. Formosa Province has developed earthworks to contain them.

- LU. IV.3.3. The rivers form an interior delta pattern, highly branched, generating an inverted dendritic configuration, with a large number of crevasses or lateral flows. A mosaic of medium-sized units is formed, with a slight predominance of woody plants. The ridges with forests in a gallery form dams, which explain the large number of lakes in contrast with the virtual absence of lakes in LU.V.1.1. The lakes are a potential alternative to irrigation for small to medium-sized parcels. Agriculture is significant, occupying about 25 to 30 percent of the land, consisting mostly of pastures and reedlands in the upper portion of the oveflow. There is no evidence of major clearings for agriculture.
- LU. IV.3.4. This unit originates on the right bank of the Guaycurú River, at the end of the Teuco-Bermejito interfluve, to its right. The Guaycurú River forms the northern boundary of the GU, up to the point where it is cut off by the overflow of the Bermejo River, which gives rise to LU.IV.1.1. The southern boundary is formed by the large mass of woods and lakes of the Nogueira River system, from which numerous overflows and crevasses issue forming the framework of this unit. Three different portions can be seen. In the northeast, there is a predominance of woods, shrubs, and a large number of generally shrub-filled depressions, with little agriculture and no bodies of water. In the center, there is a large agricultural area (Pampa del Indio), and a highly imbricated landscape with many depressions and lakes in the southeastern part. This LU.is outside the area under study.

Ecoregión V. “Humid Chaco”

The climate is humid-subhumid, with a water index of 0 to 20, a water deficit of 0 to 100 mm, and rainfall ranging from 1,100 to 1,300 mm annually. This Eco-region has a climate that allows for the cultivation of sugar cane. Recently, flooded rice paddies have been developed.

Subregion V.1. "Large marshes and streambeds with relatively undeveloped ridges"

The environment is low and floodable, but because all the drainage directions, including both the mantiforms (marshes and streambeds) as well as the ones that drain through fluvial beds, are subparallel, it is not conducive to the formation of lakes. The ridges, despite the fact that they are relatively undeveloped, favor this process of subparallel drainage.

- LU. V.1.1. It occupies the eastern part of Formosa and the northern part of Chaco. It is an extensive, homogenous Subregion characterized by remnants of allochthonous formation (rivers with ridges), all very narrow and with little potential, separated by approximately 10 km, with extensive interfluves, in many of which marshes of various sizes have formed, such as the Gallego or Mbiguá marshes. The important factor to note with these large interfluves is that despite the presence of large marshes, there are virtually no lakes or lagoons. This is attributed to the markedly linear design of the rivers, in contrast to LU.IV.3.3., where the braided design is conducive to the formation of lakes. Evidence of this organized drainage can be found in the disproportionate length of some of the Landscape Units.
- LU. V.1.2. This unit comprises the depressed area of the Guaycurú and the Iné streams, which receive waters from LU.IV.1.1. There is a clear boundary with the ridges of the Oro and Quiá rivers (LU.V.2.2.) and with the farmed areas of LU.V.2.1. The largest depressions are in the West, since the drainage is more organized in the eastern section, because of various waterways that empty into the Paraguay River.

Subregion V.2. "Highly developed ridges and restricted interfluves"

This Subregion is characterized by the predominance of powerful ridges, especially the ridges of the Oro and Quiá rivers, where the important farming areas of Las Palmas and La Leonesa are located. The southern sector is structured on the ridge of the Negro River (the southernmost distributary of the Bermejo River), where the land close to Route 16 has been largely cleared.

- LU. V.2.1. This unit is structured along the ridges of the Negro River and to a lesser extent on those of the Tragadero River, and it integrates highly disconnected branches of the woods of the Nogueira River. The woods of the Negro River ridges, because of their proximity to the City of Resistencia and National Highway 16, have been largely cleared. This GU, the southernmost distributary of the Bermejo River, is a wedge between the predominantly open landscape of the Humid Chaco and the Depressed Chaco, which begins further to the South. The unit is outside the area under study.

- LU. V.2.2. This is the largest highland LU.in Eastern Chaco and Formosa, and it is in sharp contrast to the floodable landscape of LU.V.1.2. Like LU.IV.2.1., with which it is environmentally linked; its structural axis is the Oro River, together with the Quiá River. Although large portions of these river areas have been cleared, a substantial part of the farming is done on pasturelands. There are virtually no lakes, because drainage is organized in a linear fashion.

Subregion V.3. “Floodplain of the Paraguay River”

This is the last section of the Paraguay River before its mouth, where it flows into the Paraná River. The Paraguay River is the collector for many basins, including the basins of the Bermejo River. From a biogeographical standpoint, it belongs to the Amazon Area. In other words, its hydrological and biogeographical classification is much higher than that for the Bermejo River Basin Subregion. Nevertheless, it is included as a Subregion on the basis of operational criteria, and not on the basis of its true hydrological or biogeographical classification.

- LU. V.3.1. This unit consists of the Paraguay River floodplain which runs NNE-SSW, and is the ultimate collector for the region. Although there is a dense network of ridges with woods in galleries alternating with crescent-shaped lakes, the area is not suitable for farming, because of the annual floods to which it is exposed.

The Ecological Regions are summarized in **Table 15**, **Annex II.**

ANNEX IV

ENVIRONMENTAL ZONING

ANNEX IV

ENVIRONMENTAL ZONING

Methodology

Environmental Zoning is a utilitarian and/or thematic classification of territorial units defined in the Ecological Regionalization system. Environmental Zoning is based on assigning numerical values reflecting the estimated intensity of Symptoms and Problems identified in the Regional Workshops convened by the Strategic Action Plan (SAP) project team. Results are presented at Sub-regional and Major Unit levels for the entire Binational Basin and at the Landscape Unit level for the Argentine section of the Upper Basin. Double-entry “Cartographic Unit/Indicator” matrices were constructed for each perception level, with the numerical value assigned to each celd representing the intensity of individual problems analyzed. Matrices are linked to digital map polygons at each level examined.

The following constitute the Problems identified, the abbreviation used in the matrix and a brief description of the scope of this project:

- Deforestation for agricultural purposes **Defor**
  The status of areas originally covered by native forests subsequently replaced by agrosystems is examined.

- Degradation as a result of over-use **Degrad**
  This refers to areas of pasture land, bush or woodland in which the original vegetation is preserved but altered due to over-use.

- Loss of biological properties in soil **Soil**
  Areas in which degradation resulting from erosion, flooding or secondary salinization directly or indirectly affected soil biology.

- Ligneous infestation **Infes**
  Generally over-pastured areas in which the original vegetation suffered a change in the wood/grass ratio.

- Eroded surfaces bordering domestic areas **Erosurf**
  Areas close to rural housing and stock-yards, where continual treading removes vegetation cover.

- Erosion **Erosi**
  Excessive soil loss due to wind or water action in excess of natural or geological processes.

- Salinization **Salin**
  The process which increases the salt content of soils, as a result of poor management of water resources.

- Loss of feeding capacity **Feed**

Reduced field grazing capacities due to reduced total volume and/or quality of the flora.

- Desertification **Deser**
  The process of degradation of land characterized by low levels of water availability, seriously reducing production capacity.

- Flooding **Flood**
  Areas which remain temporarily covered by rain water or water from minor water courses, as a result of their topographic, structural and textural characteristics.

- Waterloogging **Water**
  The process resulting from river overflows affecting settlements and production systems in areas close to main water courses during high water periods.

- Water deficit during the dry season **Defic**
  This is an indicator of the intensity of water deficit, affecting reserves of drinking water and water for plant growth.

- Risk of biodiversity loss **Biodiv**
  This is the sum of negative factors (fragmentation, degradation, desertification, etc.) which jeopardize the conservation of species.

- Mass Movement **Mass**
  The displacement of large volumes of earth in undulating areas, exacerbated by poor soil and water resource management.

In order to indicate the magnitude of individual problems, both the intensity and the territorial extent of individual cases were taken into consideration according to the following scale of values:

0	Non-existent
1	Minimal
2	Restricted
3	Significant
4	Serious
5	Very serious

Table IV-1 Values for Criticality of Environmental Problems at Major Unit Level.														
Major Unit	Defor	Degrad	Soil	Biodiv	Infes	Erosurf	Erosi	Salin	Feed	Deser	Flood	Water	Defic	Mass
I.1.1.	**1**	**2**	**1**	**3**	**0**	**1**	**3**	**1**	**2**	**2**	**0**	**0**	**2**	**1**
I.1.2.	**1**	**3**	**2**	**3**	**0**	**0**	**3**	**0**	**2**	**2**	**0**	**0**	**2**	**1**
I.1.3.	**0**	**4**	**3**	**1**	**0**	**1**	**3**	**2**	**4**	**5**	**0**	**0**	**5**	**4**
I.1.4.	**0**	**4**	**4**	**2**	**0**	**3**	**2**	**3**	**4**	**5**	**0**	**0**	**5**	**4**
I.1.5.	**0**	**3**	**2**	**1**	**0**	**2**	**2**	**2**	**4**	**4**	**0**	**0**	**5**	**2**
I.1.6.	**0**	**2**	**1**	**1**	**0**	**1**	**3**	**1**	**3**	**4**	**0**	**0**	**5**	**3**
I.1.7.	**0**	**0**	**3**	**1**	**0**	**0**	**3**	**2**	**2**	**2**	**0**	**0**	**5**	**3**
I.1.8.	**0**	**5**	**4**	**3**	**1**	**4**	**4**	**2**	**4**	**5**	**0**	**0**	**5**	**4**
I.1.9.	**0**	**4**	**4**	**3**	**1**	**4**	**4**	**1**	**4**	**5**	**0**	**0**	**5**	**4**
I.1.10.	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**1**	**1**	**0**	**0**	**5**	**3**
I.1.11.	**0**	**1**	**2**	**0**	**0**	**0**	**3**	**1**	**0**	**0**	**0**	**0**	**5**	**4**
I.2.1.	**4**	**4**	**2**	**3**	**3**	**0**	**3**	**0**	**4**	**2**	**0**	**0**	**2**	**0**
I.2.2.	**4**	**4**	**2**	**3**	**3**	**1**	**3**	**0**	**4**	**2**	**0**	**1**	**4**	**0**
I.2.3.	**4**	**4**	**4**	**4**	**4**	**1**	**5**	**0**	**4**	**4**	**0**	**0**	**5**	**0**
I.2.4.	**5**	**3**	**1**	**5**	**0**	**0**	**2**	**1**	**2**	**1**	**0**	**4**	**4**	**0**
I.3.1.	**1**	**4**	**4**	**3**	**1**	**3**	**4**	**2**	**4**	**5**	**0**	**0**	**5**	**4**
I.3.2.	**1**	**3**	**3**	**2**	**1**	**2**	**3**	**1**	**3**	**4**	**0**	**0**	**4**	**4**
II.1.1.	**0**	**1**	**0**	**2**	**0**	**0**	**2**	**0**	**2**	**1**	**0**	**0**	**0**	**2**
II.1.2.	**1**	**1**	**0**	**1**	**0**	**0**	**3**	**0**	**2**	**0**	**0**	**0**	**0**	**2**
II.1.3.	**0**	**2**	**1**	**1**	**1**	**0**	**3**	**0**	**2**	**0**	**0**	**0**	**1**	**3**
II.1.4.	**0**	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**1**	**2**
II.1.5.	**0**	**2**	**2**	**1**	**0**	**1**	**3**	**1**	**3**	**3**	**0**	**0**	**4**	**3**
II.1.6.	**0**	**2**	**1**	**1**	**0**	**0**	**2**	**0**	**1**	**1**	**0**	**0**	**2**	**2**
II.1.7.	**1**	**2**	**2**	**2**	**1**	**1**	**3**	**1**	**3**	**3**	**0**	**0**	**2**	**2**

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Table IV-1 Values for Criticality of Environmental Problems at Major Unit Level.													
Major Unit	Defor	Degrad	Soil	Biodiv	Infes	Erosurf	Erosi	Salin	Feed	Deser	Flood	Water	Defic	Mass
II.1.8.	**0**	**1**	**1**	**1**	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**1**	**2**
II.2.1.	**0**	**3**	**1**	**1**	**1**	**0**	**3**	**0**	**2**	**0**	**0**	**0**	**1**	**4**
II.2.2.	**1**	**3**	**2**	**2**	**2**	**1**	**4**	**1**	**3**	**2**	**0**	**0**	**3**	**3**
II.2.3.	**0**	**3**	**2**	**2**	**2**	**2**	**3**	**0**	**3**	**1**	**2**	**0**	**1**	**3**
II.2.4.	**0**	**3**	**1**	**1**	**0**	**0**	**2**	**0**	**1**	**1**	**0**	**0**	**1**	**3**
II.2.5.	**1**	**1**	**1**	**2**	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**4**
II.2.6.	**1**	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**0**	**0**	**3**	**1**
II.2.7.	**1**	**2**	**2**	**1**	**2**	**1**	**3**	**0**	**2**	**2**	**0**	**0**	**3**	**1**
II.2.8.	**1**	**3**	**3**	**2**	**3**	**2**	**2**	**0**	**3**	**2**	**0**	**0**	**2**	**2**
II.2.9.	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**0**	**3**	**3**	**0**	**0**	**3**	**0**
II.2.10.	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**3**	**0**	**0**	**3**	**2**
II.2.11.	**0**	**3**	**2**	**3**	**2**	**1**	**3**	**1**	**4**	**3**	**0**	**0**	**5**	**1**
II.3.1.	**4**	**3**	**3**	**5**	**1**	**0**	**4**	**0**	**2**	**1**	**0**	**3**	**1**	**0**
II.3.2.	**4**	**4**	**3**	**4**	**2**	**1**	**4**	**1**	**4**	**2**	**2**	**0**	**1**	**1**
II.3.3.	**2**	**2**	**2**	**2**	**1**	**0**	**1**	**0**	**2**	**1**	**2**	**5**	**3**	**0**
II.3.4.	**5**	**5**	**4**	**5**	**1**	**1**	**4**	**1**	**5**	**4**	**2**	**0**	**2**	**0**
II.3.5.	**5**	**5**	**4**	**5**	**2**	**2**	**4**	**2**	**5**	**5**	**0**	**0**	**4**	**0**
II.3.6.	**4**	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**1**	**3**	**1**	**0**
II.3.7.	**2**	**5**	**4**	**4**	**3**	**4**	**5**	**1**	**5**	**5**	**0**	**0**	**3**	**2**
II.3.8.	**5**	**5**	**4**	**5**	**2**	**1**	**4**	**1**	**4**	**4**	**0**	**0**	**2**	**0**
II.3.9. *	**5**	**5**	**4**	**5**	**2**	**2**	**4**	**1**	**4**	**4**	**0**	**0**	**3**	**0**
II.3.10. *	**5**	**3**	**4**	**2**	**2**	**1**	**4**	**1**	**2**	**2**	**0**	**0**	**3**	**0**
II.3.11.	**5**	**3**	**4**	**2**	**1**	**1**	**4**	**0**	**1**	**2**	**0**	**0**	**3**	**0**
II.3.12.	**3**	**3**	**3**	**2**	**2**	**1**	**1**	**3**	**3**	**2**	**1**	**0**	**3**	**0**
III.1.1.	**1**	**2**	**0**	**0**	**3**	**1**	**1**	**4**	**2**	**2**	**3**	**2**	**2**	**0**
III.1.2. *	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**4**	**2**	**3**	**2**	**0**	**3**	**0**

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Table IV-1 Values for Criticality of Environmental Problems at Major Unit Level.

Major Unit	Defor	Degrad	Soil	Biodiv	Infes	Erosurf	Erosi	Salin	Feed	Deser	Flood	Water	Defic	Mass
III.2.1.	**0**	**1**	**0**	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**2**	**5**	**2**	**0**
III.2.2.	**0**	**1**	**1**	**0**	**5**	**0**	**1**	**2**	**0**	**0**	**2**	**5**	**2**	**0**
III.2.3.	**0**	**2**	**4**	**0**	**3**	**4**	**3**	**3**	**4**	**4**	**3**	**5**	**3**	**0**
III.3.1.	**0**	**5**	**4**	**4**	**2**	**5**	**3**	**3**	**5**	**5**	**2**	**2**	**5**	**0**
III.3.2.	**0**	**5**	**5**	**5**	**2**	**5**	**3**	**4**	**5**	**5**	**2**	**2**	**5**	**0**
III.4.1. *	**2**	**3**	**1**	**2**	**2**	**2**	**0**	**2**	**3**	**2**	**1**	**0**	**4**	**0**
III.4.2.	**1**	**3**	**1**	**2**	**2**	**3**	**1**	**3**	**3**	**3**	**1**	**0**	**5**	**0**
III.4.3.	**1**	**3**	**2**	**2**	**2**	**2**	**1**	**3**	**3**	**3**	**2**	**0**	**5**	**0**
III.4.4.	**0**	**3**	**2**	**1**	**2**	**2**	**0**	**3**	**3**	**3**	**2**	**2**	**5**	**0**
III.4.5.	**0**	**2**	**2**	**1**	**3**	**2**	**1**	**2**	**3**	**3**	**2**	**2**	**4**	**0**
III.4.6.	**0**	**3**	**3**	**2**	**3**	**3**	**2**	**4**	**4**	**4**	**2**	**0**	**5**	**0**
III.5.1.	**0**	**3**	**3**	**2**	**3**	**3**	**2**	**3**	**4**	**3**	**3**	**2**	**5**	**0**
III.5.2.	**1**	**3**	**2**	**2**	**3**	**2**	**1**	**3**	**3**	**3**	**3**	**1**	**4**	**0**
IV.1.1.	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**3**	**4**	**3**	**0**
IV.2.1.	**5**	**4**	**3**	**4**	**1**	**0**	**1**	**0**	**1**	**0**	**2**	**0**	**2**	**0**
IV.3.1.	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**3**	**2**	**2**	**1**	**0**	**4**	**0**
IV.3.2.	**3**	**3**	**2**	**2**	**5**	**2**	**1**	**2**	**4**	**3**	**2**	**0**	**3**	**0**
IV.3.3.	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**0**	**3**	**0**
IV.3.4. *	**4**	**3**	**3**	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**2**	**0**	**2**	**0**
V.1.1.	**1**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**4**	**0**	**1**	**0**
V.1.2.	**1**	**2**	**1**	**1**	**2**	**0**	**0**	**1**	**2**	**0**	**4**	**0**	**1**	**0**
V.2.1. *	**3**	**5**	**3**	**3**	**1**	**1**	**1**	**1**	**1**	**0**	**2**	**0**	**1**	**0**
V.2.2.	**4**	**5**	**2**	**4**	**1**	**0**	**0**	**2**	**1**	**0**	**2**	**0**	**1**	**0**
V.3.1.	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**5**	**0**	**0**

(*): These **GU'**s are not included within the limits of the basin defined for the SAP project. They are not indicated in the corresponding TDA Figures.

Annex IV - 5

ENVIRONMENTAL ZONING AT SUB-REGIONAL LEVEL

Criteria for environmental zoning at Sub-regional level

For classification purposes, indicators were used that make it possible to express synthetic conditions which could be useful in policy-making. The attributes identified are as follows:

- Intensity of agricultural activity	Agri
- Conservation risks at ecosystem level	Ecos
- Soil conservation problems	Soil
- Problems of flooding and waterloogging	Flood
- Problems of geological erosion	Geol

The following four intensity levels were used for each attribute:

- 0 Absent
- 1 Low
- 2 Medium
- 3 High

In order to avoid the above-mentioned problem of a “diluting” effect when working at Sub-regional level, values will be assigned considering the fact that, at Major Unit (GU) level, the related attributes are presented as a serious problem.

Table IV-2 Levels of Criticality at the Sub-Regional Level.

Sub-region	Agri	Ecos	Soil	Flood	Geol
I.1.	**1**	**1**	**2**	**0**	**2**
I.2.	**2**	**3**	**3**	**0**	**3**
I.3	**1**	**2**	**3**	**0**	**2**
II.1	**1**	**1**	**1**	**0**	**2**
II.2.	**1**	**1**	**2**	**0**	**3**
II.3.	**3**	**3**	**2**	**1**	**1**
III.1.	**0**	**1**	**0**	**2**	**0**
III.2.	**0**	**2**	**2**	**3**	**0**
III.3.	**1**	**3**	**3**	**2**	**0**
III.4	**1**	**1**	**2**	**0**	**0**
III.5.	**1**	**1**	**1**	**2**	**0**
IV.1.	**0**	**1**	**1**	**3**	**0**
IV.2.	**3**	**2**	**2**	**1**	**0**
IV.3.	**2**	**1**	**1**	**2**	**0**
V.1.	**1**	**1**	**1**	**2**	**0**
V.2.	**2**	**2**	**2**	**1**	**0**
V.3.	**0**	**0**	**0**	**3**	**0**

ANNEX V

QUANTIFICATION AND LOCATION OF ENVIRONMENTAL PROBLEMS

QUANTIFICATION AND LOCATION OF ENVIRONMENTAL PROBLEMS

a. SOIL DEGRADATION. INTENSE PROCESSES OF EROSION AND DESERTIFICATION

QUANTIFICATION	LOCATION AND WEIGHTING
13,35 % of the basin's area corresponds to Large Units (LU) with high or very high processes of mass removal. Critical conditions of erosion in the LUs affect 22% of the basin's area. Sectors showing severe and very severe evidence of Desertification amount to 18% of the basin. In Bolivia, more than 57% of the Fluvio-lacustrine Plain of the Valle Central de Tarija has degraded areas. Nearly 66% of the soil surface is unsuitable for farming. The LUs showing intense signs of deforestation cover more than 13% of the basin's surface (or 26% of the area covered by forest or rain forests) 17% of the basin's area is affected by soil degradation from overuse. For the Eastern Andes sediment production is estimated at from 1,000 to 3,000 t/km².year. For the Subandean, in Bolivia, sediment production is estimated at between 1,500 and 3,500 t/km².year. In Argentina, the Río Iruya carries more	**I. I. ECO-REGION: EASTERN ANDES** **Subregions I.1. Montane; I.2. Valle Central de Tarija; I.3 Quebrada de Humahuaca.** Large Units: **Erosion:** I.1.8.; I.1.9; I.3.1= severe; I.2.3= very severe **Mass Removal** I.1.3., I.1.4; I.1.8; I.1.9; I.1.11; I.3.1; I.3.2 = severe **Desertification** I.1.5; I.1.6; I.2.3; I.3.2.= severe; I.1.3; I.1.4; I.1.8.; I.1.9; I.3.1 = very severe **Peridomestic barelands** I.1.8; I.1.9 = severe **Loss of biological properties of the soil** I.1.4.; I.1.8; I.1.9; I.2.3.; I.3.1= severe **II. ECO-REGION: SUBANDEAN** **Subregions II.2 y II.3. Submontane and Piedemont. Large Units:** **Erosion** II.2.2, II.2.11; II.3.1, II.3.2, II.3.4; II.3.5; II.3.8.; II.3.11 = severe; II.3.7= very severe **Mass removal** II.2.1; II.2.5 = severe **Desertification** II.3.4; II.3.8 = severe; I.3.5; II.3.7= very severe **Peridomestic barelands** II.3.7 = severe **Loss of biological properties of the soil** II.3.4; II.3.5; II.3.7; II.3.8: II.3.11= severe **III. ECO-REGION: SEMIARID CHACO** **Subregions III.2. Flood plain; III.3. Overflow channels and washouts; III.4. Washouts of the Rio Bermejo** **Large Units:** **Erosion** III.2.3; III.3.2; III.4.4 = severe **Desertification**

QUANTIFICATION AND LOCATION OF ENVIRONMENTAL PROBLEMS

a. SOIL DEGRADATION. INTENSE PROCESSES OF EROSION AND DESERTIFICATION

QUANTIFICATION	LOCATION AND WEIGHTING
than 14,000 t/km².year. The total sediment transport amounts to 100,000,000 tons a year, with an average specific solid flow of more than 1,800 t/km².year.	III.2.3; III.4.6= severe; III.3.1; III.3.2= very severe **Peridomestic barelands** III.2.3= severe; III.3.1; III.3.2 =very severe **Loss of biological properties of the soil** III.2.3; III.3.1 = severe ; III.3.2 = very severe

QUANTIFICATION AND LOCALIZATION OF ENVIRONMENTAL PROBLEMS:

b. WATER SHORTAGE AND USE RESTRICTIONS

QUANTIFICATION	LOCATION
The Large Units affected by severe or very severe water deficits during the dry season amount to more than 31 percent of the basin's area. Climatic seasonality means that up to 85 percent of rainfall in the upper valley is concentrated in the rainy season (summer). At the Juntas de San Francisco, the average annual flow of the Rio Bermejo is 480 m3/s. This can fall to a monthly minimum of 30 m3/s in the dry season. Sediment concentrations in the water system can exceed 10 kg/m3. The area under irrigation is only 2 percent of the Bolivian sector. In Argentina, only 4 percent of the upper basin and 2 percent of the lower basin is irrigated.	**I. ECOREGIÓN: EASTERN ANDES** **Subregions: I.1. Montane; I.2. Valle Central de Tarija; I.3 Quebrada de Humahuaca: Large Units** **Water scarcity** I.2.2; I.2.4; I.3.2.= severe; I.1.3. a I.1.11; I.2.3; I.3.1.= very severe **II. ECO-REGION: SUBANDEAN** **Subregions II.2. Sub-Andean valleys; II.3. Recent alluvium. Large Units:** **Water scarcity** II.1.5; II.3.5.= severe; II.2.11.= very severe **III. ECO-REGION: SEMIARID CHACO** **Subregions III. 3. Overflow channels and washouts. Large Units:** **Water scarcity:** III.4.5; III.5.2.= severe; III.3.1; III.3.2.; III.4.2; III.4.3; III.4.4; III.4.6; III.5.1.= very severe **IV. ECOREGIÓN: SUBHUMID CHACO** **Subregions IV.1. Albardones, depressions and lagoons. Large Units:** **Water scarcity:** IV.3.1.=(severe

QUANTIFICATION AND LOCALIZATION OF ENVIRONMENTAL PROBLEMS:

c. DEGRADATION OF WATER QUALITY

QUANTIFICATION	LOCATION
Sediment concentrations in the water system can exceed 10 kg/m3. Large units with severe or very severe salinization represent nearly 7 percent of the basin's area, particularly in the Semiarid Chaco Eco-region. In Argentina, 6 of 14 control points showed use restrictions due to bacterial contamination. In Bolivia, water quality at level D, with restricted use and unfit for human consumption, is found in stretches of the rivers Guadalquivir, Camacho, Salinas where it passes through Entre Rios, the Bermejo and Grande de Tarija at Bermejo. 28 of 41 sampling points in the Bolivian sector of the basin showed restrictions due to bacterial contamination. 47 percent of dwellings in the Argentine sector are substandard. In the city of Bermejo, in Bolivia, 48 percent of dwellings have no sewer service.	**I. ECO-REGIÓN: EASTERN ANDES** **Subregions: I.2. Valle Central de Tarija. Large Units:** **Water quality D**, Stretches of the following rivers: Río Guadalquivir in LU I.2.4. Río Camacho in LU I.2.4. **II. ECO-REGIÓN: SUBANDEAN** **Subregions: II.2. Submontane; II.3. Piedemont. Large Units:** **Water quality D**, Stretches of the following rivers: Río Salinas in LU II.2.2. Ríos Bermejo and Grande de Tarija in LU II.3.1. **III. ECO-REGION: SEMIARID CHACO** **Subregions: III.1. Unmodeled overflow channels of the Rio Bermejo; III.3. Washouts of the Bermejo. Large Units:** **Salinization:** III.1.1; III.3.2; III.4.6.= severe

QUANTIFICATION AND LOCALIZATION OF ENVIRONMENTAL PROBLEMS:

d. DESTRUCTION OF HABITATS, LOSS OF BIODIVERSITY AND DETERIORATION OF BIOTIC RESOURCES

QUANTIFICATION	LOCATION
Large units showing intense deforestation cover more than 13 percent of the basin, equal to 26 percent of the forests and rain forest area. Nearly 7 percent of the basin has been rendered for farming. 17 percent of the basin is affected by soil degradation from overuse. Large units with a severe or very severe risk of biodiversity loss represent about 15 percent of the basin. Available information indicates that more than 40 species of flora and fauna are threatened, another 60 are vulnerable, and an undetermined number are at varying degrees of risk. While 5 percent of the basin has protected area status, more than 60 percent of that area is subject to inadequate or no control (according to available data). In fact, only two of the 21 protected natural areas in the entire basin are sufficiently controlled.	**I. ECO-REGION: EASTERN ANDES** **Subregions: I.1 Montana; I.2 Valle Central de Tarija; I.3 Quebrada de Humahuaca. Large Units:** **Degradation from overuse** I.1.3.; I.1.4; I.1.9.= severe; I.1.8.= very severe **Loss of the soils natural productive capacity** I.1.3. to I.1.5.; I.1.8.; I.1.9, I.2.1. to I.2.3; .I. 3.1= severe **Deforestation** I.2.1.to I.2.3.= severe; I.2.4.=very severe **Loss of biodiversity** I.2.3.= severe; I.2.4.= very severe **Degradation from overuse** I.2.1. to I.2.3;. I.3.1.= severe **Invasive woody plants:** I.2.3= severe **II. ECO-REGION: SUBANDEAN** **Subregions II.2 Submontana and II.3.Pedemontana. Large Units:** **Deforestation:** II.3.1.;II.3.2; II.3.6.= severe; II.3.4; II.3.5.; II.3.8;. II.3.11.= very severe **Loss of biodiversity** II.3.2, II.3.7.= severe; II.3.1.=5II.3.4.; II.3.5.; II.3.8= very severe **Degradation from overuse** II.3.2.=severe ; II.3.4; II.3.5; II.3.7; II.3.8.= very severe **Loss of the soils natural productive capacity** II.2.11. ; II.3.2.; II.3.8. = severe; II.3.4. ; II.3.5.; II.3.7. = very severe **III. ECO-REGION: SEMIARID CHACO** **Subregion III.2 Current flood plain of the Bermejo-Teuco. Large Units:** **Loss of biodiversity;**III.3.1= severe ; III.3.2.= very severe **Degradation from overuse** III.3.1; III.3.2.= very severe **IV. ECO-REGION:SUBHUMID CHACO** **Subregions IV.2 Fluvial deposits IV.3 Albardones, depressions and lagoons. Large Units:** **Deforestation:** IV.2.1= very severe **Loss of biodiversity** IV.2.1.= severe

QUANTIFICATION AND LOCALIZATION OF ENVIRONMENTAL PROBLEMS:

d. DESTRUCTION OF HABITATS, LOSS OF BIODIVERSITY AND DETERIORATION OF BIOTIC RESOURCES

QUANTIFICATION	LOCATION
	Degradation from overuse: IV.2.1.= severe **V. ECO-REGION: HUMID CHACO** **Subregion V.2 Large Albardones and restricted interfluves. Large Units:** **Deforestation:**V.2.2.= severe **Loss of biodiversity:**V..2.2.= severe **Degradation from overuse:** V.2.2.= very severe **Loss of the soils natural productive capacity** III.2.3; III.4.6; III.5.1; IV.3.2.= severe; III.3.1; III.3.2= very severe **Invasive woody plants:** III.2.2; IV.3.2.= very severe

QUANTIFICATION AND LOCALIZATION OF ENVIRONMENTAL PROBLEMS:

e. CONFLICTS FROM FLOODING AND OTHER NATURAL DISASTERS

QUANTIFICATION	LOCATION
The LUs affected by severe and very severe inundation from overflowing rivers represent about 8% of the basin's area. Severe or very severe waterlogging conditions, primarily from rainfall accumulation in low-lying or poorly drained areas, affect more than 7% of the basin. Maximum flows recorded in the upper Bermejo and the Río Grande de Tarija reach 5,000 and 8,000 m³/s respectively; the maximum probable crest at Juntas de San Antonio (last point in Bolivian territory) is estimated at 12,000 m³/s and at the junction of the San Francisco (last point in the upper basin) it is as much as 20,000 m³/s. The Río Bermejo at Zanja del Tigre (Salta), had peak flows of 10,000 m3/s during the 1984/85 season Productive systems and road, irrigation and other infrastructure has been affected in Argentina at such points as the capital of Jujuy, Embarcación (Salta), El Sauzalito, Sauzal, Tartagal, Tres Pozos. En Bolivia, the critical urban flood points are Tarija, Ciudad de Bermejo and others. In the Chaco Eco-regions the critical flooding points are the confluence of the Río Bermejo and the Bermejito, the outflow areas of the Dorado and Del Valle rivers, the flood plain of the Río Paraguay and the estuaries and swamps of eastern Chaco and Formosa. In the province of Chaco alone, during 1983-84, more than 390,000 ha were affected. Droughts, frosts and hailstorms occur with the greatest severity in the Eastern Andes.	**I.ECO-REGIÓN: EASTERN ANDES** **Subregion I.2 Valle Central de Tarija. Large Units:** **Inundation:** I.2.4.= severe **II.ECO-REGIÓN: SUBANDEAN** **Subregion II.3 Pedemontano. Large Units:** **Inundation:** II.3.3.= very severe **III. ECO-REGION: SEMIARID CHACO** **Subregion III.2 Current flood plain of the Bermejo Teuco. Large Units:** **Inundation:** III.2.1.to III.2.3.= very severe **IV. ECO-REGION: SUBHUMID CHACO** **Subregions IV.1 Overflow channels of the Bermejo . Large Units:** **Inundation:** IV.1.1.= severe **V.ECOREGIÓN: HUMID CHACO** **Subregions V.I Estuaries and swamps V.3 Flood plain. Large Units:** **Inundation:** V.3.1.= very severe **Waterlogging** V.1.1; V.1.2.;V.3.1.= severe

QUANTIFICATION AND LOCALIZATION OF ENVIRONMENTAL PROBLEMS:

f. DECLINING LIVING STANDARDS

QUANTIFICATION	LOCATION
41.7% of the basin's population has Unmet Basic Needs (UBN). Rural conditions are more critical, reaching 73%. In the Bolivian sector more than 64% of the population has UBN, and in Argentina more than 37%. Human Development Indicators are as low as 0.758 in Chaco, 0.732 in Formosa, 0.763 in Jujuy, 0.83 in Salta and 0.6 in the Department of Tarija. More than 80,000 people are considered illiterate. More than 95% of the basin's population have no medical coverage. The unemployment rate reaches more than 18% in Salta. The infant mortality rate is 34‰ in Chaco, 31‰ in Formosa, 24‰ in Jujuy and 24‰ in Salta. In the Department of Tarija, the average infant mortality rate is 54‰, and ranges from 44 to 74‰, depending on the municipality. In Tarija, Gross Geographic Product (GGP) per capita is US$764 per year. In the Argentine sector of the basin, GGP varies between US$ 1,996 and US$ 3,771 per capita per year, depending on the province. Studies of transboundary migrations in Tarija show that more than 42% of the rural population has left for Argentina at least once, and 69.9% of them in search of work.	**I. ECO-REGION: EASTERN ANDES** **Subregions I.1 Montano, I.2 Valle Central de Tarija . Large Units:** **UNB for subregions in Bolivia** I.1.= Very high (very severe) **UNB for subregions in Argentina** I.1.= high (severe) **II. ECO-REGION: SUBANDEAN** **Subregions II.1 montana; II.2 submontana. Large Units:** **UNB for subregions in Bolivia** II.1 and II.2 = Very high (very severe) **UNB for subregions in Argentina** II.1 and II.2 = High (severe) **III. ECO-REGION: SEMIARID CHACO** **Subregions III.1. Unmodeled overflow channels; III.2. Overflow channels and washouts III.3. Washouts of the Bermejo; III.4. Distal washouts of the Bermejo** **III.5. Effluents of the left bank of the Bermejo. Large Units:** III.1.=High (severe) III.2.to III.4.= Very high (very severe) III.5.= High (severe) **IV. ECO-REGION: SUBHUMID CHACO** **Subregions IV.1. Overflow channels of the Bermejo; IV.3. Albardones, depressions and lagoons. Large Units:** IV.1.and IV.3.=Very high (very severe)