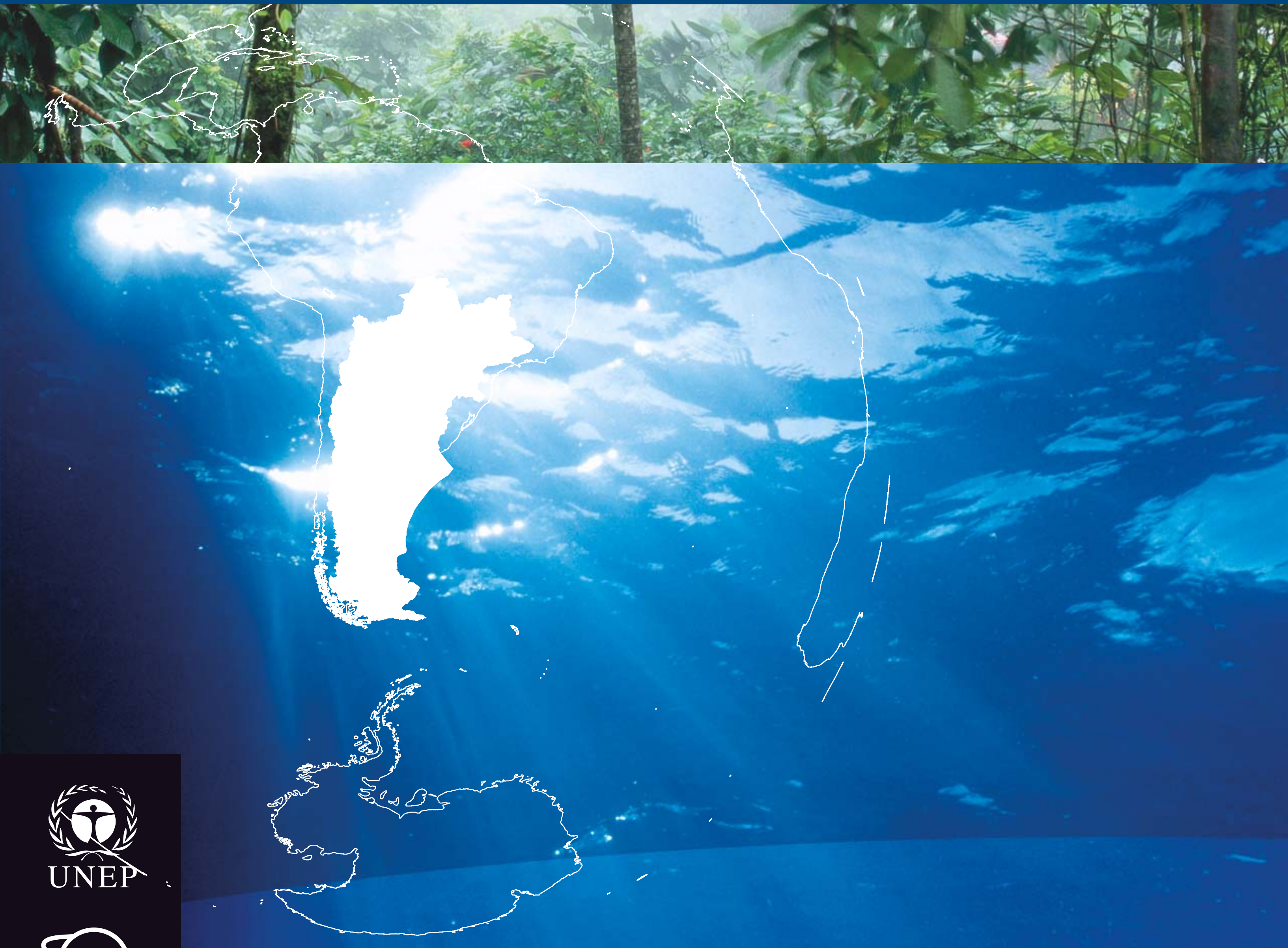
Global International Waters Assessment



Patagonian Shelf

GIWA Regional assessment 38

Mugetti, A., Brieva, C., Giangiobbe, S., Gallicchio, E., Pacheco, F., Pagani, A., Calcagno, A., González, S., Natale, O., Faure, M., Rafaelli, S., Magnani, C., Moyano, M.C., Seoane, R. and I. Enriquez

Global International Waters Assessment

Regional assessments

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Regional assessment 38
Patagonian Shelf

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Contents

Executive summary

GIWA region 38, Patagonian Shelf, comprises the La Plata River Basin, the South Atlantic Drainage System, and the Patagonian Shelf Large Marine Ecosystem. Given the significant differences in terms of biophysical and socio-economic aspects, the assessment was carried out separately for two systems: La Plata River Basin and the South Atlantic Drainage System.

La Plata River Basin

The La Plata River Basin is shared by Argentina, Bolivia, Brazil, Paraguay and Uruguay. Covering over 3.1 million km^2, it is the second largest drainage basin in South America and the fifth largest in the world. The Guaraní Aquifer, shared by Argentina, Brazil, Paraguay, and Uruguay, and containing over 40 000 km^3 of freshwater, is also located in the region.

The region contains many large urban and industrial centres and politically important cities, including Buenos Aires, Asuncion, Montevideo, Brasilia, Sao Paulo, and Curitiba.

The Basin is an important centre for the regional economy. Approximately 50% of the population of the countries sharing the La Plata Basin live within the drainage basin while around 70% of GNP of the countries involved is produced within the same area.

The La Plata River Treaty provides a supra-national legal framework for the region, and the Intergovernmental Coordinating Committee (CIC) of the La Plata River Basin provides an institutional framework for management. International institutional agreements and basin committees can also be found within several sub-basins.

Assessment

The impacts of Freshwater shortage in the La Plata River Basin were assessed as moderate. Although freshwater supply aggregated at basin level greatly exceeds demand, the temporal and spatial distribution of flow is uneven, and the degradation of water quality by pollution is progressively decreasing the usability of supplies. Shortages in many locations have already been observed, and these are likely to become more common in the future.

The modification of water sources around major cities, the rising costs of water treatment, and the high cost of restoring degraded water sources stand out as pressing socio-economic issues that could potentially initiate conflicts at both sub-national and regional levels.

The impacts of Pollution in the Basin were assessed as moderate. The limited treatment of industrial wastes leads to widespread contamination by chemical pollutants. The lack of sewage treatment leads to the contamination of supplies by pathogens, particularly in the vicinity of cities. The use of agro-chemicals has introduced significant sources of chemical pollutants, and there is evidence of eutrophication in some areas of large reservoirs. In addition, land use changes and unsustainable agricultural practices have resulted in erosion that has greatly increased the turbidity of water supplies. Finally, occasional significant oil spills occur.

Economic impacts associated with Pollution were assessed as severe, particularly due to increases in water treatment costs. There is also considerable evidence of health impacts due to water-borne diseases. For example, diarrhoea and schistosomiasis are common, and during the 1990s, cholera epidemics were registered in all of the countries of La Plata River Basin except Uruguay. At local levels, there has been evidence of decreased viability of fish stocks due to pollution. Future improvements in pollution control will require major investments, but are necessary for avoiding health problems, as well as a range of environmental and social impacts.

The impacts of Habitat and community modification were assessed as moderate. The construction of reservoirs for hydropower generation has caused modifications to several types of fluvial and riparian ecosystems. Migratory routes of fish species have been disturbed, flow regulation has affected species that use downstream floodplains for spawning, and there have been records of fish mortality due gas supersaturation caused by dam operations. In addition, alien bivalve species accidentally introduced from Asia (*Limnoperna fortunei* and *Corbicula fluminea*) have spread throughout a large part of La Plata River Basin and have displaced native benthic species. An increasing abundance of carp in the inner La Plata, Paraná and Uruguay rivers has also been evident. Urbanisation has also resulted in the loss of certain aquatic ecosystems types.

Socio-economic impacts caused by these changes include the loss of educational and scientific values, and increased costs associated with the control of invasive species and the restoration of habitats. Future impacts due to habitat modification are likely to either continue to worsen, or to improve slightly.

The impacts of Unsustainable exploitation of fish and other living resources were assessed as moderate. The sustainability of major commercial and recreational inland fisheries in the La Plata River Basin are at risk due to inadequate management practices and overexploitation. When combined with habitat modification, pollution, and impending climate change, overexploitation is threatening the long-term viability of fish stocks.

Although the fishing sector is small, socio-economic impacts have been assessed as considerable due to subsistence concerns associated with non-professional fishermen. A moderate increase in the impacts due to fishing are expected in the future.

The impacts of Global change were assessed as moderate. The La Plata River Basin has been extensively influenced by climatic variability and is very sensitive to El Niño events. In spite of present uncertainties, global change seems to have had a significant effect on the hydrological cycle, and cities located in the vicinity of rivers are now at greater risk of flooding disasters, especially in Argentina. In the future, it is assumed that global change will cause the global hydrological cycle to become more volatile and unpredictable, which will increase the risk of flooding and attendant socio-economic consequences due to impacts upon infrastructure, agricultural production, and the economy.

Based on the assessment of each major concern and the constituent issues, and a consideration of environmental, socio-economic, and health impacts, the GIWA Task team prioritised Pollution for further analysis, and chose the Uruguay River Basin to illustrate the Causal chain and Policy options analyses.

Causal chain analysis and Policy option analysis for Pollution: Uruguay River Basin upstream from the Salto Grande Reservoir

The primary immediate causes of pollution in the Uruguay River Basin were identified as: inadequate treatment of urban and industrial wastewater, application of agro-chemicals (fertilisers and biocides), inefficient irrigation practices, and soil erosion.

Identified root causes for pollution include:

- Lack of a framework for Integrated Water Resources Management, and lack of coordination between different levels of government;
- Lack of stakeholder participation in decision-making;
- Inadequate valuation of ecosystem goods and services;
- Persistence of unsustainable agricultural practices;
- Inadequate budgets of institutions in charge of management, which contributes to the lack of enforcement of existing agreements and policies;
- Poor spread of scientific and technological knowledge and training;
- Market incentives for short term economic gain;
- Poverty.

After analysing several policy options, the following policy instruments were highlighted as recommended options:

- Improved wastewater treatment by strengthening and coordinating financial mechanisms between private and public sectors (including international sources);
- Promote sustainable agricultural practices by enforcing regulations concerning agrochemicals ('polluter pays'), facilitating the introduction of practices that reduce soil erosion, and making irrigation more efficient ('user pays');
- Carry out systematic campaigns of environmental awareness and education that target specific stakeholders;
- Use subsidies to promote the treatment and/or reuse of wastes originating from livestock production;
- Create basin management mechanisms with transboundary, integrated approaches. These would include and/or extend the scope of existing institutions.

South Atlantic Drainage System

The South Atlantic Drainage System comprises basins located between the Andean ranges and the Atlantic Ocean, which drain large arid areas of Argentina and some small parts of southern Chile. This sub-system also contains one of the world's largest continental shelves, which is over 769 400 km^2, and extends up to 850 km from the coast at its southernmost point.

This system is characterised by very low population densities, and the primary economic activities include farming (e.g. fruit, sheep), mining (oil and coal), and fishing.

Assessment

The impacts of Freshwater shortage were assessed as moderate. Localised overexploitation of groundwater and pollution of water supplies have had major impacts on freshwater supplies. In addition, the construction and operation of dams has modified riparian habitats and changed seasonal flow patterns.

The impacts of Pollution were assessed as slight. Oil spills, suspended solids, and microbial pollution are responsible for most of the environmental impacts. Wastewater discharges are the main sources of microbiological pollution. The extensive use of pesticides and fertilisers has impacted some lakes, and eutrophication has been evident in areas with restricted water circulation. In addition, oil spills and toxic waste spills have had negative impacts on both ecosystems and water supplies.

The impacts of Habitat and community modification were assessed as moderate. Marine ecosystems have been extensively modified due to fishing, dredging and tourism development. In addition, reservoir development has altered many fluvial and riparian ecosystems, particularly in the Limay River.

The impacts of Unsustainable exploitation of fish were assessed as moderate. Hake has been exploited beyond safe biological limits, resulting in the collapse of fish stocks. Overexploitation, by-catches and discards of organisms without commercial value, and habitat destruction by trawling methods have generated threats to ecosystem integrity and marine biodiversity.

The impacts of Global change on the South Atlantic Drainage System were assigned a score of 0 or no impact. However, impacts of global change are expected to increase in the future.

Based on the assessment of the major concerns and their issues, the following linked concerns were prioritised within the transboundary regions of the Argentinean-Uruguayan Common Fishing Zone and the Buenos Aires Coastal Ecosystem:

- Habitat and community modification, which is tightly linked to unsustainable exploitation of fish and other living resources, and also linked to pollution.

Causal chain analysis and Policy option analysis for the Argentinean-Uruguayan Common Fishing Zone and the Buenos Aires Coastal Ecosystem

The Argentinean-Uruguayan Common Fishing Zone and the Buenos Aires Coastal Ecosystem were selected as a case study for the Causal chain and Policy options analyses. The most significant immediate causes of habitat modification are related to the fisheries sector, and include: overexploitation of target species, by-catch, and the modification of the sea floor by fishing gear. Other significant causes of habitat modification include urbanisation and shipping activities. Habitats are also being altered by pollution originating from urban and industrial wastewater discharges and agricultural non-point sources.

Besides market forces, the primary root cause for habitat modification is a general lack of surveillance and regulation. This applies primarily to fishing activities, but also to urbanisation, tourism development, and agriculture. Ineffective governance leads to inadequacies in the budgets and personnel of agencies charged with management, hinders the efficient application of legal instruments, and contributes to a lack of research and knowledge development. There is also a lack of consent between Argentina and Uruguay in many aspects related to joint administration of shared resources and joint research and assessment of ecosystems. In addition, technology to increase selectivity of fishing gears is missing, and fishers show significant socio-cultural resistance to the use or development of new types of fishing gear.

Policy options to address the identified root causes require management policies based on a set of multiple tools that should be applied simultaneously. Recommended actions include:

- Demarcate a coastal area and restrict fishing operations in this area to small boats only (under 25-30 m);
- Include a National Programme of Preservation of the Marine Environment within Argentina's Science and Technology System (SCYT);
- Link fisheries development to national programmes for the preservation of the marine environment;
- Reorient research policies to reconcile research and development issues with state policies;

- Optimise national, provincial, and state budget allocations to fisheries management agencies;
- Develop a mechanism to finance long-term research aimed at achieving the sustainable management of ecosystems;
- Strengthen efforts to systematically compile and analyse fisheries data;
- Coordinate research data from several projects at both national and international levels;
- Regulate fishing efforts "in parallel" (Argentina-Uruguay), allowing each country to develop its own fishery exploitation models and then reconcile both practices;
- Jointly evaluate the state of resources and obtain more reliable scientific data. This requires continuous bi-national research campaigns;
- Promote the exchange of data and knowledge among regional organisation through research units and workshops (Argentina, Uruguay, Brazil) to identify shared resources and assess genetic diversity;
- Optimise communication systems among scientists, administrators and managers;
- Improve the capacity of land-based and on-board fisheries inspectors to undertake control and monitoring activities;
- Involve fishermen in developing selective practices and devices;
- Disseminate information throughout communities in order to foster public awareness about goods and services related to marine ecosystems;
- Launch educational campaigns among the general population to discourage consumption of products based on endangered species, or species whose exploitation is likely to undermine the integrity of the ecosystem or disrupt ecosystem function;
- Carry out technical studies to develop selective fishing gear that minimises by-catch and safeguards biodiversity and habitats;
- Expand research on species exposed to incidental exploitation.

Acknowledgements

The Argentine Institute of Water Resources (IARH) has been the Focal Point for the regional GIWA assessment of the Patagonian Shelf.

The Argentine Institute of Water Resources (IARH) is a non-governmental organisation created in 1984 by professionals interested in water resources management. Its goal is the study, promotion and dissemination of issues related to the knowledge, use, preservation and management of water resources. In doing so, IARH promotes experience and professionals and institutions exchange, from both national and foreign locations. Among other activities, IARH gives specialised courses, organises technical meetings, workshops and seminaries, edits a newsletter, elaborates and disseminates reports, and fosters debate about relevant rational use, preservation and integrated water resources management. Since 1994, IARH has actively participated in the RIGA (Environmental and Management Research Network of La Plata Basin) implementation process.

The conduct of this project has been made possible by the collaboration of a large number of professionals and specialist who have contributed to it through the compilation of information and participation in the GIWA workshops. Therefore the Coordination of the Patagonian Shelf region would like to express thanks to the following persons who have contributed to the success of the project: Ricardo Delfino, María Josefa Fioriti, Marcelo Gaviño Novillo, Carlos Lasta, Oscar Padín, Sara Sverlij, Carlos Tucci and Víctor Pochat.

Abbreviations and acronyms

AIC	Autoridad Interjurisdiccional de Cuenca de los ríos Limay-Neuquen y Negro/Interjurisdictional Basin Authority of the Limay-Neuquen and Negro River
AIDIS	Asociación Argentina de Ingeniería Sanitaria y Ciencias del Ambiente
ANA	Agencia Nacional del Agua, Brazil/National Water Agency, Brazil
ANEEL	Agencia Nacional de Energia Electrica, Brasil/National Agency of Electric Energy, Brazil
BID	Banco Interamericano de Desarrollo/Inter American Development Bank
BTEX	Volatile lineal and aromatic hydrocarbons
CARP	Comisión Mixta Administradora del Río de la Plata/Administration Commission of the La Plata River; Argentina and Uruguay
CARU	Comisión Administradora del Río Uruguay/Administrative Commission for the Uruguay River
CCREM	Canadian Council of Resource and Environment Ministers
CEHPAR	Centro de Hidráulica e Hidrologia Professor Parigot de Souza”
CELA	Centro de Economía, Legislación y Administración del Agua
CENPAT	Centro Nacional Patagónico
CEPIS	Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente/Pan-American Center of Sanitary Engineering and Environmental Sciences
CESP	Companhia Energética de São Paulo
CETA	Centro de Estudios Transdisciplinarios del Agua
CETESB	Companhia de Tecnología de Saneamento Ambiental, São Paulo, Brasil
CFP	Federal Fishing Council
CIC	Intergovernmental Co-ordinating Committee for La Plata Basin
CITES	Convention for the International Trade on Endangered Species of Wild Flora and Fauna
CLAEH	Centro Latinoamericano de Economia Humana
CODEVASF	Companhia de Desenvolvimento do Vale do São Francisco
COFREMAR	Comisíon Técnica Mixta del Frente Marítiom/Technical Commission of Maritime Front
COIRCO	Comisión Interjurisdiccional del Río Colorado Argentina/Inter Jurisdictional Committee of Colorado river Argentina
COMIBOL	Corporación Minera de Bolivia / Mining Corporation of Bolivia
COMIP	Comisión Mixta Argentino-Paraguaya del Río Paraná/Paraná River Argentine-Paraguayan Commission
COMSUR	Bolivia's Compañia Minera del Sur
CONAMA	Comision Nacional de Meio Ambiente, Brasil/National Committee of Environment, Brazil
CONICET	Proyecto Peces Patagónicos en el Cenpat
COPEL	Companhia Paranense de Energia
CPUE	Catch per Unit of Effort
CRC	River Cuareim Commission
CYTED	Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo
DFS	Dirección de Fauna Silvestre
DINAMA	Dirección Nacional de Medio Ambiente
DINARA	Dirección Nacional de Recursos Acuáticos/Uruguayan Director of Aquatic Resources
DNH	Dirección Nacional de Hidrografía, Uruguay/National Hydrographic Steering, Uruguay
DNPCyDH	Dirección Nacional de Políticas Coordinación y Desarrollo Hídrico
DNPH	Dirección Nacional de Programas Habitacionales
DRIyA	Dirección Nacional de Recursos Ictícolas y Acuícolas, Secretaría de Ambiente y Desarrollo Sustentable de la Nación, Argentina / National Department of Ichthyic and Aquatic Resources, National Secretariat of Environment and Sustainable Development, Argentina

ENAPRENA	Estrategia Nacional parala Protecciòny el Manejo de los Recursos Naturales del Paraguay
ENOHSA	Ente Nacional de Obras Hídricas de Saneamiento, Argentina
FAO	Food and Agriculture Organization of the United Nations
FECIC	Fundación para la Educación, la Ciencia y la Cultura, Argentina/Education, Science and Culture Foundation, Argentina
FEP	Fisheries Economic System
FICH	Facultad de Ingenieria y Ciencias Hidricas
FI-UNLP	Facultad de Ingeniería - Universidad Nacional de La Plata
FPN	Fundación Patagonia Natural
FREPLATA	Protección Ambiental del Río de la Plata y su Frente Marítimo/Environmental Protection Project of the Río de la Plata and Its Sea Coast
FUCEMA	Fundación para la Conservación de las Especies y el Medio Ambiente
FUEM	Fundação Universidade Estadual de Maringá, Nupelia and Itaipú Binacional
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDL	US national Oceanic and Atmospheric Administration Geophysical Fluids Dynamic
GISS	US NASA Goddard Institute for Space Sciences
GIWA	Global International Waters Assessment
GNP	Gross National Product
GWP	Global Water Partnership
HDI	Human Development Index
IARH	Instituto Argentino de Recursos Hídricos/Argentinean Institute of Water Resources
IBGE	Instituto Brasileiro de Geografía e Estatística/Brazilian Institute of Geography and Statistical
ICA	Instituto Correntino del Agua
IDB	International Development Bank
IHH	El Instituto de Hidráulica e Hidrología
ILEC	International Lake Environment Committee Foundation
INA	Instituto Nacional del Agua, Argentina /National Institute of Water, Argentina
INDEC	Instituto Nacional de Estadística y Censos, Argentina/ National Institute of Statistical and Census, Argentina
INE-Bolivia	Instituto Nacional de Estadística, Bolivia / National Institute of Statistical, Bolivia
INE-Uruguay	Instituto Nacional de Estadística, Uruguay/National Institute of Statistical, Uruguay
INIDEP	Instituto Nacional de Investgacíon y Desarrollo Pesquero/ National Institute of Fisheries Research and Development
INTA	Instituto Nacional de Tecnología Agropecuaria
IPCC	Intergovernmental Panel of Climate Change
IPH	Instituto de Pesquisas Hidráulicas
IRGA	Instituto Riograndense de Arroz
LME	Large Marine Ecosystems
MAC	Maximum Allowable Catches
MERCOSUR	Mercado Común del Sur/Southern Common Market
MTOP	Ministerio de Transporte y Obras Públicas
NGO	Non Governmental Organisations
NTU	Nephelometric Turbidity Unit
OEA	Organización de los Estados Americanos
OMS	Organización Mundial de la Salud/World Health Organization
OPS	Organización Panamericana de la Salud/Panamerican Health Organization
PAH	Polycyclic Aromatic Hydrocarbons
PLAMACH-BOL	Plan Nacional de Cuencas Hidrográficas de Bolivia/National Plan of Hydrologic Basins, Bolivia.
POP	Persistent Organic Pollutant
PROSAP	Programa de Servicios Agrícolas Provinciales/Provincial Agricultural Services Program
ROU	República Oriental del Uruguay
SABESP	Companhia de Saneamiento Básico do Estado de São Paulo, Brasil/Basic Sanitation Company of São Paulo State, Brazil
SAGPyA	Secretaría de Agricultura, Ganaderìa, Pesca y Alimentación/ Argentinean Secretary of Agriculture, Cattle Raising, Fishing and Food
SAyDS	Secretaría de Ambiente y Desarrollo Sustentable
SCYT	Argentina's science and technology system
SECyT	Argentinean National System of Science and Technique
SEMA	Secretaria de Estado do Meio Ambiente do Paraná
SENASA	Servicio Nacional de Sanidad y Calidad Agroalimentaria, Argentina
SSRH	Subsecretaría de Recursos Hídricos de la Nación, Ministerio de Economía, Argentina/National Undersecretariat of Water Resources, Ministry of Finance, Argentina
THL	Trialomethanes
THM	Tri-Halo-Methane
UBA	Universidad de Buenos Aires
UFRGS	Universidade Federal Rio Grande do Sul
UIIC	Uniform International Industrial Classification
UKMO	United Kingdom Meteorological Office
UNEP	United Nations Environment Programme
UNL	Universidad Nacional del Litoral, Santa Fe, Argentina
WCU	World Conservation Union
ZCP	Common Fising Zone (Uruguay and Argentina)

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Regional definition

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Figure 1 Boundaries of the Patagonian Shelf region.

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the Patagonian Shelf region

The Patagonian Shelf, GIWA region 38, is located in southern South America and comprises the entire La Plata River Basin, a major part of the Argentinean continental territory, the Chilean basins draining Argentina into the South Atlantic Ocean, and part of the Uruguay maritime shelf (Figure 1). The six countries entirely or partly located within the region are Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay. The boundaries between the Patagonian Shelf region and the GIWA regions 39 (Brazil Current), 40a (Brazilian Northeast) and 40b (Amazon) to the north follow the limits of the La Plata drainage basin. In the west, the watershed between the Atlantic and Pacific drainage systems defines the boundary with GIWA region 64 (Humboldt Current). To the east, the oceanic border corresponds with the borders of the Patagonian Shelf Large Marine Ecosystem.

Given the significant differences in terms of physical, environmental and socio-economic characteristics between La Plata River Basin and the South Atlantic Drainage System, the Assessment was conducted separately for each system (Figure 1). This division also facilitated data organisation, as well as assessment development since the La Plata River Basin already has an institutional framework set by the

Intergovernmental Coordinating Committee (CIC) for the La Plata Basin, and because some basin-wide studies has been performed in the last three decades. Strongly differing cultural features and, consequently, different natural resource management characterise both systems. Both systems were separated into sub-systems comprising international reaches or sub-national inter-jurisdictional continental waters (Table 1) and the oceanic component.

The northern limit of the oceanic boundary of the region, which divides it from GIWA region 39 Brazil Current, has been fixed following the continental limit of La Plata River Basin. Based on hydrologic data in the area, there is an interaction between river freshwater discharges (particularly the La Plata River), the Malvinas Current and Brazil Current up to the Florianopolis region in Brazil (Figure 2). This interaction ranges as far as the area near "Península de Valdes". Therefore, the limits between GIWA region 38 and 39, regarding the oceanographic conditions, suppose a permeable character due to migration, dispersion, space and time variations of the convergence.

Table 1 Selected sub-systems for region 38 Patagonian Shelf.

	Shared surface or groundwater sub-system	Country
La Plata River Basin	Apa (Paraguay River system)	Brazil and Paraguay
	Bermejo (Paraguay River system)	Argentina and Bolivia
	Pilcomayo	Argentina, Bolivia and Paraguay
	Paraguay	Argentina, Bolivia, Brazil and Paraguay
	Iguazú (Paraná River system)	Argentina and Brazil
	San Antonio (Iguazú River system)	Argentina and Brazil
	Paraná	Argentina, Brazil and Paraguay
	Uruguay	Argentina, Brazil and Uruguay
	Cuareim (Uruguay River system)	Brazil and Uruguay
	Negro (Uruguay River system)	Brazil and Uruguay
	Pepiri Guazú (Uruguay River system)	Argentina and Brazil
	La Plata River	Argentina and Uruguay
	Guaraní Aquifer	Argentina, Brazil, Paraguay and Uruguay
South Atlantic Drainage System	Alfa	Argentina and Chile
	Chico del sur	Argentina and Chile
	Cullen	Argentina and Chile
	Chico	Argentina and Chile
	Gamma	Argentina and Chile
	Gallegos	Argentina and Chile
	Grande	Argentina and Chile
	San Martín	Argentina and Chile
	Tierra del Fuego	Argentina and Chile
	Colorado	Argentina
	Chubut and Chico	Argentina
	Limay, Neuquén and Negro	Argentina
	Santa Cruz	Argentina

Figure 2 Boundaries between La Plata River Basin, South Atlantic Drainage System, and GIWA region 39 Brazil Current.

Physical characteristics

La Plata River Basin

La Plata River Basin is the second largest basin in South America, occupying an area of about 3 100 000 km^2 (CIC 1997) and territories within five countries: Argentina, Bolivia, Brazil, Paraguay and Uruguay (Figure 3).

Climate

The Basin comprises several climatic zones as shown in Figure 4. One of the most important characteristics of the Basin is the high variation in rainfall (Baetghen et al. 2001). Mean annual precipitation ranges between 1 800 mm along the Brazilian coast, which is subject to marine influence, and 200 mm at the western border of the Basin. The exceptions are some areas associated with the sub-Andean ranges, where rainfall increases substantially. Spatial variation of seasonal rainfall regime is also significant. The northern area has a distinct seasonal pattern with maximum rainfall during summer, whereas in the central area seasonal distribution is more uniform, with maximum rainfall in spring and autumn. The amplitude of the annual cycle in rainfall decreases from north to south both in absolute and in relative terms. Summer rainfall exceeds winter rainfall by almost eight times in the Upper Paraguay and Upper Paraná basins, is twice as great in the Middle Paraná, and much less in the south. Since the rivers generally run from north to south, this rainfall regime contributes to the attenuation of the hydrological seasonal cycle downstream (Baetghen et al. 2001). Between the 1970s and the present, the Basin has been under the influence of a humid period, which increases annual precipitation.

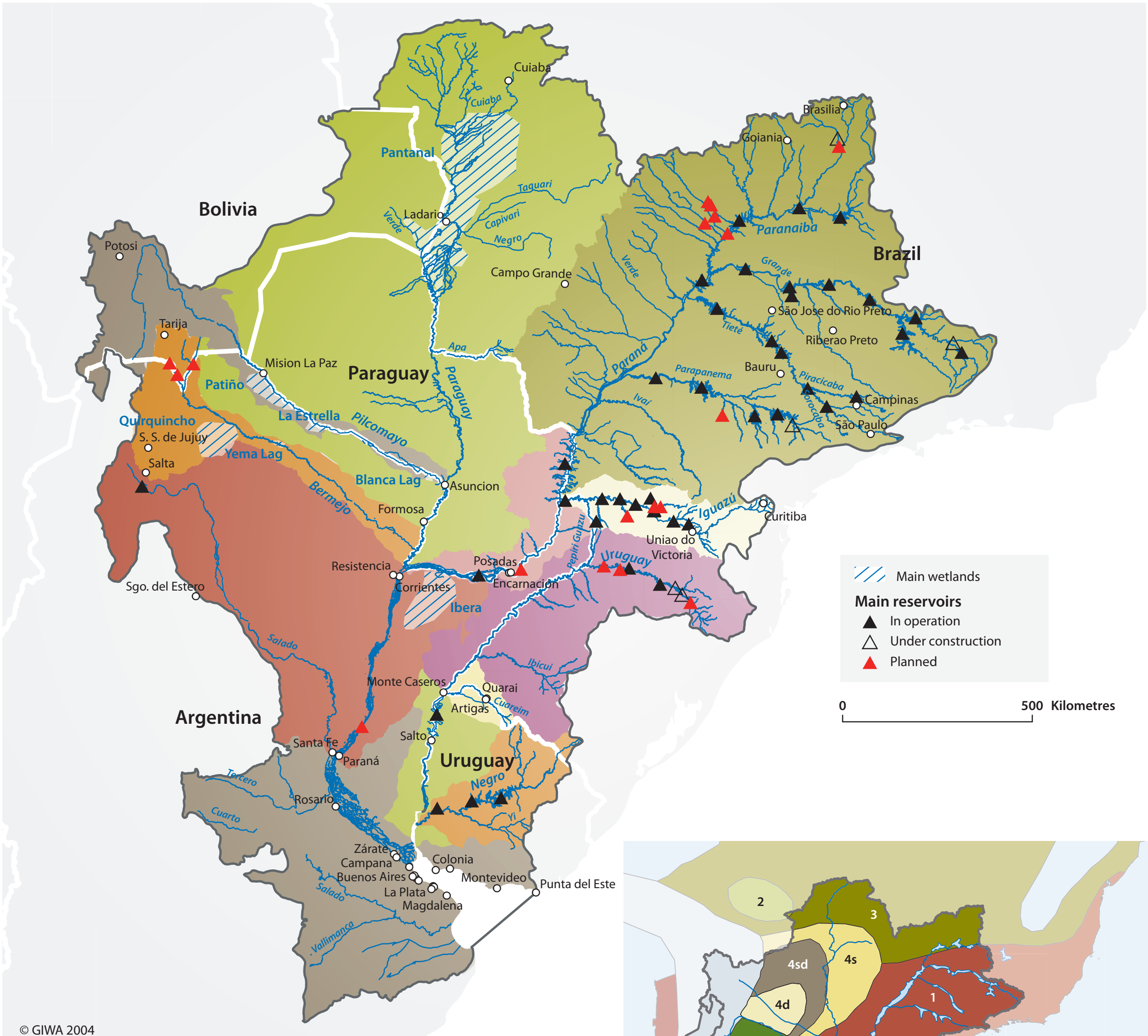

Figure 3 The drainage basins of the tributaries comprising La Plata River Basin.
(Source: ANEEL 2000)

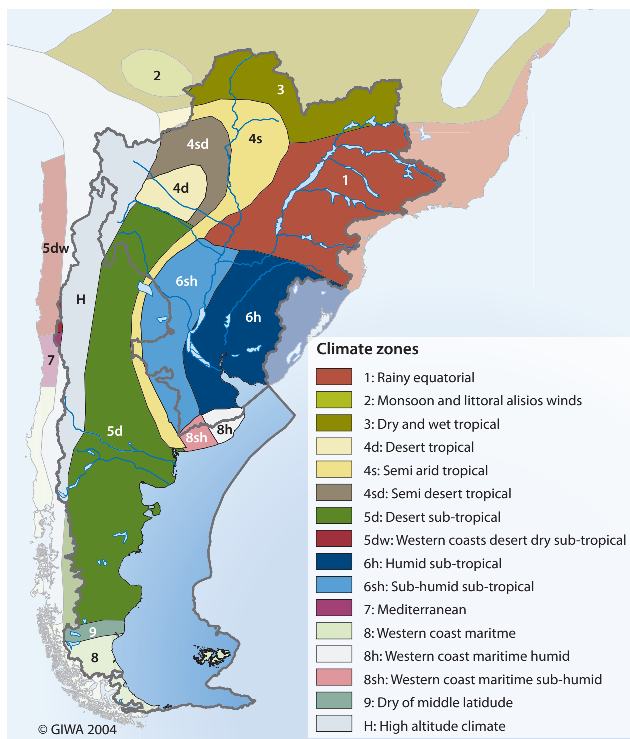

Figure 4 Climate zones.
(Source: CIAT 1998, Strahler & Strahler 1989))

The average annual temperature in the Basin ranges from 15°C in the south to more than 25°C in the northwest. In winter, there is a well established north-south gradient in monthly-mean temperatures. In July, the mean temperature in the southern area is between 8°C and 10°C, while in the northwest of the Basin, it is higher than 20°C. In summer, the gradient is governed by the land-ocean distribution. In January, the mean maximum temperatures exceed 27.5°C in the Chaco region and in western Argentina, while they are lower than 22.5°C in the coastal areas of southern Brazil, Uruguay and Argentina (Baetghen et al. 2001).

Biotopes

The main biotopes of the Basin are the forests and the savannahs. The climate and the variations in topography and soil influence these biotopes, which are also highly transformed by human intervention. The remains of the sub-tropical conifer forest, associated with humid tropical forest, are located in the Lower Iguazú Basin. There is another humid tropical forest (regionally known as "Yungas") located in the eastern Andean mountain sides. Finally, the Atlantic forest of the Brazilian littoral is a humid broad-leaf forest (Dinerstein et al. 1995).

In the central area of the Basin are the Chaco savannahs, an ecoregion shared by Argentina, Brazil, Paraguay and Bolivia and dominated by deciduous vegetation (Figure 5). The Cerrado, a savannah-forest complex composed of several types of habitats and natural communities, occupies the northern area (between 15°-22° S and 58°-59° W). The Cerrado is more open along the São Lorenço, Taquari and Paraguay rivers. Finally, in Uruguay and southern Brazil, a humid savannah of pastures has developed. The Pantanal and the Paraná deltas are important flooding pastures; the latter interrupts the Pampa, a large gramineous pasture (Dinerstein et al. 1995). There are large numbers of protected areas that were created to preserve the remains of the diverse biotypes and to protect biodiversity.

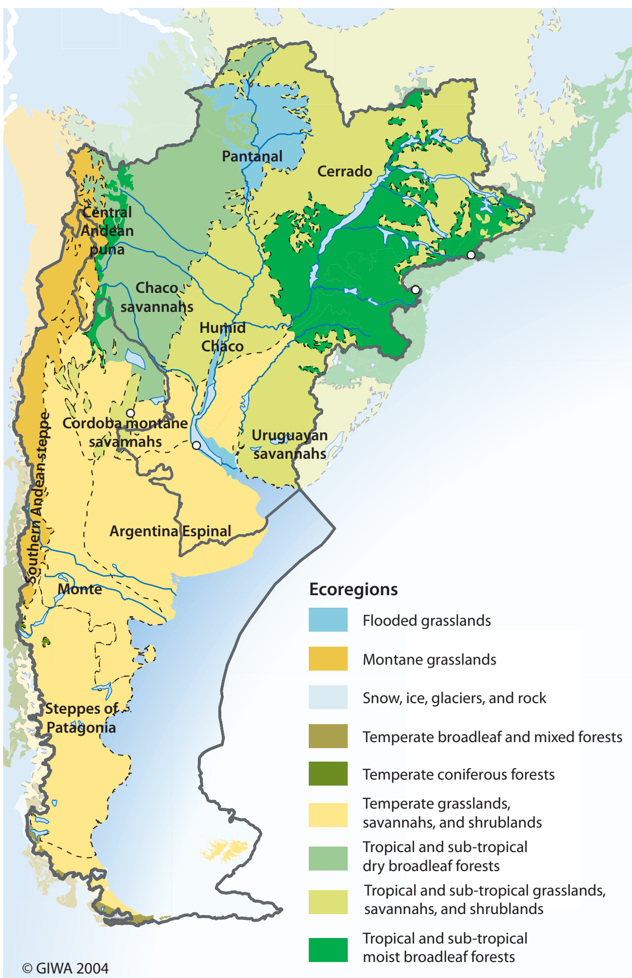

Figure 5 Ecoregions.
(Source: Olson et al. 2001)

Land use

Agriculture is the main land activity in the Basin (Figure 6). By the end of the 1960s, a gradual expansion of the farming border and changes in the main crops was registered in the Brazilian and Argentinean sectors of the Basin. For example, until 1970, most of the Paraná state (Brazil) and a large part of São Paulo state (Brazil) cultivation areas were used for coffee. Large areas of these plantations were destroyed by fire, causing major financial losses. Subsequently, annual crops such as corn and soybean replaced coffee. Meanwhile, in the Argentinean sector, the main rural areas also changed crop and agricultural systems. At the end of the 1960s, the annual wheat crop was substituted by a wheat and soybean rotation system. The same system occurs in Paraguay, where the soybean is the main crop and on the increase due to the application of new technologies and the expansion of productive areas.

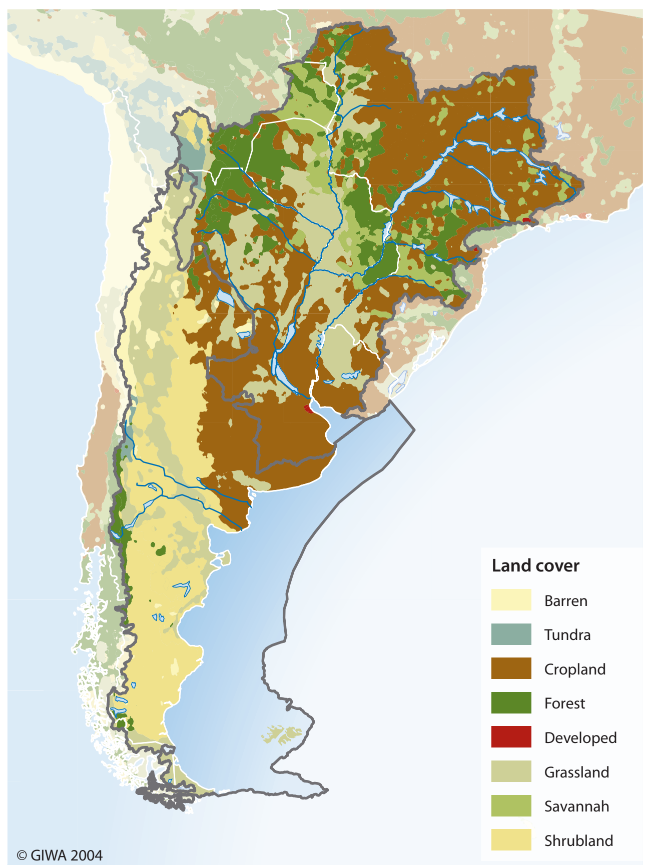

Figure 6 Land cover.
(Source: Data from Loveland et al. 2000)

Wheat, barley and oats are the main crops in Uruguay. Rice is also cultivated in southern Brazil and eastern Argentina. This crop places a strong demand on the water resources of the Uruguay River and its tributaries, for instance, about 13% of the Ibicuy river flow (Tucci & Clarke 1998).

Finally, regarding livestock farming, bovines predominate in the Basin. In Argentina, more than 70% of the country's bovines are raised within the La Plata River Basin. Likewise in Brazil, about 10% of the country's bovines and more than 80% of Uruguay's livestock are raised within the Basin. In Paraguay, 90% of the agricultural production is livestock.

Rivers

The Paraná and Uruguay rivers collect all water from the Basin, draining into La Plata River (Figure 3). The Paraná River, formed at the junction of the Paranaiba River and Grande River in Brazil, receives water from numerous large tributaries. Some major sub-basins are distinguished, as are those corresponding to the Paraguay, Pilcomayo, Bermejo and Iguazú rivers (Table 2 and Figure 3). Table 3 shows the chemical characteristics of the main rivers in the La Plata Basin.

Figure 7 Main reservoirs in La Plata River Basin.
(Source: ANEEL 2000)

Table 2 Main rivers of La Plata River Basin.

River	Basin area (km^2)	Length (km)	Average discharge (m^3/s)	Average depth (m)
Uruguay	440 000	1 850	4 500	ND
Paraguay	1 095 000	2 415	3 810[1]	5
Paraná	1 600 000	2 570	17 140[2]	15-50
Iguazú	61 000	1 320	1 540	ND
Bermejo	120 000	1 780	550	1.3
Pilcomayo	272 000	1 125	195	ND
La Plata	3 100 000	270	23 000-28 000	10

Notes: [1]Paraguay at Puerto Bermejo. [2]Paraná at Corrientes. ND = No data. (Source: Framiñan & Brown 1996, Giacosa et al. 1997, SSRH 2002 and ANEEL, SRH/MMA, IBAMA 1996)

Table 3 Main chemical characteristics of La Plata Basin rivers.

River	Nutrient concentration (mg/l)			pH	Turbidity (NTU)
	Nitrite	Nitrate	Phosphate		
Upper Uruguay (Iraí Station)	0.007	1.61	0.125	7.2	18
Middle Uruguay (Uruguaiana)	0.050	1.5	0.36	7.1	51
Lower Uruguay (Paysandú)	0.01	3.5	ND	7.0	34
Upper Paraguay (Porto Murtinho)	0.02	0.29	0.01	7.5	60
Middle and Lower Paraguay (Puerto Pilcomayo)	0.009	0.91	0.025	7.2	81
Upper Paraná (Guaira)	0.001	0.21	0.029	7.2	14.2
Middle Paraná (Corrientes)	0.05	0.178	0.198	7.3	243.7
Lower Paraná (Rosario)	0.06	1.0	ND	7.3	120
Iguazú (Foz do Iguazú)	0.63	ND	0.02	7.5	17
Bermejo	0.15	0.001	0.03	6.5	554 (mg/l)
Pilcomayo (Tres Pozos)	0.066	0.002	ND	7.7	55
La Plata (Coastal border from San Fernando to Magdalena)	0.01-0.5	4.5	0.03-0.14	7-7.4	10 - 200

Note: ND = No Data. (Source: CIC 1997)

The Upper Paraná River spreads over the Brazilian Southern Plateau, while the Lower Paraná River traverses an area of plains. The system is characterised by large mean annual flows, resulting from heavy precipitation in the upper Basin. The width and bed morphology changes greatly along the course. Several important wetlands, such as the Iberá marshes, Submeridional Lowlands, Middle Paraná alluvial valley and the Paraná Delta in Argentina, are associated with the Paraná River (Canevari et al. 1998).

In Brazil, the Paraná River and its main tributaries (Parapanema and Tietê) are mainly used to generate hydropower and a large number of reservoirs (Figure 7) have been built. Itaipú Dam (Brazil and Paraguay) stands out and, together with Yacyretá Dam (Argentina and Paraguay), they constitute examples of joint developments by riparian countries in the Basin. In Argentina, the Middle and Lower Paraná river reaches are important waterways and their shores host large urban settlements and major industrial activities. In both countries, the Paraná River is used for freshwater supply, industrial use, fishing, recreational activities and as a recipient of domestic and industrial effluents.

The Uruguay River Basin has also its upper areas on the Brazilian Plateau and the lower ones in the plains. The Uruguay River rises at Serra do Mar (Brazil) and has a graded cross section due to its geological formation which presents some significant narrow stretches along its main course (Coimbra Moreira et al. 2002). Its flow regime shows considerable seasonal variability. The Uruguay River is utilised for various purposes by the riparian countries. Its most important use is Salto Grande hydroelectric power plant (shared by Argentina and Uruguay, Figure 7), which was completed in early 1980s. The River is navigable downstream of the dam for about 340 km and it supplies water to irrigated rice fields in Uruguay and Brazil (Yelpo & Serrentino 2000). The Cuareim (or Quarai) and Negro rivers are both transboundary water bodies and are the main tributaries of the Uruguay River left margin.

The Paraguay River, the main tributary of Paraná River and its basin, spreads over an area of plains. It rises to the north, in the Parecis ranges (Brazil), which divides the La Plata River Basin and the Amazon River Basin. A major feature of the Upper Paraguay Basin is the Pantanal, the world's largest wetland. The Pantanal is a huge floodplain, 770 km long with an area of about 80 000 km^2 (high water season), that serves as a reservoir which regulates the Paraguay-Paraná regime (Canevari et al. 1998). Downstream of the Pantanal, the Paraguay River flows between high natural embankments, forming multiple meanders next to the mouth. The Paraguay River is mainly used in Brazil and Paraguay as a waterway, which also serves Bolivia.

The Iguazú (or Iguaçú) River Basin spreads on the Brazilian Plateau. The Iguazú River rises in Serra do Mar (Brazil) and because of the relief, the riverbed presents sharp changes in gradient and narrow valleys. There are many waterfalls, such as the renowned Iguazú Falls, and rapids along its course. Such features indicate the large hydropower potential of the River, which has been developed through a cascade of reservoirs (Figure 7). Furthermore, the Iguazú River supplies water for human and industrial use and is the main water source for Curitiba city in Brazil (Urban 2000). The lower section of the Iguazú River and the San Antonio River (left margin tributary) form the border between Argentina and Brazil.

Pilcomayo River Basin spreads its upper part over a plateau and the lower part over an extended sedimentary plain (Chaco plain). Pilcomayo River has two main characteristics: an exceptional production of sediments generated by erosive processes in the upper basin, and a high variability of flows owing to seasonal and spatial rainfall variation. During the flood season, the River is heavily loaded with sediments and floods several wetlands in the lower Basin (like Patiño marsh and La Estrella swamp in Paraguay, and Blanca Lagoon in Argentina), which have a central role in the development of ichthyofauna. The final section of the River has progressively receded upstream because of sediment deposition. Groundwater from this basin is the largest source of water in this part of the Chaco plain, where rainfall is relatively scarce. This water is also used for livestock and recreational activities.

The Bermejo River Basin has sectors with very active sediment generation processes, mainly in the upper basin. The Bermejo River rises in Real ranges (Bolivia) and in the sub-Andean ranges areas of Salta and Jujuy provinces (Argentina). After entering the Chaco plain (lower basin), the River dramatically reduces its slope and looses its capacity to carry sediment, which results in the deposition of part of the suspended sediments. Despite this fact, the Bermejo River contributes with over 80% of the suspended sediments transported by the Paraná River into the La Plata River (CCBermejo 2000). Its water is used to irrigate farming areas and for human and livestock consumption, both in Bolivia and Argentina. There are some wetlands associated with the Bermejo River system, such as Quirquincho swamps and Yema Lagoon in Argentina (Canevari et al. 1998).

The La Plata River is a funnel-shaped coastal plain tidal river. It is oriented in a northwest-southeast direction. Its mouth, defined by a line joining Punta Rasa (Argentina) and Punta del Este (Uruguay) is about 230 km wide. Based on its hydrodynamics and morphology, the La Plata River may be divided into two main areas: the inner area, which has a two-dimensional flow; and the outer area, which has a three-dimensional flow resulting from the widening of the River towards its mouth. The interaction of nutrient rich freshwater with coastal marine water in the outer area supports the spawning and nursery area of several important fishery resources (Framiñan & Brown 1996). On the Argentinean coast, the La Plata River waters are used for human consumption and as a disposal site for urban and industrial wastes of Buenos Aires and its metropolitan area (like Matanza-Riachuelo and Reconquista rivers). Along the Uruguayan coast, the La Plata River is used for the same purposes. Also, the wastes of agricultural activities, especially fertilisers, affect some Uruguayan tributaries, such as the Santa Lucía River. There are also recreational uses (e.g. water sports and fishing) and other activities of relative importance on both coasts.

The Guaraní Aquifer (Figure 8) is also located in the La Plata River Basin. It is one of the biggest groundwater storages in the world, with about 40 000 km^3 of freshwater, spreading below the territories of Argentina, Brazil, Paraguay and Uruguay. Its average thickness is about 250 m. It ranges from a few metres at the borders of the Basin to about 600 m in central areas. The aquifer recharge areas, which are also the most vulnerable, coincide with its outcropping areas, generally next to the boundaries of the groundwater basin. The depth of the aquifer drops to over 1 000 m near the Uruguay River in Argentina. In such regions, thermal water flows naturally from deep wells with temperatures between 33°C and 50°C, and average flows of about 100 m^3/hour. Currently, thermal waters are used for health and tourism purposes, although it could be potentially used as a heat source for industrial purposes (GEF-OAS 2002).

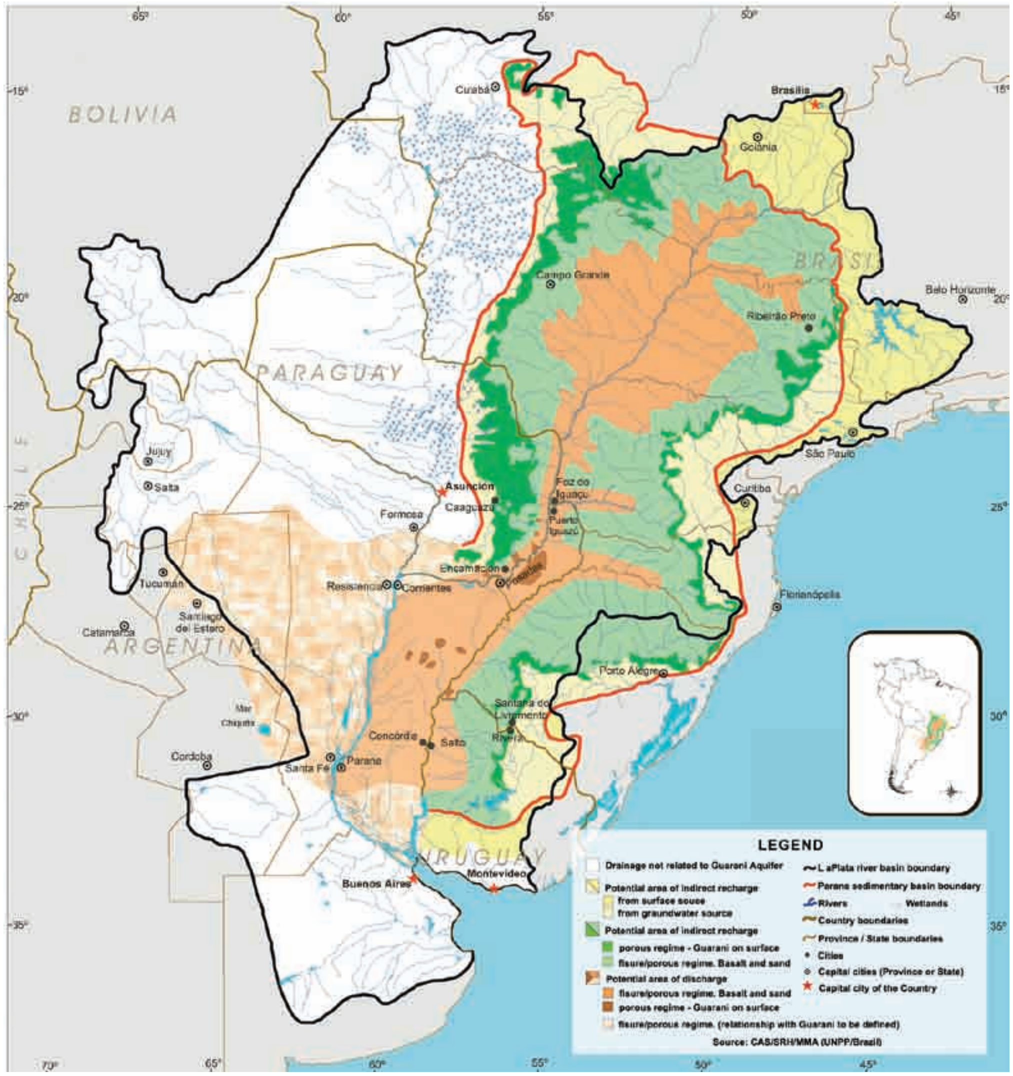

Figure 8 Guaraní Aquifer.
(Source: CAS/SRH/MMA (UNPP/Brazil))

South Atlantic Drainage System

This system comprises the basins located between the Andean ranges and the South Atlantic Ocean coast, which drain across extended arid areas of Argentina, into the sea (Figure 9). The main feature of the area is the Andean ranges and the Patagonian Plateau. The plateau develops to the south of the Colorado River. It is over 1 000 m high in the west and progressively slopes down to the sea. The Colorado, Negro, Chubut and Santa Cruz rivers are the main water systems crossing the plateau from west to east. The Gallegos and Chico del Sur rivers (Santa Cruz province) and the Alfa, Cullen, San Martín, Gamma and Chico y Grande rivers (Tierra del Fuego province), located in the extreme southern part of Argentina, are water resources shared with Chile (Table 4). All of these rivers rise in the Andean ranges and their flows increase with melting snow and rainfall. In general, on their way to the ocean, these rivers do not receive significant tributaries (Urciuolo 2001).

Table 4 Main rivers of South Atlantic Drainage System.

River	Basin area (km^2)	Length (km)	Average discharge (m^3/s)
Colorado	50 236	923	1 301
Negro	19 778	637	846
Neuquen	50 774	510	308
Limay	61 723	430	ND
Chubut	53 801	820	30
Santa Cruz	28 056	383	698
Chico del Sur[1]	1 335	75	ND
Gallegos[1]-Cüllen[1]-Chico[1]-Gamma[1]	676	ND	ND
Grande[1]	7 021	230	ND
San Martín[1]-Tierra del Fuego[1]	8 406	ND	ND

Notes: [1]Transboundary waters. ND = No data. (Source: SSRH-INA 2002, Castellanos 1975)

Figure 9 South Atlantic Drainage System and main reservoirs.
(Source: CIAT 1998)

No	Name	Country	Area (ha)	Founded
1	Reserva Particular do Patrimonio Natural SESC Pantanal	Brazil	87 871	2002
2	Pantanal Matogrossense	Brazil	135 000	1993
3	Pantanal Boliviano	Bolivia	3 189 888	2001
4	Palmar de las Islas y las Salinas de San José	Bolivia	856 754	2001
5	Río Negro	Paraguay	370 000	1995
6	Cuenca de Tajzara	Bolivia	5 500	2000
7	Laguna de los Pozuelos	Argentina	16 224	1992
8	Lagunas de Vilama	Argentina	157 000	2000
9	Estero Milagro	Paraguay	25 000	1995
10	Tinfunque	Paraguay	280 000	1995
11	Rio Pilcomayo	Argentina	55 000	1992
12	Lago Ypoá	Paraguay	100 000	1995
13	Laguna del Negro Francisco y Laguna Santa Rosa	Chile	62 460	1996
14	Reserva Provincial Laguna Brava	Argentina	405 000	2003
15	Lagunas y Esteros del Iberá	Argentina	24 550	2002
16	Jaaukanigás	Argentina	492 000	2001
17	Bañados del Río Dulce y Laguna de Mar Chiquita	Argentina	996 000	2002
18	Lagunas de Guanacache	Argentina	580 000	1999
19	Laguna de Llancanelo	Argentina	65 000	1995
20	Bahía de Samborombón	Argentina	243 965	1997
21	Laguna Blanca	Argentina	11 250	1992
22	Bertha's Beach	Falkland Islands/Malvinas Islands	4 000	2001
23	Sea Lion Island	Falkland Islands/Malvinas Islands	1 000	2001
24	Reserva Costa Atlantica de Tierra del Fuego	Argentina	28 600	1995

Figure 10 Ramsar sites and protected areas.
(Source: UNEP-WCMC 2003)

Climate, biotopes and land use

The South Atlantic Drainage System is located in a predominantly arid area, characterised by a significant water deficit (mean annual rainfall below 400 mm). Nevertheless, the Andean ranges and the influence of anticyclones from the South Pacific (south of Colorado River) and the South Atlantic (north of Colorado River) determine the existence of areas relatively more humid southeast of Buenos Aires province and in the southern Andean hillsides. The Patagonian Plateau (provinces of Río Negro, Chubut and Santa Cruz) is covered in a shrub steppe, with low dispersed vegetation. The central area, the so-called "arid diagonal" (La Pampa and Mendoza provinces), is covered in another steppe shrub called "Monte", and has few vegetal species and communities (Figure 5). The "Espinal" is a distinctive ecoregion that surrounds the Pampa pasture, characterised by the presence of low woods alternating with savannahs and pastures. Finally, in the Andean hillsides, the relative high humidity supports the existence of the Patagonian-Andean forests (Daniele & Natenzon 1994, Dinerstein et al. 1995).

The main land use is sheep rearing in the steppe areas and forestry activity in the forest areas (Figure 6). The intense use of shrubs for sheep grazing has led to desertification of the steppe. The beautiful landscape in the Andean forest is an attraction for national and international tourism. Both La Plata River Basin and South Atlantic Drainage System have a large number of protected areas and Ramsar sites (Figure 10).

Rivers

The Colorado River Basin extends from west to east, comprising areas of mountains, plateaus and plains. The Colorado River rises from the confluence of two mountain rivers (Grande and Barrancas) and, on its way to the ocean, constitutes the border of five Argentinean provinces (Buenos Aires, La Pampa, Neuquén, Mendoza and Río Negro) (see Figure 11). Relief features determine some reaches where the River flows through narrow stretches and other zones where meanders are formed. Next to its mouth, the River develops a small delta formed by several branches. The principal water uses are mainly the supply of riparian urban settlements and irrigation. The Casa de Piedra Dam has been built for irrigation and flow-regulating purposes. The Desaguadero River drains into the Colorado River and collects water from several rivers (Atuel, Diamante and Tunuyán), that irrigate farming areas in the western part of the Mendoza province.

The Negro River rises from the junction of Neuquén and Limay rivers, which drain from mountain range and lake areas in the west. Important systems of hydropower plants and reservoirs have been built on both rivers, providing flood control and supplementing river flows for irrigation when water is scarce. The Neuquén River supplies water to a large irrigation system in the Negro River valley, known as the "upper valley oasis", devoted to high quality fruit plantations. The Negro River itself crosses the Patagonian Plateau before it discharges into the Atlantic Ocean. It supplies water to riparian urban settlements and smaller irrigation systems.

The Chubut River rises from mountain streams flowing down from the Nevado Mayor range and, on its way to the sea, crosses three different areas: mountains, the central Patagonian Plateau and the lower valley. The Florentino Ameghino Reservoir regulates water supply to the irrigation system of the lower valley (Urciuolo 2001). Apart from being the water source of Rawson and Trelew cities (Chubut province) located in the lower valley, the Chubut River also supplies water to the industrial city of Puerto Madryn (fisheries, aluminium). The Chico/Senguerr River and its lakes system is an old tributary of the Chubut River, rarely active nowadays, only with exceptional high flows.

The Santa Cruz River is the most important in the Santa Cruz province because of the extent of its basin and the magnitude of its flows. It possesses a very important undeveloped hydroelectric power potential. The River rises in the eastern end of the Argentino Lake. The upper river flows through narrow reaches, rocky beds and numerous rapids. Downstream, in the lower reaches approaching the estuary, the River enlarges and forms meanders, providing a navigable zone.

The Gallegos and Chico del Sur rivers form the most austral basin of continental Argentina. Their upper basins lies in territories of Argentina and Chile, constituting transboundary water resources. The Chico del Sur River is almost an independent watercourse, which drains into the same estuary together with the Gallegos River in its mouth. Coal mining in the Río Tubio deposit (near the Argentinean-Chilean border) is one of the most important activities in this basin. Rio Gallegos, the capital of Santa Cruz province, is located at the mouth of Gallegos River.

Tierra del Fuego has a dense drainage system, as it benefits from a relatively uniform distribution of rainfall through the year. Rivers of glacial origin flow predominantly in the west-east direction, following the geological formations that define the fluvial valleys. In the northern part of the province, the resources of the Alfa, Cullen, San Martín, Gamma and Chico rivers are shared with Chile where their upper basins are located. The Chico River is the most important of these rivers, which generally have small flows. Activities linked with oil extraction are significant in the Cullen River Basin (Urciuolo 2001).

To the south, there are the so-called "transition basins" that occupy the mountainous area of Tierra del Fuego Grande Island. The Grande River is the major surface drainage system and its main flow contribution comes from the Chilean side, although there are important tributaries in the Argentinean sector. Its valley is constrained by glacier terraces that have been eroded by water in many sectors (Urciuolo 2001).

The Oceanic component

The Patagonian Shelf region comprises one of the world's largest continental shelves (769 400 km^2). The continental shelf is relatively narrow in the north, but widens progressively to the south, where it extends about 850 km from the coast. The Patagonian Shelf Large Marine Ecosystem has a total area of 2.7 million km^2 (Patagonian Shelf LME 2003). The joint influence of the Brazil warm current, which flows to the south, and the Malvinas cold current, which flows to the north, results in nutrient rich waters that maintain a large variety of marine mammals and birds, fish and invertebrates (DRIyA 2001).

Within the region the Argentinean coastline stretches 4 989 km between La Plata River and Tierra del Fuego (excluding the oceanic islands). From a geological point of view, the coast of Argentina can be split into two regions that are divided by the mouth of the Colorado River: the coast of Buenos Aires province to the north and the Patagonian coast to the south, which corresponds to the Río Negro, Chubut, Santa Cruz and Tierra del Fuego provinces (DRIyA 2001). From a biological point of view, the Uruguayan-Argentinean coast is one of the world's most productive and complex marine systems in terms of interactions among fauna, flora and physical marine and terrestrial elements. Finally, taking into account the fishing activity, the marine ecosystems can be divided into two sectors, the Argentinean province (north of 41° S) and the Patagonian province (south of 41° S) (Lasta et al. 2001).

As well as the California and Benguela currents, the Patagonian Shelf exhibits a combination of important factors for several valuable fish and mollusc species: (i) enrichment of food web by physical processes, (ii) concentrated patch structure of food particles (lack of turbulent mixing and/or convergence in frontal structures), and (iii) availability of mechanisms to promote retention or transport of larvae to appropriate habitats. These three factors only combine favourably in special configurations as otherwise turbulence and mixing may disperse larvae away from food source (Patagonian Shelf LME 2003).

Hake (*Merluccius hubbs*i) and prawn (*Pleoticus muelleri*) are the most valuable species and are the focus of Patagonian commercial fishing. The total catch of fish and invertebrates has increased four-fold since the 1970s (DRIyA 2001).

Socio-economic characteristics

The countries[1] that share the Patagonian Shelf region have experienced different situations related to their economic profiles[2] in the 1990s. Each country experienced a decline in their Gross Domestic Product (GDP) between 1998 and 1999, but Brazil, Bolivia and Paraguay have since experienced a period of growth (Table 5). The participation of the different economic sectors in the GDP reflects the importance of services associated particularly with the main urban centres (Table 6).

There is an enormous disparity in the distribution of income in urban areas. Table 7 shows the differences between the poorest and the richest households in all countries of the region and illustrates that the most equal income distribution occurs in Uruguay, while Brazil exhibits the biggest differences between rich and poor.

In all the countries within the Basin, the lack of sanitary services coincides with the location of deprived housing areas. Consequently, access to basic sanitary services, drinking water and sewerage constitutes a problem that relates to poverty. Considering the five great cities of the region, Curitiba possesses the greatest percentage of the population in marginal settlements, followed by the Buenos Aires Metropolitan Area, Montevideo, São Paulo and Asunción. Table 8 shows the percentages of urban and rural poor households in 1999.

Table 5 Gross domestic product by country.

Country	Growth of Gross Domestic Product (GDP) Average annual rates (%)					
	1990	1997	1998	1999	2000	2001
Argentina	-2.0	8.0	3.8	-3.4	-0.8	-4.4
Bolivia	4.4	4.9	5.4	0.8	2.3	1.3
Brazil	-4.6	3.1	0.1	1.1	4.0	1.5
Paraguay	3.0	2.4	-0.6	-0.1	-0.6	2.4
Uruguay	0.4	5.0	4.3	-3.8	-1.9	-3.4

Note: Based on figures at constant 1995 market prices. (Source: CEPAL 2003)

Table 6 Structure of economy by country.

Country	Sector		
	Agriculture (% of GDP)	Industry (% of GDP)	Services (% of GDP)
Argentina	5.7	28.7	65.6
Bolivia	15.4	28.7	55.9
Brazil	8.4	28.8	62.8
Paraguay	24.9	26.2	48.9
Uruguay	8.5	27.5	64.0

(Source: World Bank 2000)

Table 7 Distribution of income in urban households, by quintiles.

Country	Percentages (1999)						
	Quintile 1 (poorest)		Quintile 2	Quintile 3	Quintile 4	Quintile 5 (richest)	
	Decile 1	Decile 2				Decile 1	Decile 2
Argentina	2.3	3.7	9.8	13.3	19.2	14.9	36.7
Bolivia	1.6	3.5	10.1	14.3	21.0	16.8	32.7
Brazil	1.1	2.3	7.1	10.2	17.6	15.9	45.7
Paraguay	2.0	3.9	10.6	14.7	22.1	13.9	32.8
Uruguay	3.6	5.1	12.9	16.0	20.9	14.5	27.0

(Source: CEPAL 2003)

Table 8 Poor households in urban and rural areas by country.

Country	Poor households (1999)		
	Urban (%)	Rural (%)	Total (%)
Argentina	16	ND	ND
Bolivia	42	76	55
Brazil	26	45	30
Paraguay	41	65	52
Uruguay	6	ND	ND

Note: ND = No data. (Source: CEPAL 2003)

[1]This section does not include considerations about socio-economic aspects of Chile since the participation of the Chilean territory in this system is minimal and it is not possible to specify the quantitative data for such area. [2]Data related to health status, GDP per capita, structure of economy, income distribution and poverty are analysed country by country, with no differences between La Plata River Basin and the South Atlantic Drainage System. The remaining socio-economic data is analysed seperately for the two systems.

Despite the lack of information that explicitly links morbidity and mortality with water pollution, there are reports that indicate the existence of water-related diseases in each of the countries. In the 1990s, a cholera epidemic occurred in the region. Between 1992 and 1996, there were 2 000 cases registered in Argentina, 2 600 in Bolivia, 150 000 in Brazil and 10 in Paraguay. Other water-related diseases that generate concern among the community and government, are schistosomiasis (especially in Brazil) and diarrhoea. Diarrhoea is the primary cause of morbidity in children up to one year of age in Bolivia, and the second most important in Paraguay and Brazil.

La Plata River Basin

Population

The distribution of the population in the five countries (Argentina, Bolivia, Brazil, Paraguay and Uruguay) within the La Plata River Basin is unequal. With the exception of Uruguay, population density is relatively low in all countries. The rate of population increase, based on the last two Censuses[3], exhibits large variations (Table 9).

The La Plata Basin is inhabited by about 50% of the combined population in all five countries. The main industrial belt of Argentina (between Santa Fe and La Plata), including the two biggest urban settlements (Great Rosario and Buenos Aires Metropolitan Area), is located in this basin; the former area included Buenos Aires City, the Argentinean capital. The most densely populated areas in the south and southeast of Brazil, including the large metropolitan areas of São Paulo and Curitiba, also occur within the La Plata River Basin. Montevideo, Brasilia and Asunción, the capital cities of Uruguay, Brazil and Paraguay, respectively, are also located in the La Plata River Basin. Table VI.1 in Annex VI shows the main cities of the La Plata Basin.

With the exception of Paraguay and Bolivia, the urban population largely exceeds the rural population in each of the countries. High urbanisation rates in Argentina, Brazil and Uruguay reflect the importance of the large metropolitan areas of the region, especially in Argentina and Brazil (Table 9). The growth of intermediate cities has also been important in the last decades. All the larger cities have, in general, good water supply and sanitation systems. However, sewage treatment is still underdeveloped. Table 10 shows the current situation in the countries and urban areas.

Table 9 Total population, area, density, and population growth per country.

Country[1]	Total population	Area (km²)	Density (inhabitants per km²)	Inter census population growth (% per decade)	Urban population (%)
Argentina	27 740 527	1 176 840	23.6	9.2	82.8
Bolivia	3 661 232	577 986	6.3	32.8	61.5
Brazil	91 668 241	3 026 539	30.3	8.1	86.9
Paraguay[2]	5 496 450	406 752	13.5	32.4	45.5
Uruguay	3 198 147	154 936	9.6	4.9	86.5

Notes: [1]Provinces in Argentina, states in Brazil and departments in Uruguay and Bolivia which are partially or totally included in La Plata River Basin. [2]Projected to year 2000 .
(Source: INDEC 2001, INE (Bolivia) 2002, IBGE 2000, DGEEC 2002, INE (Uruguay) 2002)

Economic sectors

Table 11 shows the annual water extraction by each economic sector. Though this data is analysed by country, it can be considered as representative of the water demand in the La Plata River Basin. As the table shows, agriculture is by far the most water-demanding sector, being the most important activity in the Basin. Industrial water use is also important, especially in Argentina and Brazil.

The La Plata River Basin is an important centre for the regional economy; about 70% of the Gross National Product (GNP) of Argentina, Brazil, Uruguay, Bolivia and Paraguay is produced within the Basin (Tucci & Clarke 1998).

Cereals, soybean and oleaginous fruit are grown in the Argentinean plains, soybean and sugar cane in southern Brazil, soybean, cotton and grains in Paraguay and cereals and forage in Uruguay. The cultivation of soybean has greatly increased in the last years. Data compiled in 2001 shows that soybean is the most important crop in Argentina

Table 10 Population with access to drinking water and sanitation.

Country[1]	Drinking water		Sanitation			
			Total (%)		Urban areas (%)	
	Total (%)	Urban areas (%)	With connection	In situ[2]	With connection	In situ[2]
Argentina	67.0	72.0	48.7	35.3	54.7	33.8
Bolivia	64.6	87.4	28.0	35.5	45.1	37.2
Brasil	75.3	90.6	47.5	37.3	59.1	34.5
Paraguay	42.2	69.0	7.1	91.9	13.2	85.8
Uruguay	90.3	93.7	46.2	48.2	50.6	44.7

Note: [1] Data refer to entire countries. [2] Houses with cesspools. (Source: OPS-OMS 2000)

Table 11 Annual extraction of water by economic sector.

Country[1]	Domestic (%)	Industry (%)	Agriculture (%)
Argentina	9	18	73
Bolivia	10	5	85
Brazil	22	19	59
Paraguay	15	7	78
Uruguay	6	3	91

Note: [1] Data refer to entire countries. (Source: GWP 2000)

[3] The last two National Censuses were made in different years in each country. In Argentina they were made in 1991 and 2001; in Bolivia 1992 and 2001; in Brazil 1991 and 2000; and in Paraguay 1992 and 2002. In Uruguay the last Census was made in 1996; this country makes annual publications to update demographic data. This report has used information from Censuses and other statistical publications in those cases where available data is old.

Table 12 Harvested area and percentage covered by main crops by country.

		Argentina	Bolivia	Brazil	Paraguay	Uruguay
Harvested area (1 000 ha)		25 000	1 944	53 200	2 290	1 300
Main crops (% of harvested area)	Cotton	1.4	2.7	1.6	13.0	ND
	Rice	0.6	7.7	5.9	1.2	11.8
	Coffee	ND	1.3	4.3	0.2	ND
	Sugar cane	1.1	4.4	9.4	1.9	0.2
	Sunflower	7.6	6.9	0.2	1.3	3.8
	Maize	9.9	15.7	23.2	15.7	2.8
	Cassava	0.07	2.2	3.3	11.2	ND
	Soybean	41.3	28.6	25.6	52.8	0.8
	Sorghum	2.5	2.2	0.9	1.1	2.9
	Wheat	28.4	5.6	3.2	7.5	9.8

Note: ND = No Data. (Source: CEPAL 2003)

Figure 11 Political division of the Patagonian Shelf region.

and Paraguay, representing around 50% of the total harvested area. In Bolivia, it represents almost 30% of the total harvested area. In Brazil, soybean represents 26% of the farming area, followed by maize, 23% (Table 12). In some areas of Argentina, Brazil and Uruguay farming is complemented with cattle raising and dairy industry (GWP 2000).

The Basin includes the main industrial centre in Argentina, which extends between Santa Fe and La Plata cities. In southern Brazil, industries are diverse and expanding. Many industries process raw material, refine steel and oil, produce food, paper and clothes. In Uruguay, industry has grown thanks to the import of fuel and raw materials. The main industrial produce is food, followed by fertilisers and transport equipment.

Water-related infrastructure

International waterways and bridges, irrigation schemes and dams are included among the engineering projects undertaken in the region. The Paraguay-Paraná waterway and the Tietê-Paraná waterway are partially developed projects. The Paraguay-Paraná waterway extends from Cáceres Port in Brazil to Nueva Palmira Port in Uruguay. The total length is approximately 3 400 km and it directly influences 1.75 million km^2 of the South Common Market (Mercosur) countries and Bolivia, with an estimated population of 17 million. The Tietê-Paraná waterway is another important transport system that will help Brazil to increase the competitiveness of its agricultural products in foreign markets. The main reference points at the extremities of the waterway

Table 13 Area under irrigation in the La Plata River Basin.

Country	Irrigation area						
	Year	Public irrigation (ha)	Private irrigation (ha)	Total irrigation (ha)	% of cultivated area	% of potential area	Current irrigated area (%)
Argentina	1995	1 209 182	341 051	1 550 233	5.7	25.3	ND
Bolivia	1999	23 800	104 439	128 239	5.7	6.4	100
Brazil	1998	160 000	2 710 204	2 870 204	5.8	9.8	56
Paraguay	1997	ND	ND	67 000	3.0	ND	ND
Uruguay	1998	0	181 200	181 200	13.9	10.3	100

Note. ND = No Data. (Source FAO 2000)

are Foz de Iguazú, in the south, Conchas and Piracicaba, in the east, Três Lagoas, in the west and São Simão, in the north. The Tietê-Paraná waterway impacts an area of 1.5 million km^2 with 75 million inhabitants. Once the Tietê-Paraná and Paraná-Paraguay waterways are finished, the system will impact a total area of 4.8 million km^2 with 90 million inhabitants, generating more than 85% of Mercosur GDP.

Irrigated agricultural areas in the region are described in relation to countries within the Basin (FAO 2000). The area under irrigation is shown in Table 13. Finally, the main hydroelectric reservoirs and dams are shown in Annex VI, Table VI.2 and in Figure 7. The most important dams at a bi-national level are the Itaipú (Brazil-Paraguay, hydro capacity of 12 600 MW), Yacyretá (Paraguay-Argentina, hydro capacity of 1 800 MW) and Salto Grande (Uruguay-Argentina, hydro capacity of 1 890 MW).

Legislation and institutions related to water

Argentina and Brazil have a federal institutional organisation whereas Uruguay, Paraguay and Bolivia have a centralised organisation. Figure 11 shows the political division of the Patagonian Shelf region.

Brazil is the only country with modern water legislation striving for sustainable use of surface and groundwater. An explicit policy, management organisations with a high hierarchic level, and instruments, have been created in support of this goal. Bolivia and Uruguay have outdated legislation, which does not fulfil present requirements, and their management organisations are ineffective. Argentina and Paraguay have no national legislation related to water. There is a division at legislative and institutional level that also affects responsibilities and decision-making. In Argentina, the situation is aggravated due to the federal system; the provincial states own and administer their waters. Brazil also has a federal system and each state owns its waters. There is, however, federal jurisdiction in the case of interstate, bordering or border crossing waters, and the system falls under current legislation.

Argentina and Brazil have environmental laws at national level and most of the states (Brazil) and provinces (Argentina) have established regulations within their jurisdiction. Paraguay and Bolivia have modern Constitutional Letters and advanced framework laws on environmental matters that are no more than "intention" politics, lacking in effectiveness and efficiency (policy). Uruguay is at an intermediate level between the two above-mentioned countries.

The legislation and institutions of these countries (with the exception of Brazil) possess common flaws as they do not relate to national or local problems, or guarantee environmental sustainability.

The supranational legal framework is provided by the La Plata River Treaty, which contributes to common and integrated research on the Basin and tries to establish a juridical regime of the waters. The results, however, have not lived up to expectations, although the Intergovernmental Coordinating Committee (CIC) (Comité Intergubernamental Coordinador para la Cuenca del Plata) has made advances in the interchange of information and the coordination of some joint actions.

Some of the sub-basins within the La Plata River Basin with shared water resources have institutional agreements based on treaties between countries, with specific purposes. The most important ones are:

- Bi-national Commission for the Administration of the Lower Basin of the Pilcomayo River; Argentina and Paraguay (Comisión Binacional Administradora de la Cuenca Inferior del Río Pilcomayo);
- Tri-national Commission for the Development of the Pilcomayo River Basin; Argentina, Bolivia and Paraguay (Comisión Trinacional para el Desarrollo de la Cuenca del Río Pilcomayo);
- Bi-national Commission for the Development of the Upper Basin of the Bermejo River and Grande de Tarija River; Argentina and Bolivia (Comisión Binacional para el Desarrollo de la Alta Cuenca del Río Bermejo y el Río Grande de Tarija);
- Paraná River Argentine-Paraguayan Commission (COMIP) (Comisión Mixta Argentino-Paraguaya del Río Paraná);
- Administrative Commission for the Uruguay River; Argentina and Uruguay (CARU) (Comisíon Administradora del Río Uruguay);
- Brazilian-Uruguayan Commission for the development of the Cuareim River (Comisión Mixta Brasilero-Uruguaya para el Desarrollo del Río Cuareim);
- Administration Commission of the La Plata River; Argentina and Uruguay (CARP) (Comisión Mixta Administradora del Río de la Plata).

Annex V presents a list of conventions and environmental and water agreements by country, including the most important treaties and institutions through their legal framework.

South Atlantic Drainage System[4]

Population

This system is characterised by a very low population density (Table 14) and a high dispersity. Populations are concentrated especially around water bodies (rivers and lakes), in coastal areas or in areas with relatively favourable climatic conditions.

The main urban areas are located in the Argentinean territory, the Córdoba and Mendoza provinces. The population of the metropolitan

[4] *The description of this system is mainly centered in the socio-economic features linked with interjurisdictional and international water bodies, which are located mostly in western and southern areas.*

Table 14 Total population, area, density and population growth in the Argentinean provinces of the South Atlantic Drainage System.

Argentinean province	Total population	Area (km^2)	Density (inhabitants/km^2)	Population growth (%) (1991-2001)
Catamarca	333 661	102 602	3.3	26.3
Chubut	413 240	224 686	1.8	15.7
Córdoba	3 061 611	165 321	18.5	10.3
La Pampa	298 460	143 440	2.1	14.6
Mendoza	1 576 585	148 827	10.6	11.6
La Rioja	289 820	89 680	3.2	31.3
Neuquen	473 315	94 078	5.0	21.7
Río Negro	552 677	203 013	2.7	9.1
San Juan	622 094	89 651	6.9	17.7
San Luis	366 900	76 748	4.8	28.1
Santa Cruz	197 191	243 943	0.8	23.4
Tierra del Fuego	100 960	21 571	4.7	45.8

(Source: INDEC 2001)

Table 15 Main cities of South Atlantic Drainage System.

City	Province	Last registered population (2001)
Great Córdoba	Córdoba	1 368 109
Great Mendoza	Mendoza	1 576 585
Mar del Plata	Buenos Aires	541 857
San Miguel de Tucumán	Tucumán	525 853
Santa Rosa	La Pampa	298 460
Bahía Blanca	Buenos Aires	272 166
Neuquen	Neuquen	201 729
San Luis	San Luis	152 918
La Rioja	La Rioja	143 921
San Fernando del Valle de Catamarca	Catamarca	140 556
Comodoro Rivadavia	Chubut	135 813
San Juan	San Juan	115 556
Trelew	Chubut	88 397
Río Gallegos	Santa Cruz	79 072
Viedma	Río Negro	46 767
Usuahia	Tierra del Fuego	45 205
Puerto Madryn	Chubut	57 571

(Source: INDEC 2001)

areas of these two cities were 1 208 600 and 773 100 respectively in 2001. Other cities of regional and provincial importance are shown in Table 15. During recent years, in areas with very few inhabitants such as Patagonia, it was noted that the urban population is increasing faster than the total population.

According to data from 1990-2000, the total population with access to drinking water reached 61.2% and 31.8% of the population was connected to sewage networks (INDEC 1991). In urban areas, the percentage of the urban population with access to drinking water and connected to a sewage network has improved to 79.9% and 51.6% respectively (ENOHSA 2002).

Economic sectors

Farming is developed in many areas along the system. In the large area south of the Colorado River (Patagonian steppes), the widespread traditional activity is sheep farming. This activity has degraded the soil, resulting in severe desertification. To the north of the Colorado River (area of "Monte" shrubland), the aridity restricts animal rearing. In this area, goats cope better with the environmental conditions than other species.

Farming is limited to the oases related to the existence of rivers (or other water bodies) and the "mallines", the regional name given to flood meadows in Patagonia. The oases of San Juan, Mendoza and La Rioja provinces are centres for wine production, for local and international markets, as is the Pampeanas Hills oasis, located in the western central part of the country.

Fruit growing is also an important activity in the Negro River high valley (Río Negro and Neuquén provinces). Forests located in the Patagonian Andean hillsides are set apart for different uses. There are several protected areas (especially national parks) to preserve the environment and forest species (see Figure 10). On the other hand, the forest is exploited to obtain diverse products (even for export) and is deforested for the purpose of small-scale farming.

Another central activity in this system is the exploitation of underground resources (oil and coal). The main Argentine petroleum poles are: the Neuquina Basin (Upper Colorado River Basin); the Cuyana Basin (Mendoza and San Juan provinces); the San Jorge Gulf Basin (South of Chubut province and North of Santa Cruz province) and the Austral Basin (Santa Cruz province and North of Tierra del Fuego province). Oil production is exported through the ports of Comodoro Rivadavia (Chubut province) and Bahía Blanca (Buenos Aires province).

Water-related infrastructure

The main water-related engineering projects include irrigation schemes and dams. Irrigated agricultural areas in the Argentinean provinces (years 1984 and 1994) are shown in Table 16. A small increase during this time can be noted. The more important provinces with irrigation systems are Mendoza and Río Negro. Table 17 shows current

Table 16 Evolution of areas under irrigation in Argentinean provinces of South Atlantic Drainage System.

Argentinean province	1984		1994	
	Irrigation area (1 000 ha)	% of irrigated area in Argentina	Irrigation area (1 000 ha)	% of irrigated area in Argentina
Catamarca	26.9	1.8	29.3	1.8
Chubut[1]	26.4	1.8	26.4	1.6
Córdoba	55.9	3.8	55.9	3.4
La Pampa	4.0	0.3	6.5	0.4
Mendoza	359.5	24.7	359.5	22.1
La Rioja	13.5	0.9	13.5	0.8
Neuquen[2]	14.4	0.9	17.7	1.1
Río Negro[2]	117.1	8.0	117.1	7.2
San Juan	96.1	6.6	96.1	5.9
San Luis	8.8	0.6	8.8	0.5
Santa Cruz[1]	2.0	0.1	2.2	0.1
Tierra del Fuego	-	-	-	-
Total area in Argentina	1 455	100	1 627	100

Notes: [1]Mountain areas are not included. [2]Chocón and Patagonian mountain areas are not included. (Source: Morábito 1997)

Table 17 Argentinean PROSAP projects.

Project name	Status	Province	Co-financing amount (USD)
Rehabilitation of irrigated area in Constitutión.	Currently under execution	Mendoza	6 883 000
Rehabilitation of irrigated area in Monte Caseros.	Currently under execution	Mendoza	3 227 289
Rehabilitation of irrigated area in the low reach of Mendoza River.	Currently under execution	Mendoza	24 989 000
Programme remains in the province of Mendoza (minor works; Controlled Water and Soil Quality, Follow-up and Assessment; Modernisation of Hydric Resources Management).	Currently under execution	Mendoza	11 125 377
Rehabilitation of irrigated area in Colonia Centenario.	Currently under execution	Neuquén	12 848 000
Hydric Resources Management Program and productive transformation of the irrigated areas in the province of Chubut.	To be executed	Chubut	1 747 874
Modernisation of irrigation system of Mendoza-Luján Sur River right margin.	-	Mendoza	14 154 169
Los Andes Reduction (Irrigation network and alluvium Protection, Transference of Technology, Institutional Fortification).	-	Mendoza	9 942 857

(Source: PROSAP 2003)

Table 18 High Seas fishing in South Atlantic Drainage System by port.

Year	Mar del Plata (tonnes)	Puerto Deseado (tonnes)	Punta Quilla (tonnes)	Puerto Madryn (tonnes)	Cdro. Rivdavia (tonnes)	Bahía Blanca (tonnes)	Quequén (tonnes)	San Antonio Este (tonnes)	San Antonio Oeste (tonnes)	Others (tonnes)	Total (tonnes)
1996	340 413	140 023	131 648	124 637	28 798	26 007	25 019	22 024	1 862	2 784	1 059 613
1997	325 419	148 054	117 392	106 962	35 061	26 389	40 738	17 618	2 112	29 923	1 180 291
1998	271 653	128 020	49 189	121 537	88 614	21 226	34 147	4 668	2 216	24 497	996 961
1999	222 550	119 818	47 119	106 043	31 135	11 187	38 216	5 885	3 069	11 608	886 956
2000	194 625	82 981	43 759	109 000	16 493	9 601	28 723	3 329	2 621	23 987	759 475

(Source: SAGPyA, Dirección Nacional de Pesca y Acuicultura 2003)

Table 19 Coastal fishing in South Atlantic Drainage System by port.

Year	Mar del Plata (tonnes)	Rawson (tonnes)	Usuahia (tonnes)	Puerto Madryn (tonnes)	Cdro. Rivdavia (tonnes)	Bahía Blanca (tonnes)	Quequén (tonnes)	San Antonio Este (tonnes)	San Antonio Oeste (tonnes)	Others (tonnes)	Total (tonnes)
1996	139 318	17 853	445	777	1 389	309	3 090	1 571	5 965	7 948	178 665
1997	116 590	17 790	463	85	10 267	242	3 021	2 415	5 875	4 220	160 967
1998	74 633	6 649	475	469	18 870	191	4 698	2 127	4 564	7 054	119 729
1999	81 275	7 582	327	493	16 189	260	3 152	635	6 673	9 264	125 849
2000	65 599	5 439	328	99	6 317	203	3 461	508	6 330	4 966	93 206

(Source: SAGPyA, Dirección Nacional de Pesca y Acuicultura 2003)

projects (May 2003) in relation to irrigation processes financed by the World Bank and Inter-American Development Bank, and implemented by the Provincial Agricultural Services Programme (PROSAP) (Programa de Servicios Agrícolas Provinciales) from the Argentinean Secretary of Agriculture, Cattle Raising, Fishing and Food (SAGPyA) (Secretaría de Agricultura, Ganaderìa, Pesca y Alimentación). The hydropower stations and dams in this region are shown in Annex VI, Table VI.3 and in Figure 9.

The Atlantic Ocean coast is the centre for fishing activity. Mar del Plata (Buenos Aires province) and Puerto Madryn (Chubut province) are the main high sea fishing ports of Argentina, while Mar del Plata and Puerto Deseado (Santa Cruz province) are the main coastal fishing ports (Tables 18 and 19).

Fish catch in Patagonia is distributed as follows: 71% from factory fleet, 18% from trawling fresh fleet and 11% from coastal fleet. Processing involves both factories and cooperatives. Although the whole sector employment rate has decreased about 11% between 1987 and 1996, there was a manufacturing employment rate increase (about 37%) in Patagonia due to the establishment of several plants (DRIyA 2001). In recent years, the arrival of foreign ships increased the catch, which put several valuable species at risk of extinction; particularly the Argentine hake (*Merluccius hubbsi*).

In 1997, a maximum crew employment rate was registered. As shown in Table 20, the employment rate has decreased by about 22% since 1997. In 2000, the decrease was about 8-9%, 13% in the Patagonian coastal provinces (Río Negro, Chubut and Santa Cruz) and 6% in the Buenos Aires province (Bertolotti et al. 2001a).

Table 20 Evolution of the coastal fleet crew employment in the South Atlantic Drainage System.

Years	Crew in the Buenos Aires littoral*	Crew in the Patagonian littoral	Total crew
1997	1 540	259	1 799
1998	1 416	265	1 681
1999	1 459	265	1 724
1st semester of 2000	1 283	233	1 516
2nd semester of 2000	1 272	241	1 513
1st semester of 2001	1 199	202	1 401

*Note: * Buenos Aires data referred to maritime littoral. (Source: Bertolotti et al. 2001)*

Production, fishing days and employment rates of the high sea fleet decreased around 13%, 9% and 9% respectively, between 1999 and 2000. In the same period, the decrease for factory fleets was 14%, 7% and 9% (Bertolotti et al. 2001a).

Out of 38 industrial plants established in 2001, only 26 remained operative in the same year. Since 1998, some fishing factories are operated as cooperatives. The consequences have been lower incomes and loss of work benefits such as social security. The processing plants of Comodoro Rivadavia, Trelew and Rawson (Chubut province) are mainly devoted to hake processing. Due to the decrease in hake landing, there has been a sharp reduction in the fishery industry. Consequently, many plants were closed and numerous jobs lost. In 1999, fishery export reached 794 million USD showing a decrease compared with previous years; 1 014 million USD in 1996, 1 003 million USD in 1997 and 860 million USD in 1998. This was mainly due to international and national market conditions, and smaller catches.

Legislation and institutions related to water

In the continental area, the situation does not vary from that described in the section on La Plata River Basin as the legislative and institutional fragmentation problem still exists due to Argentina's federal government system.

Each province in the region owns its natural resources and is responsible for establishing its legal-institutional regulations. Argentina lacks clear policies on this. Although there has been some advances in national environmental legislation, it does not apply to water legislation. A principle solution has been found in the constitution of basin organisations:

- Interjurisdictional Committee of the Colorado River (COIRCO) (Comité Interjurisdiccional del Río Colorado);
- Interjurisdictional Basin Authority of the Limay-Neuquen and Negro River (AIC) (Autoridad Interjurisdiccional de Cuenca de los ríos Limay-Neuquen y Negro).

These organisations constitute "supra-provincial" authorities. Their functions are limited to research, information and planning, and do not include management, as they are an approving authority. Recently, the Patagonian Hydrological Council (Consejo Hídrico Patagónico) was formed.

In accordance with the specific Environmental Agreement and the Additional Protocols subscribed by Argentina and Chile, both countries are working on various basins of shared water resources, seeking criteria harmonisation for the sustainable management of such resources.

In Argentina and Uruguay, the territorial sea covers up to 12 nautical miles, the adjacent zone up to 24 nautical miles and the exclusive economic zone up to 200 nautical miles. In Uruguay (a country with centralised organisation), the territorial sea belongs to the nation, while in Argentina, it belongs to the provinces, due to its federal system. Argentina has legislated federal fishing rules, it has constituted the Federal Fishing Council (Consejo Federal Pesquero), it has national environmental and fishing institutions and its coastal provinces (Buenos Aires, Río Negro, Chubut, Santa Cruz and Tierra del Fuego) have specific legislation and environmental and fishing institutions. Uruguay also has specific legislation and environmental and fishing institutions.

In the northern area of the oceanic component of the system, Argentina and Uruguay share the administration of the so-called Common Fishing Area. Annex V presents a list of conventions and environmental and water agreements by country, including the most important treaties and institutions through their legal framework.

Assessment

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This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 21 and 27.

Table 21 Scoring table for La Plata River Basin.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)

IMPACT 0 No known impacts; IMPACT 1 Slight impacts; IMPACT 2 Moderate impacts; IMPACT 3 Severe impacts

The arrow indicates the likely direction of future changes.

↗ Increased impact; → No changes; ↘ Decreased impact

La Plata River Basin	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1.4* ↗	2.0 →	1.6 →	1.9 ↗	1.8	
Modification of stream flow	1					
Pollution of existing supplies	2					
Changes in the water table	1					
Pollution	1.9* →	3.0 →	1.6 →	2.3 →	1.9	
Microbiological pollution	2					
Eutrophication	2					
Chemical	2					
Suspended solids	2					
Solid waste	1					
Thermal	1					
Radionuclide	0					
Spills	2					
Habitat and community modification	2.5* ↗	2.0 ↗	0 →	2.0 ↗	2.0	
Loss of ecosystems	3					
Modification of ecosystems	2					
Unsustainable exploitation of fish	1.5* ↗	2.2 ↗	0 →	2.2 ↗	1.6	
Overexploitation	2					
Excessive by-catch and discards	1					
Destructive fishing practices	1					
Decreased viability of stock	1					
Impact on biological and genetic diversity	2					
Global change	0.8* ↗	2.7 ↗	2.4 ↗	2.0 ↗	1.9	
Changes in hydrological cycle	2					
Sea level change	0					
Increased UV-B radiation	0					
Changes in ocean CO_2 source/sink function	0					

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

La Plata River Basin

Freshwater shortage

The impacts of Freshwater shortage are moderate in the La Plata River Basin. Although the available freshwater resources in the La Plata River Basin easily exceeds the current total demand, uneven temporal and spatial distribution of water flow in the basin headwaters and degradation of water sources are causing freshwater shortages in some areas.

There is evidence of significant decreases in discharge in localised areas due to intensive water extraction in shared basins, which will probably increase in the future. Changes in low water flow and also, to some extent, in high water flow have occurred in the international stretch of the Paraná River system (Argentina, Brazil and Paraguay) because of land use changes and the construction and operation of reservoirs. As a result of reports of fish kills, extended bacteriological contamination due to raw sewage discharges and high pollution levels in some urban and industrial areas, including toxic substances close to rivers with different transboundary status, pollution of freshwater sources was considered the most significant cause of freshwater shortage. In addition, sub-national and multi-national aquifers that are used as urban and industrial water supplies are contaminated by domestic and industrial pollution and intensive agriculture and cattle raising activities. Also, there is evidence that water tables are receding and, as a result, wells have been deepened, and that overexploitation of aquifers has caused salinisation in some hot spots in Brazil, Uruguay and Argentina (Buenos Aires Metropolitan Region).

Socio-economic issues are more significant than environmental issues in terms of their potential to cause conflicts at sub-national and regional levels.

Environmental impacts

Modification of stream flow

In the Upper Paraná River Basin, stream flows have increased by 20 to 45% in several tributaries upstream of the Itaipú Reservoir compared with those recorded during the 1960-1970s (Müller et al. 1998). Similar trends were found in the Uruguay and the Paraguay River Basins (Figure 12) where, despite only minor increases in rainfall, there has been a considerable increase in the water level of the rivers since 1970 (Collishonn et al. 2001). In addition, other factors, such as changes in land use and land cover, have increased terrestrial run-off and have also contributed to the increased stream flows observed in these rivers (Müller et al. 1998).

Taking into account the history of river discharges, it is possible to identify three periods within the Middle and Lower Paraná River Basin. The first period, from the beginning of 1900 up to 1930 river flows generally increased, while in the second period, between 1930 and 1970, the lowest flows of the century were recorded. Finally, the last period from 1970 to 1998, was characterised by increased stream flow and more frequent outstanding peak flows (Giacosa et al. 2000).

Although lack of information indicating the contribution of climate changes and seasonal anomalies to changes in stream flow makes it difficult to assess the influence of human activities on these issues, the environment of these basins has been modified by changing land uses and the construction of reservoirs and dams for hydropower

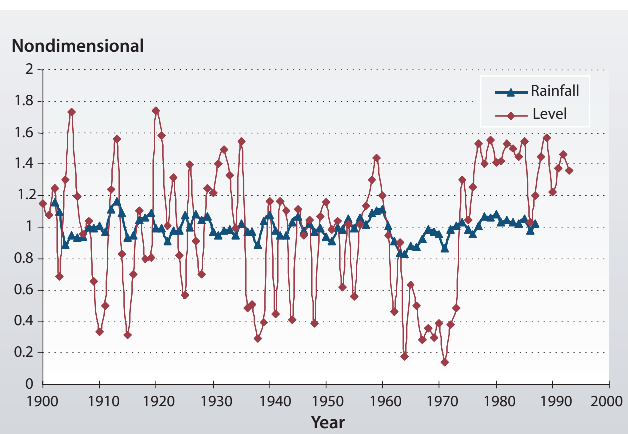

Figure 12 Variation in annual water level at Ladário (Upper Paraguay) and rainfall (3 year moving average) at Cuiabá (Paraguay River).
(Source: Tucci & Clarke 1998)

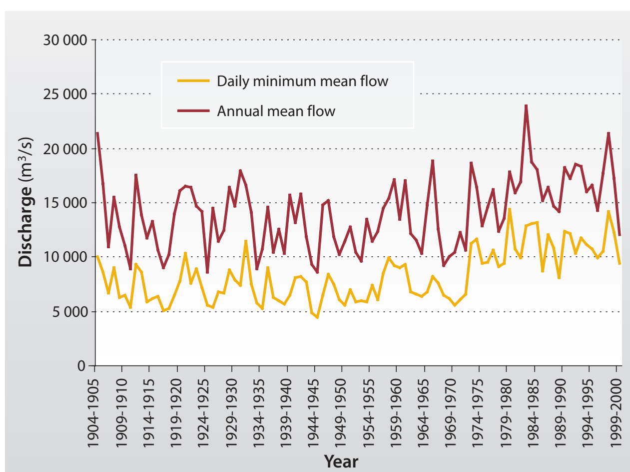

Figure 13 Daily minimum mean and annual mean flow of Paraná River at Tunel (Paraná-Santa Fe, Argentina).
(Source: SSRH 2000)

generation and irrigation. Dam operation changes the hydrological regime downstream since it causes either a decrease in peak flows and/or an increase in minimum flows. Figure 13 shows changes in the mean daily minimum discharges and mean annual discharges of the Paraná River (Paraná-Santa Fe cities, Argentina) from 1970.

Notwithstanding the history of water supply and irrigation demands within the La Plata River Basin, at present, in some areas, urban water supply and irrigation compete for available water, especially during periods of low flow, when the demand for water increases (Arcelus 1999, ANA 2001). In the Uruguay River Basin, there is a private rice production development. Irrigation occurs mainly along the Ibicuí River in Brazil and the Cuareim River, which is shared by Uruguay and Brazil, both tributaries of the Uruguay River. In these areas, there are conflicts between the demand for water for human consumption and the demand for irrigation during the dry months (Tucci & Clarke 1998).

Rice, irrigated between November and February, has been cultivated for 25 years in the Cuareim River Basin, which is about 14 900 km^2 in size (Figure 3). Since 1986-1987, cultivated areas have significantly increased and water availability has become an obstacle to continued growth (Comision del Rio Cuareim 2003).

In several areas within Tietê River Basin and Grande River Basin in São Paulo state (Brazil), irrigation cannot be expanded since there are conflicts between domestic water supply and irrigation due to freshwater shortage. Similar conflicts between industrial and domestic water supply have occured in Baxio Pardo-Mogi (São Paulo) where sugar cane and alcohol industries are responsible for about 22% of the industrial water consumption (Tucci 2001).

Pollution of existing supplies

Pollution of surface and groundwater bodies is becoming an extended problem with growing trends in the Basin. Consequently, the costs of treatment have increased and there is a need to find alternative sources to cope with growing demand and increasing shortages of water.

The Pilcomayo and Bermejo rivers and their tributaries are important sources of domestic water in Bolivia. Water quality is good except in the vicinity of human settlements. However, additional pre-treatment of the water is required because of the increase in turbidity due to large sediment loads carried by these systems during the summer rainy season. The Water Monitoring Programme in the Department of Tarija (Bolivia) have detected higher concentration levels of arsenic, lead, cadmium, nickel, zinc, manganese, cyanide, phosphorous, iron and boron than permitted under Bolivian environmental legislation. Additionally, incidental pollution events have been recorded, such as a mining spill at Porco in the Upper Pilcomayo River in 1996 and a hydrocarbon spill at Bloque de los Monos, which affected the Pilcomayo River 5 km upstream of Villamontes in 1998. These events illustrate the risks to humans resulting from consumption of untreated water and the problems associated with the accumulation of pollutants in biota (Centro de Análisis y Desarrollo de la Universidad Juan Saracho 2001, Instituto de Tecnología de Alimentos 2002).

In the Upper Paraguay River, the main sources of pollution are mining (Mato Grosso, Brazil), sediment loads from erosion due to soil fragility and overgrazing, mainly in the Taquarí River Basin (Mato Grosso do Sul, Brazil), and untreated discharges. In general, water quality is good except near the cities.

Figure 14 shows graphically the results of a short-term assessment of water quality at selected stations associated with international river reaches in the Brazilian area of the La Plata River Basin. The graphs are based on water quality index parameters over a one-year period.

The Upper Paraná Basin in Brazil supports a population of 46.7 million and covers 1 million km^2, five states and the Federal District (see Figure 11). A major part of the industries and many of the greatest cities of the La Plata Basin are located in this region. Organic matter discharge is estimated at 730 000 tonnes BOD_5 per year. Pollution of water supplies is a common but localised problem in many urban settlements (CETESB 2001).

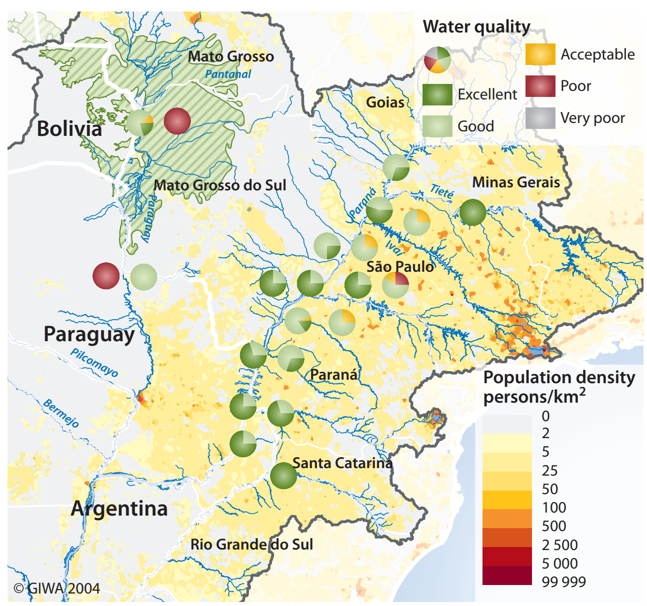

Figure 14 Water quality in the Brazilian area of La Plata River Basin.
(Source: ANEEL 2001)

Figure 15 Aerial view of São Paulo Metropolitan area (Brazil).
(Photo: PMAI)

The metropolitan area of São Paulo located in the Upper Tietê River Basin has 18 million inhabitants (Figure 15) which require about 60 m^3/s of safe drinking water. At present, 33 m^3/s are imported from neighbouring basins since the Tietê system lacks high quality water (Tucci & Clarke 1998). Water pollution is a significant concern, as untreated domestic and industrial effluents are discharged in the rivers and reservoirs. The Tamanduateí and Pinheiros rivers (upper metropolitan zone of São Paulo) have a high pollution load with extremely low or even zero dissolved oxygen levels (CETESB 2000). The Cantareira system supplies around 50% of the metropolitan area's requirement, while the Billings-Guarapiranga Reservoir system, mainly to the southern part of São Paulo Metropolitan Region, supplies an additional 20%. According to the Water Quality Report of Inland Waters in São Paulo state (CETESB 2001), the concentration of phosphorous and chlorophyll a indicate that both reservoirs exhibit generalised eutrophic conditions and that, since 1999, these levels have increased in the Guarapiranga Reservoir.

A similar stress on water sources is found in Curitiba, in the Upper Iguazú River, where the water quality in general is good (ANEEL 2001). However, there are local cases of high pollution, such as the main reach of the Iguazú River and Iraí Reservoir, that cause water supply problems, mainly due to increasing eutrophication (ANEEL 2001). In the Iguazú River, sewage is discharged without prior treatment. The potential pollution load is about 140 tonnes BOD_5 per day. Only 29% of the urban population is connected to sewage network.

Nitrate and coliform bacteria has been found in wells indicating that some groundwater sources are polluted. Groundwater vulnerability studies identify Ribeirao Preto/Franca, Bauru, Campinhas and the recharge zone of the Guaraní Aquifer in Brazil as the main areas of environmental concern (CETESB 2001).

Run-off from rural and urban areas is another source of pollution. This region has accelerated agricultural growth which is replacing forests with intensive mechanised agricultural areas. This process has resulted in significant consumption of natural resources that has caused serious erosion problems resulting in increased turbidity in water withdrawn for domestic purposes and, as a consequence, a higher degree of purification is needed (Merten 1989).

In the Lower Paraná River near Rosario city, the algal concentration is about 15 000 to 300 000 cells per litre and turbidity is about 30-230 NTU (Nephelometric Turbidity Unit). Although conventional water treatment plants guarantee the absence of pathogens in the treated water, they cannot guarantee the absence of algae, even with the improvements carried out in several treatment steps. Consequently, there are operative problems, possible increase in trihalomethane (THM) and nutrients, such as organic matter, which might enable microorganisms to grow in the water supply network (Vazquez et al. 1997, Cepero 2000).

Intense urban and industrial water uses and poor water quality causes severe impacts in a large inshore coastal area of the La Plata River that is associated with the Buenos Aires Metropolitan Area, although the concentrations of pollutants decline rapidly away from the shore. Oxygen demands (BOD and COD) show high values between the Riachuelo River and Punta Colorada. Dissolved oxygen reaches the lowest values near the coast and the maximum about 3 km offshore. High concentrations of ammonium, nitrates and phosphates, as well as heavy metals, agro-chemicals and biphenyl poly-chlorines have also been found. The highest bacterial concentrations occur within 500 m from the coast, and decreases beyond 3 km. Microbiological parameters such as total coliforms and faecal coliforms exceed the values recommended by the Environmental Protection Agency of the United States. In 1997, a geometric mean of about 12 000 faecal coliforms/100 ml were detected in the Riachuelo River (Consejo Permanente para el Monitoreo para la Calidad del Agua de la Franja Costera Sur del Río de la Plata 1997).

In the Buenos Aires Metropolitan Area, leaching from illegal landfills impact on water availability for human consumption (Aguas Argentinas 1997, Virgone 1998). In addition, Buenos Aires and Rosario (the third urban area of Argentina) discharge untreated sewage and other waste directly into the La Plata and Paraná rivers, respectively. Further, even when waste treatment is carried out, as in La Plata City, only a minor fraction of collected sewage water is purified (CEPIS & OPS 2000).

Severe pollution problems have been identified in several water supplies in Uruguay. In the Santa Lucía River Basin, which supplies water to 60% of the country's population and in the Laguna del Sauce

Basin, eutrophication reduces the quality of water to unacceptable levels causing water shortages for Maldonado and Punta del Este cities (OEA et al. 1992).

Changes in water table

Information about quantity, availability and exploitation of groundwater in La Plata Basin is still incomplete and variable. However, groundwater overexploitation for domestic water supply has been observed in the urban belt of Buenos Aires City, the most densely inhabited area in Argentina, with about 12 million inhabitants. It extends from Zárate City to La Plata City (Figure 16). In La Plata for example, groundwater was overexploited before 1950 (Banco Mundial 2000). During the 1970s, the salt intrusion rate was 70 m per year, but the trend has now decreased as many wells have been abandoned and others have reduced the extraction. At the same time, the intensive exploitation resulted in a decrease of the hydraulic potential of the good quality semi-confined aquifer which supplies the city, favouring the downward flow of water polluted with nitrates from the upper aquifer (CYTED 2000).

Nowadays, in the aquifer supplying Buenos Aires Metropolitan Region, there is an increase in water availability, mainly due to: (i) rainfall increase in the aquifer recharge area; (ii) a decrease of industrial activity and water use; and (iii) substitution of groundwater by surface water supply. In the Buenos Aires urban belt, 55% of the population receives freshwater from the network, while only 33% is served by sewage collection systems (Unidad Ejecutora de Programas para el Conurbano Bonaerense 1996).

In the northwestern part of Buenos Aires province, irrigation and domestic water supply compete for the same groundwater sources. Salinisation processes due to a lowering of the mean water table makes

Figure 16 Location of major cities in Metropolitan area of Buenos Aires.
(Photo: Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC)

this conflict more serious by reducing water availability, particularly during the summer months when domestic and crop requirements are higher (Gonzalez & Hernández 1998).

Preliminary studies of the Guaraní Aquifer System (Figure 8) have found no evidence of overexploitation at regional level. However, at local level, mainly in recharge areas or natural spring areas with urban development, there is evidence of overexploitation and risk of pollution from human activities (Gregoraschuk 2001).

In the state of São Paulo, Brazil, groundwater sources are not highly exploited. The extraction rate is about 60 m^3/s, representing only 18% of the available recharge, estimated at 336 m^3/s. However, in local areas such as do Pardo (Ribeirão Preto); Turvo/Grande (São José do Rio Preto); Paraíba do Sul (São José dos Campos); and Tietê/Jacaré (Bauru), overexploitation has resulted in a lowering of the water table (CETESB 2001).

In the Upper Tietê River Basin, extraction rates from the sedimentary aquifer are higher than the recharge rates. This negative balance is due to losses from freshwater and sewage networks. In addition, lower levels in the water table due to aquifer overexploitation are inverting the natural underground flow from the River towards the aquifer, reducing the basic discharge of the River (CETESB 2001).

Socio-economic impacts

Economic impacts

Contamination of water supplies was identified as the most important cause of economic impacts. This results from the loss of drinking water supply, which leads to increased costs in water treatment or the incorporation of alternative supply sources. The loss of surface and groundwater water supply sources for urban settlements in large metropolitan areas, such as São Paulo, Buenos Aires and other important cities in Argentina like Rosario, Santa Fe, Resistencia, Posadas or La Plata, affects millions of people and many industries, increasing provision service costs.

A good approach for evaluating the problem is based on the percentages of the population with access to drinking water and sewage system. Table 10 shows the urban and total percentage of the population with access to water and are serviced by a sewage system in the countries sharing the La Plata Basin. It illustrates that a greater percentage of the population in cities are supplied with water and are connected to a sewage system. In addition, during the late 1990s, there has been an increase in coverage in all countries and urban areas within the La Plata Basin (CEPIS & OPS 2000).

In all the countries the lack of sanitary services coincides with the location of poor housing areas and consequently, poverty. According to the CEPIS & OPS's report analysing the five great cities in La Plata River Basin, Curitiba has the highest percentage of population in marginal settlements, followed by the Buenos Aires Metropolitan Area, Montevideo, São Paulo and Asunción (CEPIS & OPS 2000).

The percentage of treated effluent varies between a maximum of 76% in Uruguay and a minimum of 8% in Paraguay. Values for Argentina and Brazil are at the lower end, with only 10% treated in each country. Bolivia treats approximately 30% of its effluent (CEPIS & OPS 2000).

In the Upper Paraná system, problems associated with the supply of drinking water in the São Paulo Metropolitan Area are related to the pollution of the Tietê River. In addition to high water treatment costs, the treatment of sewage has required considerable investment in sanitation measures. The Tietê Project, an integrated sanitation plan (SABESP 2002, CEPIS & OPS 2000) and the "Projeto de Despolução do Rio Tietê" (SABESP 2002) aims to completely clean the Tietê River in approximately 20 years. During its first stage, which finished in 1999, the sewage network was extended and effluent treatment capacity increased from 20 to 60%. It is calculated that approximately 80 tonnes of untreated effluent was prevented from being discharged into the Pinheiros River (Tietê tributary) during 1995-1999.

Additionally, the intensive use of natural resources, which has caused serious erosion problems, has economic implications for agriculture and the environment. For example, the increase of turbidity has resulted in increased costs for water purification operations (Merten 1989). Within Brazil, water shortages are reducing the capacity to generate hydropower, which affects large economic sectors and the population as a whole.

Health impacts

Although reliable epidemiological records to quantitatively assess water-related diseases are not available, water pollution is known to be the cause of many health problems, particularly in urban populations in marginal tropical areas that lack safe water supply. In addition to the impacts caused by domestic and industrial pollution, the health of the population is also affected by contamination of water supplies by microbes, nitrates and even toxic metals.

In Brazil, about 65% of hospitalised people suffer from water-related diseases which affects especially low-income populations that do not have either freshwater supply or sewage infrastructure.

The rural and urban population in marginal areas is the worst affected by water shortages. In tropical regions, with high temperatures, there are health problems, particularly in low-income populations with greater water demands.

The presence of nitrates in the groundwater on the outskirts of Buenos Aires Metropolitan Area may affect populations not served by sewage systems. In the Pilcomayo River Basin, it can be assumed that indigenous people may have health problems related to the consumption of the fish Sábalo that have accumulated heavy metals (lead) in their tissues.

Other social and community impacts

Social and community impacts include the increase in potential upstream-downstream conflicts due to reservoir management which, in some cases, have transboundary implications.

There are also conflicts due to differences in regulations regarding the physical-chemical and bacteriological parameters of water quality in Argentina and Brazil. Table 22 shows the main parameters of water quality measured in the transboundary reaches of the Brazilian rivers. Brazilian guidelines describing the physical-chemical and bacteriological standards of water quality that should be met through conventional treatment are different from Argentinean guidelines. Brazilian guidelines take into account water uses together with aquatic life supporting variables, while Argentina treats these separately.

In the Pilcomayo River, high heavy metal concentrations in sediments, originating from mining activities, deleteriously affects water and fishing for human consumption. The dramatic reduction of artisanal fishing and a decrease of economic resources induce migration of indigenous people to the urban centres of Bolivia (e.g. Yacuiba and Santa Cruz) and Argentina.

Losses in recreational uses due to water shortage in extreme low flow situations have been considered. Although the critical period only lasts for about two months, this issue is very significant in Uruguay where the river integrates culture and traditional lifestyle. As the crops of small farmers located next to the riverbanks become affected, social problems arise as a result of the reduction of cultivated areas and the increasing size of settlements.

Conclusions and future outlook

It is difficult to assess the relative contribution of human activities and climate change to impacts associated with freshwater shortage because of the lack of historical information describing climatic trends and seasonal anomalies. Although pollution of freshwater sources is

Table 22 Water quality in transboundary reaches of Brazilian rivers.

Parameter	MVA*	Foz do Iguazú (Paraná River)		Iguazú National Park (Iguazú River)		Murtinho Port (Paraguay River)		Iraí (Uruguay River)	
		1998	1993-1997	1998	1993-1997	1998	1993-1997	1998	1993-1997
Arsenic (mg/l)	0.05	0.005	0.02	0.005	0.02	0.01	0.02	ND	ND
Cadmium (mg/l)	0.001	0.004	0.001	0.004	0.001	ND	0.001	ND	0.001
Lead (mg/l)	0.03	0.04	0.03	0.04	0.03	0.02	0.02	0.01	0.02
Cyanide (mg/l)	0.01	0.01	0.01	0.007	0.01	0.01	0.008	ND	ND
Chloride (mg/l)	250	2.2	2	1.3	2	5.5	3.5	3.5	1.5
Copper (mg/l)	0.02	0.01	0.01	0.009	0.01	0.003	0.007	ND	0.02
Faecal coliforms (#/100 ml)	1	25	110	320	210	20	110	ND	ND
Total coliforms (#/100 ml)	5	10	700	3.2	1.3	650	4	10.3	12.1
Colour (mg Pt/Co)	75	70	40	85	50	85	60	ND	135
Total Chromium (mg/l)	0.05	0.05	0.01	0.05	0.01	0.005	0.005	ND	0.01
BOD (mg/l O_2)	5	1	1	1	1	5	7	0.5	1
Detergents (mg/l LAS)	0.5	0.02	0.05	0.03	0.05	0.07	0.04	0.04	0.08
Total Phosphate (mg/l P)	0.025	0.02	0.015	0.036	0.03	0.12	0.074	0.09	0.14
Phenol Index (mg/l C_6H_5OH)	0.001	0.001	0.005	0.001	0.005	0.003	0.001	0.002	0.007
Mercury (mg/l)	0.0002	0.0002	ND	0.0002	ND	0.0002	0.0002	ND	0.0002
Nitrates (mg/l)	10	0.33	0.23	0.49	0.47	0.15	0.17	0.6	1.6
Nitrites (mg/l)	1	0.008	0.005	0.003	0.005	0.001	0.003	0.007	0.02
Ammonium (mg/l)	0.02	0.03	0.03	0.04	0.03	0.35	0.23	0.1	0.1
Oils and grease (mg/l)	Absent	5	4	5	4	ND	0.25	ND	ND
Dissolved oxygen (mg/l)	5	9.6	9	9.6	9.2	3	4.6	6.1	7.8
pH	6-9	7.5	7.5	7.2	7.4	5.8	6.8	7.5	7.5
Turbidity (NTU)	100	17	9.5	27	9.2	30	15	35	28
Zinc (mg/l)	0.18	0.02	0.06	0.04	0.03	0.06	0.02	0.1	0.16

*Notes: ND = No Data. * MVA: maximum values allowed by CONAMA 20/1986, Brazil. In red: Data that exceed the guide values of water sources for human consumption with conventional treatment suggested by Technical Argentine Group to the La Plata River Basin Intergovernmental Coordinating Committee (1987). In green: Data that exceed the maximum values allowed in Brazil. (Source: IARH 2003 based on Diagnóstico da situaçao do monitoramento da qualidade da água da bacia do Prata em territorio brasileiro. Brasilia: Agencia Nacional de energia Elétrica 2001)*

moderate, the present environmental impacts of freshwater shortage as a whole are slight, while the socio-economic impacts are moderate.

Importantly, there was no comparable information for the five countries of the La Plata River Basin, and only scarce information about groundwater exploitation for different uses. As a consequence, it is recommended that further regional studies on groundwater availability, exploitation and management should be conducted.

The economic consequences of pollution are reflected in the source changes, which take place in the main cities, increased water treatment costs, and the restoration of supply sources. However, pollution control, particularly at an industrial level and within major urban settlements, will improve. Population growth, urban concentration and economic limitations may restrict the possibility of drastically improving the very low percentage of wastewater that is currently treated. Thus, water sources will continue to be degraded, while water demands will naturally be greater. Health problems associated with the lack of safe water will increase and consequently, social and community impact will increase. The economic and health impact is expected to increase during the next decade and then decline in the long-term. Therefore, the impacts of freshwater shortage are not expected to increase in the future due to implementation of quality controls in the countries within the Basin and are predicted to remain moderate.

IMPACT Pollution

The general lack of sewage treatment in the La Plata River Basin has had a negative impact on the water quality of many rivers, mainly in the vicinity of cities. Industrial contamination as a result of the limited treatment of industrial waste and revamping of industrial processes is particularly important. Heavy metal pollution is ubiquitous in the La Plata River Basin and is the main chemical pollution stress. Waste discharges from mining activities in the Upper Pilcomayo River Basin have transboundary consequences for Argentina and Bolivia downstream.

Inadequate treatment of domestic sewage is demonstrated by numerous instances of bacteriological contamination. Usually, the impacts resulting from microbial contamination of rivers are restricted to sub-national levels but, in some cases, the impacts extend beyond national frontiers, as seen in the Bermejo River (Argentina and Bolivia), Pilcomayo River (Argentina, Bolivia and Paraguay) and Uruguay River (Argentina, Brazil and Uruguay).

Large amounts of suspended sediments can be found in particular rivers, e.g. the Bermejo and Pilcomayo rivers, but most of the suspended material originates from natural landslides and soil erosion. However, there are indications of increased turbidity in some rivers due to changes in land use and unsustainable agricultural practices. This is occurring mainly in humid and semi-arid areas that have been subjected to extensive deforestation, such as the Upper Paraná, Paraguay and Uruguay basins in Brazil, which have exerted impacts downstream in Argentina, Paraguay and Uruguay.

Eutrophication is mainly a localised problem but can cause major economic loss, since algal blooms affect the operation of dams and require increased water treatment. Accidental oil spills and heavy metal contamination from mining activities occur regularly and often has transboundary implications. Accidental spills have also caused major economic loss in terms of emergency and remediation costs.

There is no impact from radionuclide pollution due to the absence of radionuclide sources in the region. Slight impact was assigned to thermal pollution because of the effects of water discharges of open cooling systems of major thermoelectric facilities located next to the Paraná River in the cities of Rosario and San Nicolas. In the La Plata River in Buenos Aires City water discharges are quite limited without transboundary effects.

Health impacts related to pollution mainly concerns water-related diseases. Cholera epidemics have occurred in all countries of the La Plata River Basin, except in Uruguay, during the 1990s, and diarrhoea is a significant disease affecting children.

Overall, pollution is considered to have a moderate impact in the La Plata River Basin.

Environmental impacts

Microbiological pollution

There is a generalised lack of sewage treatment in the La Plata River Basin that impacts on the water quality of many rivers, mainly in the vicinity of cities. In the Upper Uruguay, Peixe, Cuareim and Lower Uruguay rivers microbiological pollution can be considered severe and, in the Upper Paraguay River, it is moderate due to the dilution capacity of the River.

In the São Paulo Metropolitan Region (Brazil), the Upper Tietê River system is anoxic due to discharge of untreated industrial effluents and sewage. The absence of fish and the emission of disagreeable odours for most of the year have turned it into a sewage dump. It receives permanent wastewater discharges, at a rate of about 40 m^3/s, which represents 60% of the river's mean dry-weather flow. This pollution affects 8 million people and it is the cause of water quality deterioration in the reservoirs downstream (IDB 1995). The Paranoa Lake receives treated effluents from Brasilia City and exhibits water quality problems (Figure 17) (CAESB 2002).

The "Guidelines of Water Quality for La Plata River Basin" proposed by Argentina recommend a maximum number of faecal coliforms of 200/100 ml for leisure activities with direct contact and 1 000/100 ml for water for human consumption with conventional treatment. In the Middle Paraná River, faecal coliforms measured in 1994 showed an average number of 609/100 ml and a median of 210/100 ml, exceeding the standard for leisure activities. The same situation occurs in the Paraguay River; with an average and median of 651/100 ml and 218/100 ml, respectively. Although in the Lower Uruguay River the average and median of faecal coliform concentrations measured have been below the guidelines, there are values in the range of 4-480/100 ml which has had a significant influence on the type of recreational activities allowed in the coastal areas (DNPCyDH & SSRH 1999).

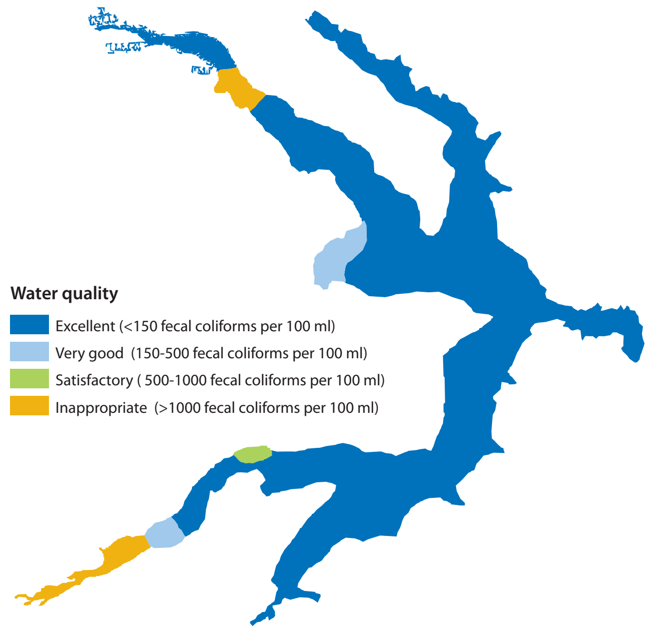

Figure 17 Water quality for leisure use in Paranoa Lake, Brasilia (Brazil).
(Source: CAESB 2002)

In the La Plata River and its southern shoreline during 1994-1995, the average faecal coliform concentration ranged between 13-630 957/100 ml, significantly exceeding acceptable standards. The highest bacteria concentrations occur within 500 m of the coast. In 1997, a geometric mean of about 12 000/100 ml faecal coliforms was detected in the Riachuelo River. Consequently, recreational activities resulting in direct contact were prohibited in many areas along the coast (Consejo Permanente para el Monitoreo para la Calidad del Agua de la Franja Costera Sur del Río de la Plata 1997).

Eutrophication

Eutrophication is present in localised areas of the large reservoirs in the transboundary rivers but is more common in a number of water bodies in their tributaries. In all cases, eutrophication affects water treatment.

In the Brazilian territory of the Paraná River Basin, serious problems in water treatment affects the water supply of São Paulo from the Billings-Guarapiranga Reservoir system due to excessive algal blooms (Beyruth 2000). The series of reservoirs in the Middle Tietê River, Brazil, receive input from sugar cane processing plants and upstream discharges from São Paulo City (CETESB 2002b).

In the Negro River Basin (Uruguay), deterioration of the water quality in reservoirs became evident through increased nutrient levels (mesotrophic-eutrophic) and toxic algal blooms, particularly of nanoplanktonic phytoflagellates, diatoms (*Aulacoseira*) and cyanobacteria (*Microcystis* accompanied by *Anabaena)* (Gorga et al. 2001).

In the south coastal fringe of the La Plata River, nutrients originate from different sources, such as industries and domestic effluents. The most affected zone extends 500 m offshore. The phytoplanktonic species found are characteristic of freshwater environment, with a predominance of mesosaprobic and eutrophic species (Gómez & Bauer 1998).

Chemical pollution

Chemical pollution, due to its broad spatial and temporal scale, is the main aspect of pollution. In the Paraná River, heavy metal concentrations in the São Paulo metropolitan zone have been found to exceed Brazilian guidelines (CONAMA 1986) for "Freshwater Aquatic Life". Persistent organic pollutants such as DDT and hexachlorocyclohexane have been detected in fish from the Paraná River (ENAPRENA 1995). In the Tamanduateí and Pinheiros rivers, the concentrations of zinc (0.64 mg/l), mercury (0.00039 mg/l), copper (0.12 mg/l) and lead (0.13 mg/l) exceeded acceptable levels (zinc: 0.18 mg/l, mercury: 0.0002 mg/l, copper: 0.02 mg/l and lead: 0.03 mg/l). The Tietê River registered the highest nickel levels (0.07 mg/l) (CETESB 2002b).

The Upper Paraguay River Basin has been subject to intensive gold mining and agricultural exploitation. Mercury pollution from mining operations is particularly significant in the state of Mato Grosso, Brazil (Banks 1991). Agro-chemicals such as fertilisers, herbicides and insecticides, constitute another significant problem, as they are washed into streams.

Agriculture and industry are the major threats concerning the Paraguay River in Paraguay. Traces of heavy metals and pesticides have been found. Lead, chromium, cadmium, iron and mercury concentrations (1988-1995, Pilcomayo and Formosa ports) exceed international water quality guidelines for freshwater aquatic wildlife. Concentrations of chromium and zinc in sediments at different points at Asunción Bay exceeded those reported for moderately polluted world rivers (chromium: 103 mg/kg versus 16-27 mg/kg; zinc: 163.2 mg/kg versus 26-99 mg/kg) (ENAPRENA 1995).

Persistent organic pollutants such as DDT and hexachlorocyclohexane have been detected in fish (ENAPRENA 1995) also in the Paraguay River. Heavy metal contamination of sediments in the Pilcomayo River system is particularly problematic since the predominant fish species are detritivorous organisms (Sandi 1998). High concentrations of lead, arsenic, copper, mercury, zinc and silver in sediments were found at Misión La Paz (Salta, Argentina) (Comision Trinacional para el Desarrollo de la Cuenca del Río Pilcomayo 1999). At Potosí (Bolivia), lead, cadmium and zinc concentrations were sufficiently high to declare the water supply unacceptable for human consumption and for recreational use with direct contact.

The Uruguay River receives organic pollutants from agricultural exploitation. These inputs are generally associated with pesticides and aromatic and aliphatic hydrocarbons from urban activities. In addition, phenol concentrations that exceeded the Environmental National Council (CONAMA) (Conselho Nacional do Meio Ambiente) guidelines were found (1993-1998, Iraí station, Brazil). A similar situation was observed at Monte Caseros (Argentina, Uruguay) where the concentration of phenol exceeds the Administrative Commission for the Uruguay River (CARU) (Comisión Administradora del Río Uruguay) guidelines for freshwater aquatic life (INA 1999).

Critical metal concentrations of lead, iron, cadmium and, especially, mercury have been recorded at El Soberbio (Brazil and Argentina). The latter may be referred to an industrial discharge point (INA 1999).

Organic pollutants also affect water quality in the southern reach of the Uruguay River. The heavy use of agro-chemicals is a consequence of agricultural exploitation. High concentrations of pp'DDT and aldrin exceeding the CARU guidelines have been found at Monte Caseros (INA 1999).

Water samples taken in the Iguazú River (Iguazú National Park station, 1998) exhibited high concentrations of cadmium and lead exceeding CONAMA guidelines. Significant phenol levels were reported between 1993 and 1997, also exceeding the above guidelines (ANEEL et al. 1999).

The La Plata River system receives either directly or through its tributaries, urban and industrial wastes that flow through agricultural areas. Some records of chromium and lead concentrations exceed water quality guidelines. Metal concentrations in sediments, bivalves and in suspended particulate matter are comparable with those reported for other moderately polluted world rivers. The chromium concentration in suspended particulate matter is relatively high; the highest value is double that of the maximum concentration recorded for the Rhine/Meuse estuary (Bilos et al. 1997).

Persistent organic pollutants (POPs) are widely distributed and concentrated in sediment and biota. Despite its considerable dimensions, POPs affect the entire La Plata River coastal ecosystem. These pollutants concentrate in organic sediments and in detritivorous organisms such as Sábalo (*Prochilodus lineatus*), a fatty fish that is an efficient accumulator of POPs (Colombo et al. 2000).

Suspended solids

Erosion due to changes in land use and unsustainable farming practices have caused an increase in water turbidity, mainly in areas subject to deforestation for agricultural use in both humid and semi-arid areas of the La Plata River Basin. The development of agriculture and urban settlements has resulted in extensive deforestation in the Upper Paraná, Paraguay and Uruguay basins in Brazil. Table 23 shows changes in original cover in the states of Paraná and São Paulo, Brazil, both of which are within the Paraná River Basin (Tucci & Clarke 1998).

In the state of Rio Grande do Sul (Brazil), forest cover at the beginning of this century was about 40% of the total area of the state. Today, it is estimated to cover only about 2.6% (Tucci & Clarke 1998). Since 1970, there has been a change in land use within the Upper Paraná, Uruguay and Paraguay River basins. In the Brazilian sector, annual crops such as corn and soya, have replaced the main perennial coffee crop.

The rate of erosion in the Upper Paraguay Basin is about 4 tonnes/ha/year. In the Middle Paraná River, erosion rate is less than 10 tonnes/ha/year, while in the Lower Paraná River it varies between 18 tonnes/ha/year, when agriculture and cattle raising are rotated on an annual basis, and

Table 23 Deforestation evolution in São Paulo and Paraná states (Brazil) and in eastern Paraguay.

Year	Original forest cover of Paraná state (%)	Year	Original forest cover of São Paulo state (%)	Year	Original forest cover eastern Paraguay (%)
< 1890	83.4	< 1886	81.8	1945	55
1890	83.4	1886	70.5	1960	45
1930	64.1	1907	58.0	1970	35
1937	58.7	1935	26.2	1980	25
1950	39.7	1952	18.2	1990	15
1965	23.9	1962	13.7		
1980	11.9	1973	8.3		
1990	5.2				

(Source: Tucci & Clarke 1998)

28 tonnes/ha/year when agricultural production is continuous. In the Upper Uruguay Basin, the rate of erosion is ranges between 16 and 32 tonnes/ha/year and in the Bermejo River Basin it is between 390 and 2 000 tonnes/ha/year (FECIC 1988, Tucci & Clarke 1998, Brea et al. 1999).

The amount of sediment carried by the Bermejo and Pilcomayo rivers is usually high. Sediment discharged by the Bermejo River represents about 70% of the total suspended solids of the Paraná River at Corrientes (Argentina). During the last 20 years, it has constituted 80% of the total sediment load. The construction and operation of reservoirs upstream in the Paraná and Iguazú basins may explain the increase in the discharge of suspended solids (Brea et al. 1999).

The amount of sediment carried by the Upper Pilcomayo Basin is about 84 million tonnes per year with mean suspended solid concentrations as high as 12 g/l (Villamontes, Bolivia). The large amount of sediment deposited along the River in the Chaco Plain is reducing flow rates and increasing the rate of deposition upstream in the Argentinean and Paraguay territory. The rate of recession was estimated at about 5 km per year between 1940 and 1975, and up to 40 km per year in recent years (CONAPIBE 1994).

The production and transport of sediment in the Upper Paraguay Basin is of great concern. In the Planalto, there has been a dramatic increase of the areas planted with annual crops since the 1970s, which has resulted in a significant increase of soil erosion and sediment transport into the Pantanal. At the same time, the short-term increase of annual rainfall in the upper part of the Basin has caused soil losses in the Planalto with deposition in some reaches and, in the Pantanal, greater deposition of sediment and reduced channel conveyance (Tucci 2002, Collischonn et al. 2001). In the Salto Grande Reservoir (Lower Uruguay River), the deposition rate, originally estimated at 330 m^3/year, is now about 1 130 m^3/year, due to changes in land use in the upper basin as well as stream flow. The above increase was measured between the years 1980 to 1992 (Irigoyen et al. 1998). Normal reservoir operation causes bank erosion downstream with an increase in water turbidity.

Solid waste

The impact of solid waste is negligible in surface waters and has a local impact on groundwater in large metropolitan areas within the region. Nevertheless, attention should be given to the increasing development of unregulated disposal of municipal and industrial waste in urban areas, linked to the declining socio-economic status of the Mercosur countries.

The Pilcomayo River receives solid waste from different human activities in Bolivian territory. This is a result of urban growth and unsustainable solid waste disposal along streets and rivers and in open dump sites. Final disposal of solid waste is around 50% in controlled landfills, and 50% in open dump sites (Acurio et al. 1998).

The estimated generation of solid waste in Paraguay is around 3.3 tonnes per day; less than 20% is collected and disposed of in a controlled manner (BID et al. 2001). Some hazardous solid waste containing heavy metals and toxic organic compounds is dumped in the environment with industrial wastewaters or goes into landfills as solid waste.

The Upper Paraná River, in Brazil, receives a significant load of solid waste and wastewater from human activities in riparian cities and urban shanty towns, which affect the quality of the watercourse. For example, in São Paulo's Metropolitan Area the quantity of solid waste generated is 22 100 tonnes per day with 1.3 kg per inhabitant per day (Acurio et al. 1998).

The La Plata River receives solid waste from the coastal cities Montevideo and Colonia in Uruguay and Buenos Aires Metropolitan Area in Argentina. In Montevideo City, one of the most important environmental problems is the dumping of waste in watercourses due to a malfunctioning sewage collection system. The dumping is performed by solid waste scavengers (hurgadores) concentrating the waste near the river shores or on open dump sites, leading to disease and uncontrolled plague (Acurio et al. 1998).

The Buenos Aires Metropolitan Area generates 10 500 tonnes per day of solid waste. In 1994, on the outskirts of Buenos Aires City more than 100 open dump sites were detected affecting 400 ha of soil with 1.2 million tonnes of urban and industrial solid waste. Recently, the percentage of solid waste that receives some kind of controlled final disposal has declined, increasing the number of open dump sites (Virgone 1998).

Spills

Occasional major oil spills occur in the La Plata and Iguazú rivers, with significant impact at local levels. The La Plata River has seen four such spills. In 1996, in the access channel to Buenos Aires port, two ships collided and lost 2 400 m^3 of fuel oil, contaminating 40 km of the coastal area (BRECHA Newspaper). In 1997, a ship breached 20 miles from Punta del Este (Uruguay) and spilled 2 000 to 3 000 tonnes of crude oil. The spill of raw petroleum reached the beaches of Uruguay and affected 20 km of coastline and the Sea Wolves Island. In 1999, two ships collided in the La Plata River near Magdalena's coast, Argentina. The spill of 4 600 m^3 affected 20 km of the Buenos Aires coast (Villalonga 2000). In 2000, a ship spilled 3 000 litres of crude oil in the La Plata River near the Berisso coast, Buenos Aires. Contingency operations were hampered by bad weather conditions, allowing hydrocarbon waste to reach the coast (Villalonga 2000).

In the Iguazú River Basin, in 2000, a spill of 4 000 m^3 of petroleum from a refinery, occurred in Curitiba (Paraná state, Brazil). The estimated amount of oil that reached the River was 1 300 m^3. Volatile lineal and aromatic hydrocarbons (BTEX), and polycyclic aromatic hydrocarbons (PAH) were however not detected in dissolved and particulate phases (INA 2002).

A heavy metal spill from the tailings pond of the COMSUR Mine has had a significant impact. In the Upper Pilcomayo River Basin (Porco, Bolivia) in 1996, 235 000 m^3 of mine tailings containing high concentrations of heavy metals were spilled because of a ruptured dike (Vargas Ballester 1996). Concentrations of heavy metals and suspended solids exceeded Bolivian standards. Immediate remediation measures were performed along a 10 km reach of the River. The load of heavy metals was transported along the entire basin through particles, limiting heavy metal bioavailability. Today a Mining Residues Recovery Programme is carried out in Bolivia.

In the Bermejo River Basin (Argentina), incipient contamination from oil residues originating from oil exploration wells were reported in 2001. A spill from a breaking mine tailings pond was also reported in this basin (Aguilar Mine). Issues related to water quality and quantity, are of a high concern in the Bermejo River Basin due to increasing and diversified water uses.

In 1992, a truck-tank transporting liquefied phenol crashed (Caieiras, São Paulo), spilling 22 m^3 on the roadside. Part of this spilled material entered the road drainage system and eventually ended up in Juquerí River (Paraná tributary). After this accident, the phenol concentration in the Juaqueri River exceeded its mean value by 20 times; contaminating water for a two-month period (Haddad & Aventurato 1994).

Socio-economic impacts

Economic impacts

The polluted state of the Tietê River requires great investments in water treatment and sanitation in São Paulo (Brazil). Sanitation measures have been carried out by the Drainage Company of São Paulo state (SABES) (Companhia de Saneamiento Básico do Estado do São Paulo). Algal blooms in the Guarapiranga Reservoir have affected dam operations due to their resistance to algaecide and consequently, have cause an increase in water treatment costs (Beyruth 2000).In the São Paulo state (Brazil), emergency and remediation operation costs of an accidental spill in the Juquerí River system (1992) was estimated at about 150 000 USD (Haddad & Aventurato 1994).

Problems related to suspended solids of anthropogenic origin were detected in Paraná state (Brazil), where erosion caused by land use changes produced a considerable increase in river turbidity in water supplied to more than 200 cities, which caused an increase in water treatment costs (Merten 1993).

Several activities in the Pantanal have been seriously impacted resulting in higher maintenance costs for navigation in the Paraguay River and significant economic loss to commercial and sport fishing (Moiragh de Pérez 2000). Sediment progressively fills channels and riverbeds, increasing overflow and flooding. This has a negative economic impact on cattle raising and land values (Tucci 1996).

Due to successive mining accidents in the Pilcomayo River system, environmental actions were started. The World Bank, the Swedish International Development Cooperation Agency (Sida), and the Bolivian Mining Corporation (COMIBOL) (Corporación Minera de Bolivia) assigned 3 million USD for mitigation and prevention actions (Veneros 1998). In the Lower Pilcomayo River (Argentina), it is necessary to remove heavy metals present in suspended solids and to treat water for human and agricultural uses (Lopardo 1998).

As a consequence of the spills in Magdalena on the La Plata River coast (Argentina), the Government and affected people have filed indemnity claims against the companies responsible for the spills.

Until 1976, the water intake for the Buenos Aires Metropolitan Area was located some 600-700 m from the coast. Because of the high pollution levels, the intake was moved to 1 050 m from the coast. The cost of this is directly associated with the negative impact of pollution. Despite this change, the water intake point continues to receive discharge from the Reconquista River (one of most contaminated rivers in the Buenos Aires Metropolitan Area), which may lead to increased water treatment costs (World Bank 1995).

Health impacts

Despite the absence of information to explicitly link morbidity and mortality with water pollution, there are reports that indicate the existence of water-related diseases in each country. In Argentina, the most frequent diseases are gastrointestinal disease, paratyphoid, typhoid fever, intestinal parasites and methemoglobinemia (CEPIS & OPS 2000). Between 1992 and 1996, cholera epidemics were reported, which affected principally the indigenous communities of the Salta province (CEPIS & OPS 2000). The most important epidemic centres were cities within the Bermejo and Pilcomayo river systems, with a peak of 2 080 cases (6.5 per 100 000 inhabitants) and a mortality rate of 1.6% in 1993 (OPS & OMS 1998). There were also reports of disease outbreaks in the province of Chaco (Norte Newspaper 1997).

In Brazil, the most problematic water-related diseases are schistosomiasis, malaria and dengue fever. In addition, there are a few cases of yellow fever and filariosis. It is estimated that there are approximately 10 million people affected with schistosomiasis (a disease caused by water contact) (CEPIS & OPS 2000). Information from 1995 indicates that diarrhoea was the second biggest reason for hospitalisation and the third largest cause of mortality among 1-year-olds. An epidemic of cholera was also registered in the early 1990s (OPS-OMS 1998), but the majority of cases were located outside the Patagonian Shelf region.

In Paraguay, diarrhoea is the most common water-related disease and the second biggest cause of mortality among of children between the age of 0 and 5 (CEPIS & OPS 2000). The regional cholera epidemic that occurred in the 1990s also involved Paraguay, although the number of registered cases was relatively few (seven in 1993 and four in 1996). Although there are no studies that associate the occurrence of infectious and parasitic diseases with solid waste pollution, it is possible to associate the 1999 dengue epidemic with poor waste management (BID et al. 2001).

In Uruguay, there have not been any cases of diseases produced by vectors (schistosomiasis, malaria and dengue). Intestinal infections in children under the age of one are the second largest reason for consultation in public hospitals, while in 1995, severe diarrhoea was the 8th most common cause of infant mortality. No cholera cases were registered during the 1990 epidemic (OPS & OMS 1998).

Finally, in Bolivia, diarrhoea is the most significant water-related disease and accounts for 64% of all registered cases of water-related diseases (PLAMACH-BOL 1996). Despite the lack of statistical information, studies link the occurrence of diarrhoea in urban areas with microbiological pollution and deficiency in sanitary services (Barrera Arraya 1996). This is also common among indigenous populations, where diarrhoea is the primary cause of infant mortality. The regional cholera epidemic reached a maximum peak in 1996, with 2 634 registered cases and a mortality rate of 2.4% (OPS & OMS 1998), concentrated in La Paz and Potosí departments.

Serious problems affect the water supply of São Paulo from Billings-Guarapiranga Reservoir system due to excessive algal blooms. Massive applications of copper sulphate in the dam to control algae growth are becoming less efficient and hazardous to human health (Beiruth 2001).

Phenol spills in the surroundings of the Juquerí River (Upper Paraná system) caused an interruption of the water supply service during several days, which placed the local population in a risk situation (Haddad & Aventurato 1994). In the Pilcomayo River Basin, the population's health is considered at risk due to pollution caused by mining residues and effluents discharged by Sucre, Potosí and other cities (Arce et al. 1998). In Potosí and Chuquisaca departments (Upper Pilcomayo River Basin), cases of lead poisoning have been registered (Sandi 1998).

In the Paraguayan tributaries of the Upper Paraná system, pollutants from agro-chemical origin have been detected (Azodrín 400, Apadrín 60), and have been related to cases of poisoning (Gobierno de la República del Paraguay 2000).

In the La Plata River, some municipalities of Buenos Aires Metropolitan Area are at high sanitary risk due to water pollution from biological (lecptospirosis and diverse parasites) and chemical origin (metahemoglobinemia). These diseases together with the above mentioned severe effect of diarrhoea are related to deficient sanitary services, especially in deprived settlements (CEPIS & OPS 2000). The leptospirosis cases are related to water recreational uses such as bathing in rivers and ditches and coastal fishing. Cases of metahemoglobinemia are related to anthropogenic aquifer pollution (Aguas Argentinas 1997).

Other social and community impacts

In the Upper Paraná system, severe pollution of the Tietê River has affected the urban landscape (Secretaria Estadual do Meio Ambiente 2002). At Guarapiranga Basin, landscape degradation, loss of vegetable and animal species and loss of ecosystem ecological functions have been observed (CETESB 1997). In the Guarapiranga Reservoir's beaches, microbiological pollution impacts recreational use (CETESB 2002a).

High concentrations of cadmium and lead and significant phenol levels in the Iguazú River at Iguazú National Park is a priority concern, not only because Iguazú National Park is a major international tourist resort, but because this area is an important habitat for the conservation of local biodiversity (ANEEL & SRH/MMA 2000).

The negative impact of pollution in Pilcomayo River on the economy of indigenous communities has caused migration towards urban centres, both in Bolivia and Argentina. There is, however, a lack of quantitative information, which makes it difficult to evaluate the magnitude of the problem. It is estimated that forced migration jeopardises the survival of the communities, through loss of identity, communal disintegration and loss of native language (Castro Arze 1998). The accident in the Porco Mine temporarily aggravated the process of migration (Condori 1997). In 1996, at the Group of Work of Indigenous Peoples assembled in Ginebra, the death of three indigenous farmers due to polluted drinking water was denounced (Más sobre el Río Pilcomayo 2002).

The oil spill near Punta del Este (Uruguay) affected tourist beaches in high summer season, as well as other places such as the Sea Wolves Island, an important habitat of birds and marine mammals (Villalonga 2000). The spill near the coast of Magdalena, Argentina, degraded the coastal landscape and affected recreational activities (INA 2000). These spills have direct and indirect consequences on human health and there are claims from people affected.

Conclusions and future outlook

Present environmental impact of pollution in the region is moderate, although microbiological and chemical pollution is severe at local levels. Solid waste, thermal and radionuclides have lesser impact. Nevertheless, the economic impact is severe, although there are no quantitative regional data. Health and other social and community impacts are moderate.

In the long-term, a slight improvement is expected due to governmental action, the influence of environmental NGOs, enhanced community awareness and commitment and increased self-regulation of industry (ISO standards). There is a trend towards reducing organic pollution in Argentina and Brazil, and it is considered that an improvement and more effective enforcement of the regulatory framework to control pollution should take place in the Basin. Most effort should be devoted to cope with large pollution sources, mainly represented by industrial facilities and large urban settlements.

Improvements in pollution control will require major investments by the private and public sectors and, as a consequence, improvements in the condition of the environment will come with increased economic costs. In the future, the economic impacts of pollution will remain severe, but it is anticipated that impacts on the health of the population and other social and community impacts will be slightly reduced as a consequence of better environmental conditions.

Habitat and community modification

The major part of the population and annual gross national production of Argentina, Bolivia, Brazil, Paraguay, and Uruguay is located in La Plata River Basin. A major loss or transformation of aquatic fluvial and riparian ecosystems has taken place within this basin as a consequence of the construction of reservoirs for hydropower generation as well as the settlement of large urban areas.

The construction of a large number of reservoirs in the main reaches and their tributaries has caused the transformation of fluvial lotic systems into lentic[1] or almost lentic ecosystems. Riparian river ecotones have been turned into lake ecotones and the impoundment has turned terrestrial habitats into aquatic littoral habitats. These losses affect more than 30 % of the internationally shared portion of the river. As many of these reservoirs are bi-national developments, the ecosystem loss has impacted on the territories of the countries involved.

In the Paraná River, the construction of polders has resulted in the disruption of natural delta habitats. The development of large urban settlements along the river shores, such as São Paulo (Brazil), Posadas (Argentina) and Encarnación (Paraguay), the coastal belt of the Lower Paraná River and the La Plata River in Argentina has destroyed riparian habitats.

Reservoir cascades built on internationally shared rivers and their tributaries, such as the Paraná River (Argentina, Brazil and Paraguay), have altered the habitats and interrupted system continuity, affecting community structure and the population dynamics of migratory species of biological and commercial value. Their impact is important at international and sub-national level.

Accidentally introduced alien species of Asiatic origin, such as Golden mussel (*Limnoperna fortunei)* and Asian clam (*Corbicula fluminea)*, have spread in a great part of La Plata Basin with evidence of substitution and displacement of native benthic species in the Pantanal, inner and medium La Plata River, Paraná, Paranapanema, Iguazú and Uruguay rivers. The great area that these species have invaded (in Argentina, Brazil, Paraguay and Uruguay) has resulted in severe impact with transboundary consequences.

It is evident that there is an increasing abundance of carp in the inner La Plata River, Paraná and Uruguay rivers. Wide distribution of alien tilapia is well known in reservoirs and lakes in the sub-tropical areas of the Basin. As a consequence, the ecosystems exhibit species exclusion and changes in the food web.

There are also habitat modifications due to heavy pollution, such as in the Tietê and Riachuelo rivers with sub-national transboundary impact in Brazil and Argentina respectively.

There is no indication of direct impact on human health as a result of habitat losses, even with the creation of lentic littoral ecotones (as a result of reservoir water impoundments, areas with a tendency to harbour tropical diseases, like schistosomiasis, yellow fever, etc. are increased).

Consequently, habitat and community modification in the La Plata River Basin is moderate, although there are frequent cases of severe local impact.

Environmental impacts

Loss of ecosystems and ecotones

Although quantitative indicators reflecting the degree of transformation have not yet been published, it is possible to state, based on the compilation of graphic and written data[2], that over 35% of the total length of the Paraná River, about 2 570 km, has been altered by the creation of large reservoirs, such as the Ilha Solteira, Jupia and Porto Primavera (Brazil), Itaipú (Brazil-Paraguay) and Yacyretá (Argentina-Paraguay). Likewise, the riparian zones have been transformed into urban settlements built along the riverbanks, mainly in the urban and industrial belt of the Lower Paraná River in Argentina. For example, Rosario, Zárate and Campana each occupy stretches of the River more than 100 km long[3].

In addition, a large number of reservoirs have been built on the tributaries of the Paraná River in Brazilian territory. A considerable proportion of the lotic environments have been transformed into lentic and semi-lentic habitats. Along the Uruguay River about 10% of the lotic environments have been transformed, while in the Tietê, Iguazú, Grande and Paranapanema rivers, 36%, 46%, 48% and 64% have been transformed respectively[2]. Also, the expansion of large metropolitan regions of São Paulo and Curitiba has resulted in substantial losses of natural riparian ecosystems in the Tietê and Iguazú systems respectively.

The fauna of reservoirs is poorer than the fauna of the rivers due to the decrease in flow velocity and the formation of a great pelagic area.

[1]A lentic system is a non-flowing or standing body of freshwater, such as a lake, swamp, marsh or pond and a lotic system is a flowing body of freshwater, such as a river or stream (National Weather Service 1997). [2]IARH, based on data of original river lengths from ANEEL 2000 and 2001, SSRH 2002 and Castellanos 1975 and data of modified river lengths by reservoir building calculated on GIS (information provided by ANEEL 2000 and CIAT 1998). [3]IARH, based on data of original river lengths from SSRH 2002 and Castellanos 1975 and data of urban coast calculated on GIS (information provided by CIAT 1998).

Figure 18 Itaipú dam, Paraná River.
(Photo: Stillpicture)

For example, in the Itaipú Reservoir, several studies have described the changes in the fauna after the river closure. Prior to the construction of the reservoir (1978-1981), there were 113 species of fish upstream of Saltos de Guayra while only 83 species were found after the construction of the reservoir (Agostinho et al. 1994).

The creation of a reservoir transforms fluvial riparian ecosystems into lake type ecosystems, notably increasing their longitudinal development, as well as changing terrestrial ecosystems into aquatic ones. The sum of reservoir areas by sub-basin[4] is a proxy indicator of the latter which, in the case of reservoirs on the Paraná River, amounts to about 6 800 km^2. The total area of the main reservoirs in the Paraná system, including major tributaries, is over 16 000 km^2, which amounts to about 1% of its basin (Figure 18). The Salto Grande Reservoir (Argentina and Uruguay) has modified almost 8% of the length of the Uruguay River, including a development situated on the shoreline that occupies over 500 km^2.

In the Iguazú River, mainly in its middle zone, several reservoirs devoted to hydropower generation have been built changing the physical, chemical and biological features of the River. The cascade of reservoirs has transformed about 36% of lotic environments into lentic and semi-lentic habitats, and over 40% with Salto Caxias in operation (Agostinho & Gomes 1997). Before the Segredo Reservoir started to operate, rooted aquatic plants characterised the aquatic vegetation of this reach of the Iguazú River, while floating plants were extremely rare. Today, in a lentic environment, aquatic macrophytes and floating plants dominate. In addition, there have been changes in the trophic web among aquatic fauna. Such changes might have important consequences for biodiversity, not only because there are fewer species in the Iguazú River but also because of their high endemism. However, the fish community was already affected by Foz do Areira Reservoir, located upstream (Agostinho & Gomes 1997).

Another interesting indicator of transformation is the increase in average annual residence time in the various water sub-systems. Table 24 illustrates the situation before and after the construction of the reservoirs, revealing significant transformations imposed on the natural fluvial environment.

In the Salado River Basin, province of Buenos Aires, negative impact on the ecosystems has resulted from the construction of drainage canals, especially in the Samborombón Bay, which is a Ramsar Site. In 1997, Channel 15 was made deeper and wider and, as it takes all the water from the Salado River except during floods, some downstream reaches have become lentic as a consequence of such interruption (Miretzki et al. 2002).

[4]IARH, based on data of original reservoirs areas from SSRH 2002, ANEEL 2000 and data calculated on GIS (information provided by CIAT 1998).

Table 24 Mean annual residence time of water in river sub-systems of La Plata River Basin.

River sub-system	Residence time (days)	
	Natural[1]	Reservoir[2]
Grande	15	695
Paranaiba	14	627
Tietê	12	593
Paranapanema	8	907
Iguazú	15	355
Paraná	30	159

Notes: [1]Reference values assuming a mean velocity of 1 m/s. [2]Calculated on the basis of reservoir maximum total volume and mean annual discharges. (Source: Values specially calculated by IARH for the GIWA Project. Based on ANEEL 1999 and 2001, SSRH 2002)

Modification of habitats or communities

The main human impact comes from overexploitation of fish, pollution and eutrophication, as well as the building and operation of reservoirs. Fish mortality resulting from agro-chemical discharge, organic discharge, hydrocarbon pollution, and gas oversaturation due to dam operations has influenced structural and community dynamics (DRIyA 2002). The death of around 120 000 fish, mainly demersal species, due to gas oversaturated water (bubble illness) as a result of the floodgate operation of Yacyretá Reservoir has caused ecological damage to the trophic web (Jacobo et al. 1994).

Habitat modification, mainly due to reservoir building, has a direct impact on the aquatic wildlife and biodiversity (Agostinho et al. 1997). Of the 10 most frequently occurring species in the Itaipú River before the construction of the dam, only the "Corvine" (*Plagioscion squamosissimus*, an alien species imported from the Paranaíba River) remained after the River was closed (Figure 19). During the first stages of the river closure and impoundment, there was high production of plankton, other invertebrates and small fish, with a significant increase in abundance of the fauna that preyed on these food sources (Canevari et al. 1999). "Curimbata" (*Prochilodus scrofa*), the dominant fish prior to the construction and of high commercial value, suffered a reduction of around 25% after damming. The abundance of Piranhas (*Serrasalmus marginatus*) increased significantly in the upper reaches of the reservoir farthest from the dam.

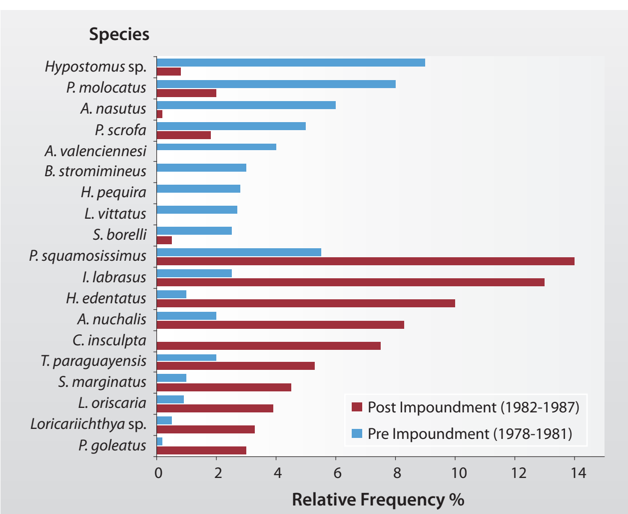

Figure 19 Relative frequency of species in Itaipú River.
(Source: Agostinho et al. 1994)

Analysis of fish communities with similar food habits revealed that detrivorous fish were more abundant before the impoundment amounting to 57% of the catch and that, in the following six years, this figure decreased to between 8.6% and 19.7%. Insectivores have proliferated in the reservoir area and, together with piscivorous species, they are the predominant group in the community. The number of carnivorous species remained stable, but changes in their specific composition have been observed (Agostinho et al. 1997).

Reservoir developments have reduced spawning and reproduction areas. For example, in the Itupararanga Reservoir in the Sorocaba River (tributary of the Tietê River), fish biodiversity may have diminished due to the decrease and species, such as *Apareiodon cf. piracicabae*, "Sábalo" (*Prochilodus lineatus*) and "Tabarana" (*Salminus hilarii*) which are present in unaffected reaches, may have become extinct in the reservoir (Smith & Petrere 2001).

The ichthyofauna has been largely affected by the construction of large reservoirs in the Upper Paraná River and its tributaries. Due to lack of fish ladders aiding the passage of migratory species, vital functions,

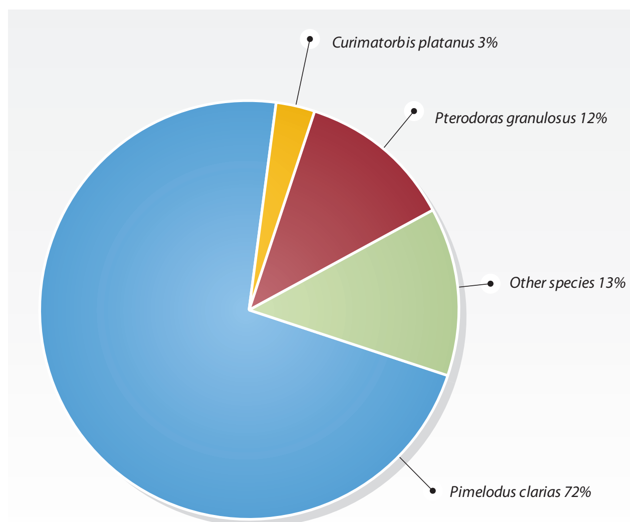

Figure 20 Percentage of species transferred in Yacyretá Reservoir (Argentina-Paraguay).
(Source: Baigún & Oldani 2001)

such as reproduction, or spawning that occurred in upstream reaches of the rivers, were retarded. Furthermore, where fish ladders have been constructed, they have not functioned properly or have not been able to mitigate the negative impacts of the reservoir development on the environment (Canevari et al. 1998). The fish ladders built in Yacyretá (Figure 20), have not facilitated the migration of important species that constitute the basis of regional fisheries (Baigún & Oldani 2001). Instead, they have really only helped the transfer of small species, such as Yellow catfish (*Pimelodus clarias*) and "Armados" (*Pterodoras granulosus*), that are ubiquitous and have little importance to fishing. Among the important migratory species, Sábalo was the most abundant in the fish ladders but only represented 2.5% of all fish migrating through the transfer facilities. However, experimental examination of the fish community downstream of the reservoir revealed that Sábalo comprised 30% of the community. This suggests that fish reach the bottom of the dam but do not enter the fish ladders. The efficiency of transfer mechanisms of the dam is too low; only 1.9% of the total migratory species reach the reservoir and the efficiency is as low as 0.6% taking into account only the most valuables species (Fundación Proteger 2001). Similar impact on migratory species has been found in the Salto Grande Reservoir in the Uruguay River (Canevari et al. 1998).

In addition, the regulation of stream flow by the reservoir has affected species that use downstream floodplains for spawning. The most affected species was the Sábalo with a reduction of about 50% of the stock in the Upper Paraná River (Agostinho & Gomes 2002).

Impact has also been recorded in the community structure and dynamics due to pollution from point and diffuse sources. In the Lower Uruguay River, pollution concentrations above the Uruguay River Administrating Committee aquatic living standards have been found.

In the Upper Pilcomayo River so-called "tailings" or toxic mud from mining activity in the Potosí department have negatively impacted several tributaries. There is a high concentration of heavy metals in water and sediments and a sharp decrease has been observed in the benthic fauna, as well as fish extinction in some reaches where water cannot be used even for irrigation (Medina Hoyos 1996).

In the La Plata River, the major source of pollution is the urban belt from Riachuelo (Figure 21) to Berazategui because of its high industrial and population concentration. Persistent organics pollutants (POPs) are widely spread and concentrated mainly in sediments and bioaccumulated in detritivorous organisms such as Sábalo. Organo-chlorate agro-chemicals as well as PCBs are accumulated in the fat tissue of fish (Canevari et al. 1998).

The introduction of alien species, such as carp (*Cyprinus carpio*), negatively affects the community structure and dynamics at higher trophic levels. As a consequence, the ecosystems exhibit species exclusion and changes in the food web (DRIyA 2002).

In lower trophic levels, Asian molluscs have been introduced by international shipping. Among them, Asian clam (*Corbicula fluminea and C. largillerti*) and the mytilidae *Limnoperna fortunei* have spread widely in the La Plata River, Lower and Middle Paraná River and Uruguay River causing significant ecological impacts. Autochthonous benthic species have disappeared as a result of these invasive molluscs (Canevari et al. 1998). In addition, the introduction of these molluscs has modified the food web mainly for ox-eyed cackerel, catfish and atherine, all of them economically important species (CARU 2002). Also, because these molluscs are filter feeders they can increase the clarity of the water by as much as 200 times and, as a consequence, the ecosystem can be dramatically modified.

Limnoperna fortunei, which was presumably introduced via shipping traffic between Hong Kong and Argentina, maintains large populations in estuarine habitats. This mollusc species has spread from La Plata River where it has established a stable population as dense as 80 000 per m^2 in littoral areas of the River (Dress 1996) reaching up to the Yacyretá Reservoir. It has also reached Brazilian waters and occurs in the Itaipú Reservoir (Paraná River), the Salto Osorio and Salto Santiago (Iguazú River), Mato Grosso (Pantanal), the Paranapanema River and the water supply in Foz do Iguazú City.

Serious ecosystem impact due to accidental spills has already been reported under Pollution. In Magdalena town, province of Buenos Aires, spills of raw oil has affected mainly the riparian ecosystem. Although the impact on the fish community is low, invertebrate, amphibian, mammal and bird habitats have been seriously affected.

Figure 21 Riachuelo River in Buenos Aires (Argentina).
(Photo: Strategic Planning Website for Buenos Aires)

According to an assessment carried out by a United Nations specialist, the restoration of the damaged ecosystem will take at least 10 years (Morton 1999). In 1996, at Porco in the Upper Pilcomayo River, a dam containing mine tailings broke causing a widespread impacts on the ecosystem due to high concentrations of heavy metals (Preston 1998).

Finally, selective fishing practices in local areas in the La Plata Basin may cause changes in the community structure and dynamics, since the most valuable sport and commercial species are the main target. There are many indications of overexploitation of different species in the Paraná, Paraguay, Upper Pilcomayo and Middle and Lower Paraná rivers. Such overexploitation by fisheries is strongly linked to the Unsustainable exploitation of fish and other living resources in the La Plata River Basin.

Socio-economic impacts

Economic impacts

Considering the present economic situation, the economic impact of habitat destruction and modification is moderate. It becomes evident mainly in relation to decrease in fishing and the decline of commercially important species in communities dependent on them for food or trade. Consequently, there is a greater impact on regional economies and fishing, sporting and tourism activities. For example, in the Itaipú Reservoir, the fishing effort has increased and is now above the optimal recommended rate, while the Catch per Effort Unit (CPUE) has been decreasing (FUEM et al. 1999, Okada 2001).

The cost of controlling invasive species, habitat restoration, loss of educational and scientific values and fundamentally, generational inequity, should be added. The invasion of *Limnoperna fortunei* causes significant socio-economic impact due to the obstruction of filters in water supply pipes, acceleration of corrosive processes in all metallic components of ships, tanks, etc. In the Itaipú Dam alone, losses of nearly 1 million USD per day occur due to operational standstills for cleaning purposes, with consequent lack of hydropower generation (Agencia Brasil 2003).

Other social and community impacts

A number of communities, riparian or directly related to water systems that depend on the characteristics, goods and services provided by the ecosystems and shoreline ecotones, have been affected. Many of these communities carry out crafts of great social, economic and cultural significance at local level. The decrease in fish stocks due to overexploitation could have serious impact on communities that depend on this resource. Experts believe that if Sábalo resources decrease, between 300 000 and 500 000 people who rely on subsistence fishing would move to the cities, resulting in impoverishment (Dario El Litoral 2002).

In the Middle Iguazú River, due to the modification of the ecosystem by reservoir building, the riparian fishing communities had to change their fishing practices. The adaptation to such new fishing practices is considered to be an important social impact resulting from the reservoir building (Agostinho & Gomes 1997). The lack of conservation and the systematic destruction of the ecosystem may damage traditional ways of life which, in many cases, are merely of subsistence character. These changes in traditional ways of living generate economic as well as cultural losses, inducing migration.

Conclusions and future outlook

The present impact of environmental issues related to habitat and community modification is severe. The loss of ecosystems or ecotones is serious as it transforms fluvial lotic systems into lentic or semi-lentic ecosystems in a large number of reservoirs in the main reaches and its tributaries.

Although dam construction and reservoir development is expected to decrease in the next decades, the loss and modification of ecosystems already caused by existing dams and reservoirs will not change. Nevertheless, in the future, the dam construction process will be longer and will take into consideration environmental, social and health issues. The process will be based on option assessments and multi-stakeholder participation, thus minimising impact, through the selection of less impacting options and improved mitigation measures.

Though the long-term impacts of alien species introduced either deliberately or accidentally is unknown, a social awareness about water resources to stop degradation is emerging. As regards continental habitats and ecosystems, new nature conservation areas are being created, but it is generally expected that there will be an increase in the pressure on natural resources and environment, while no restoration is taking place in areas that are already degraded. Consequently, the degradation of the environment will continue and the impacts resulting from the most likely future scenario until 2020 will remain severe.

Despite efforts and improvements carried out by the various sectors of society towards environmental protection and restoration, it is anticipated that habitat and community structures will continue to be modified and, as a result, it is expected that economic and social impacts, directly associated with ecosystem degradation will increase, but will remain moderate.

Unsustainable exploitation of fish and other living resources

The La Plata River Basin is the primary focus of the continental fishery, both from a commercial and recreational point of view. Sustainability of fisheries is at risk due to the inadequate management of aquatic resources. Building and operation of reservoirs, mainly in Brazil, is the main cause of human impact on fisheries, with transboundary consequences at multinational and sub-national level.

There are important fisheries in all Brazilian basins, and the species composition shows an important spatial and temporal heterogeneity. Species present in the rivers within the Paraná Basin are generally migratory with a great predominance of Spotted sorubim (*Pseudoplastitoma corruscans*) and "Dorado" (*Salminus maxillosus*). In the Itaipú Reservoir (Paraná River), landings are composed of around 50 species, five of which contribute 78% of the annual yield (1 600 tonnes). Fisheries in the Paraguay River are mostly commercial and sporting and include large migratory species. Between 1999 and 2002, the continental fishery in Brazil showed a moderate increase in total catch.

In the Paraná River in Argentina, some 220 species can be found, 20 of which are valuable either commercially or as food. Among them the Sábalo (*Prochilodus lineatus*) is the key species of the ecosystem due to its role in the trophic chain; 70% of the chain depends on it and it also affects other fishing resources such as "Surubí" (*Pseudoplatystoma* sp.) and Dorado. In Victoria City (Entre Ríos province), there is evidence of an alarming increase in the exploitation of Sábalo in the Lower Paraná over the past few years. The fishery in the Paraná is mainly commercial and for recreational sport. There are also subsistence fishers, but there is limited information available on their activities. There is no data confirming that fishery is at risk in the medium and lower sections of the Paraná, although the opinions of local experts differ.

Most fishing activities in the upper Paraná and Paraguay rivers are by trawling, while long lines with several fishhooks and gill nets are used in the lower Paraná and Uruguay rivers. Exploitation of stocks in these rivers have transboundary impacts as many species are migratory.

There is evidence of a decreased viability of fish stocks due to pollution at local level, but the effects are not significant at regional level. The introduction of alien species could have a detrimental effect on community structure and dynamics in the rivers of the La Plata Basin, such as species exclusion and changes in the food web, with transboundary impact.

Although the fishing sector is small, impacts on the national economy and social impacts are significant. In addition, fishing is an important subsistence activity. Human health issues are not more important than environmental issues in terms of their impact on potential conflicts at sub-national and regional level.

Overall, the impacts of Unsustainable exploitation of fish and other living resources are moderate in the La Plata River Basin.

Environmental impacts

Overexploitation

Latin-American rivers show a remarkable fish biodiversity comprising migratory species of economic importance such as Sábalo, ray-finned fish (*Leporinus*), "Patí" (*Luciopimelodus*) and Surubí. Their migratory cycles have a great influence over the trophic structure of the fish community. The Sábalo is one of the system key species since its eggs and larvae are the base of the food web (Oldani 1990).

There are indications of overexploitation of "Pacú" (*Piaractus mesopotamicus*) and "Manguruyu" (*Paulicea lüetkeni*) in the Brazilian areas of the Paraná River and Paraguay River basins (Ministério do Meio Ambiente y Programa Nacional do Meio Ambiente II 2001). Quirós (1990) suggests that the decrease of Pacú in the lower sector of the Paraná and Uruguay rivers is due to deforestation.

In the Upper Paraná River, there has been a reduction in the catfish *Rhinelepis aspera* stock, and the catch has decreased by 70%. Overexploitation of granulated catfish (*Pterodoras granulosus*), Manguruyu and Spotted sorubim has been reported in the Itaipú Reservoir (FUEM et al. 1999). In this reservoir, fishing effort was 67.5 days in 1987, 120 days in 1993 and 106.5 days in 1998. The optimal recommended rate is 95.5 days per year (FUEM et al. 1999). Catch per Effort Unit has been decreasing; 21.7 kg per day in 1987, 15.5 kg per day in 1992 and 11.5 kg per day in 1998 (Okada 2001).

There is evidence of Sábalo exploitation in the Middle Paraná River since its capture rate is now twice or three times higher than previously. Of 200 recorded species, about 20 feed on Sábalo, its loss might therefore cause the extinction of many valuable species (Fundación Proteger 2002). In the San Javier river area, the catch is frequently comprised of fish under four years old and smaller than the legal minimum size, affecting the probability of Sábalo population recuperation (Oldani et al. 2001).

There is also evidence of a decrease in the catches of fish species downstream the Santa Fe-Paraná axis, such as catfish and Pacú.

Some local experts attribute these decreases to overexploitation, stating that the mean size of fish, such as Sábalo and Dorado, has decreased. Catches of "Armado chancho" (*Oxydoras kneri*), silverside (*Odontesthes bonariensis*), salmon (*Brycon orbignyanus*), Manguruyu and "Tres Puntos" (*Hemisorubin platyrhynchus*) have also dramatically declined, and some species have not been registered for years. These declines are attributed to a variety of factors by local experts, such as overexploitation, environmental impact of dams on migration, loss of habitat for reproduction, deforestation and pollution.

In the Upper Pilcomayo River, high inter-annual variations in the capture of valuable species have been reported. The catches of Sábalo illustrate the decline with average landings decreasing from over 1 000 tonnes per year between 1980-1989 to 400 tonnes per year between 1990-1998 and, in some years, as low as 100 tonnes per year (Smolders 2001). The Bolivian Red Book of vertebrates has classified Sábalo as a vulnerable species (Correo del Sur 2002). Although the decrease in stream flow of the Pilcomayo River in the 1990s may have affected Sábalo landings, the decreasing catch rate may also be due to overexploitation together with river receding in the Lower Pilcomayo, which has isolated upstream populations making them more vulnerable (Smolders 2001).

Finally, selective fishing practices in local areas in the La Plata Basin may produce changes in the community structure and dynamics, since the most valuable sport and commercial species like Surubí and Dorado are the main target.

Excessive by-catch and discards

In rivers of the La Plata Basin in Argentina, by-catches involve non-migratory species. In the Uruguay and Paraná Rivers by-catch by entanglement is negligible.

Lake conditions in Itaipú Reservoir have caused a depletion of large piscivores and an increased density of piranhas. This compels fishers to use gill nets, increasing both the number of species exploited and the amount of by-catch but reducing overall profitability.

Destructive fishing practices

The lack of definite policies or changes in sustainable practices has made fisheries management difficult and has generated conflicts. Some existing resources are threatened or continue to be managed inadequately (Baigún 2003). Although there a few land-based subsistence fishers that use lines with several fishhooks or nets, trawling is the most common fishing practice (Agosthino & Gomes 1997).

Commercial fishing in the Pilcomayo River, carried out by Argentinean, Bolivian and Paraguayan fishermen, particularly indigenous people, includes different practices such as traps, nets and explosives (Correo del Sur 2002).

Decreased viability of stocks through pollution and disease

There are records of fish mortality due to different causes such as agro-chemical and organic discharge, high temperatures, pollution by hydrocarbons, and gas oversaturation due to dam operations, which affect structure and community dynamics. There is evidence of decreased viability of stocks due to deforestation, pollution and disease, in the most polluted areas.

Heavy metal pollution in the Pilcomayo River poses hazards to both human and other biota. Bioaccumulation of these toxins in fish fat and muscles is a major problem. Detritivorous fish, such as Sábalo, are particularly affected and, because of its commercial importance as a primary source of income, there are economic impacts resulting from the contamination of these species. In the Upper Pilcomayo Basin, the main water quality impact associated with the presence of heavy metals from mining effluents and spills is closely related to the impact on edible fish species such as Sábalo, Long-whiskered catfish (*Pimelodus albicans*) and Tiger fish (*Hoplias malabaricus*).

In the Brazilian Pantanal, the use of mercury in mining can be detected and quantified in sediment core chronologies and biological tissues, although species at different trophic levels show dissimilar impact. Mechanisms involved in mercury magnification along food chains deserve more attention, particularly in tropical regions where the threat of chronic exposure to this neurotoxin may have the greatest implications for biodiversity (Leady & Gottgens 2001).

Persistent organic pollutants are also degrading the water quality of the southern reaches of the Uruguay River. Heavy agro-chemical use is likely, as agricultural exploitation is a major economic activity in Uruguay. Organic pollution is regarded as an important cause of decline in the population of migratory fish species in the upper and middle course of the Uruguay River, posing negative commercial impact (FAO 2003).

Impact on biological and genetic diversity

The introduction of alien species generally has a negative effect on community structure and dynamics and, as a result, ecosystems exhibit species exclusion and changes in the food web. The introduction of carp (*Cyprinus carpio*) in the entire La Plata River Basin could seriously threaten native species such as silverside, catfish and Sábalo, although its effect has not been demonstrated. Similar effects could be produced by the introduction of South American silver croaker (*Plagioscion squamosissimus*) and tilapia (*Oreochromis* sp.) in the Upper Paraná River, and sturgeon (*Ascipencer baeri*) in the Lower Uruguay River and in the Middle and Lower Paraná River (DRIyA 2002).

Two Amazon predators are captured in Itaipú Reservoir, South American silver croaker and ray-finned fish (*Cichla monoculus*), which came from upstream reservoirs. In 1997, an accidental introduction of alien species from an aquatic farm occurred in the Parapanema River due to an extraordinary flood. In addition to the many alien species spread in the River after the accident, the parasite *Laernea cyprinacea* was also introduced (Agostinho & Gomes 2002).

Socio-economic impacts

Economic impacts

Economic impact is moderate in relation to decreased catches of commercially valuable species in communities relying on fishing for food and trade.

The Sábalo fisheries have both an economic and social value in the Upper Pilcomayo Basin, mainly in Villamontes (Tarija, Bolivia), where a decrease in catch since the late 1980s (Smolders 1998), has affected the regional economy. More than 3 000 families in Villamontes (90 % of the total employment) depend on fishing income during five month of the year. Fishing of Sábalo is the only subsistence for the "matacos", indigenous of the region (Correo del Sur 2002).

In the Upper Paraná River, a closed fishing season from November 1 to January 31 has been established in order to ensure the migration of migratory species to spawning areas. Although the impact on fisheries has not yet been assessed, such prohibition produces social and economical problems due to a lack of income for many fishermen to support their families during those three months (Agostinho & Gomes 2002).

Social and community impacts

A large proportion of the population along more than 3 000 km of the Paraná River, from Mato Grosso up to the delta, relies on this water resource for their livelihood. Due to the high rate of unemployment and the hard economic situation in Argentina, many people practice subsistence fishing as a way to feed their families and obtain some income by selling fish.

Decreasing fish populations due to overexploitation could have a serious impact on the communities depending on this resource. Some experts believe that if the catch of Sábalo decreases, many people who practice subsistence fishing will move to the cities, resulting in impoverishment (Diario El Litoral 2002).

In the Upper Paraná River, during the closed season, fishers have no income to support their families. Thus, many engage in illegal activities such as car thefts and drug trafficking across the Brazil-Paraguay border (Agostinho & Gomes 2002). During this period, Argentinean Provincial governmental bodies offer a subsidy or some form of aid (e.g. food) to fishermen.

In the Middle Iguazú River the adaptation of riparian fishing communities from using fish line and fishhook to waiting nets, due to the modification caused by the construction of reservoirs, is considered an important social impact of the construction of the reservoirs (Agostinho & Gomes 1997). These changes have generated economic and cultural loss, inducing migrations.

Conclusions and future outlook

Environmental issues relating to the unsustainable exploitation of fish and other living resources are of major concern and have a moderate impact, although overexploitation in some sectors of the La Plata Basin is severe. In the future, a moderate negative change is foreseen in the development of this concern. It is thought that the exploitation of fishery resources will remain stable in areas where regulations have been instituted, but will tend to deteriorate in other areas. The unsustainable exploitation of fish is strongly linked to habitat and community modification since it is evident that it affects population and community structure.

Economic, social and community impacts of overexploitation of fish and other living resources are moderate at present. A slight increase in the severity of these impacts can be expected as a result of continued unsustainable exploitation of fish and the environmental impact associated with these practices.

Impacts to the health of the population of the sub-system are negligible because of the relative low fish consumption in the region. It is likely that the proportion of fish in the diet of people living in the basin will not increase and, as a consequence, the future impacts of overexploitation of fish and other living resources on health will remain negligible.

Differing opinions from local experts have been observed regarding overexploitation in the Argentinean Paraná River. Future research efforts in the whole basin are considered a priority. At present, it is not possible to describe the actual situation due to lack of reliable information.

Global change

In 1996, the Second Assessment Report of the IPCC concluded that the balance of evidence suggested that there was a discernible human influence on the global climate. Nevertheless, there was an array of uncertainties concerning the real magnitude of that influence on global warming and other effects of global climate change. The Third Assessment Report of the International Panel on Climate Change (IPCC 2001a) partially resolved these uncertainties, concluding that the best agreement between model simulations and observations over the last 140 years has been found when both the anthropogenic and the natural factors were combined. Simulations of the response to natural forcing alone do not explain the warming in the second half of the 20th century, but they may have contributed to the observed warming in the first half of the 20th century (IPCC 2001a).

The La Plata Basin has been permanently influenced by the climatic variability with consequent variations in river level. Fluctuations have reached extremes, which produces frequent high and low water conditions.

Even though it is still uncertain how global warming may affect frequency and intensity of extreme events, extraordinary combinations of hydrological and climatic conditions have historically produced disasters in some parts of the La Plata River Basin. To this natural variability must be added the possible impact in the Basin of global change produced by human activities. Cities and other settlements developed on the banks of the big rivers within the Basin have suffered flooding, especially in northeastern Argentina. Consequently, the economic impact is severe.

An increase in frequency and magnitude of extreme events associated with El Niño phenomena, like flooding, is expected. The La Plata River Basin is one of the most sensitive regions to El Niño signals.

There is no evidence of change in the sea level, increase in UV-B radiation or changes in the ocean function as a CO_2 source/sink.

Consequently, the impacts of climate change are moderate in the La Plata River Basin considering variations in the rainfall and stream flow patterns mainly due to El Niño phenomena.

Environmental impacts

Changes in the hydrological cycle and ocean circulation

Precipitation is the main driver of variability in water balance over space and time, and changes in precipitation have very important consequences for hydrology and water resources. Flood frequency is affected by changes in the year-to-year variability in precipitation and by changes in short-term properties. The frequency of low or drought flows are affected primarily by changes in the seasonal distribution of rainfalls and year-to-year variability, and the occurrence of prolonged droughts.

Since 1960, significant increases in annual precipitation has been recorded in the eastern and central regions of Argentina, southern Brazil and Uruguay. The greater values go as far as 50%, which indicates exceptional change (Barros 2002).

Stream flow in the La Plata Basin (especially in the Paraguay, Paraná and Uruguay rivers) showed a negative trend from 1901 to 1970, but reversed after this period. Variability over decades is also observed in discharge. Moreover, there are written reports of alternating flood and drought periods during the 16th and 18th centuries, indicating high natural variability. In sub-tropical Argentina, Paraguay and Brazil, rainfall exhibits a long-term change, with a sharp increase between 1956 and 1990, after a drier period during 1921-1955. There is a positive precipitation trend in the period 1890-1984 in the Argentinean plains. This increase in annual precipitation was accompanied by a relative increase in rainfall during spring and summer (IPCC 2001b).

Impact assessments of climate change obtained from the General Circulation Model (GCM) vary depending on the latitude and longitude considered in the La Plata Basin. There is a case study of one application of GCM approach to assess the impact of climate change in the Uruguay River Basin (Tucci & Damiani 1994). US NASA Goddard Institute for Space Sciences (GISS), US National Oceanic and Atmospheric Administration Geophysical Fluids Dynamic Laboratory (GFDL), and the United Kingdom Meteorological Office (UKMO) which simulate the percentage increase of temperature and rainfall, produced different results. The GISS scenario predicts a reduction in the maximum and annual mean stream flow of 9 to 14%, although stream flow increases in February-March. The GFDL's scenario, on the other hand, anticipates an increase of 14 to 33%, with the largest increase in October, which is consistent with warmer sea surface temperature in the tropical Pacific at a time of year when connections with the climate in southeastern South America are strongest. The UKMO's scenario predicts increases of 5 to 21%. Minimum stream flows were shown to decrease in all cases. Nevertheless, the models are still not consistent with each other, and regional precipitation is not accurately simulated for present climate conditions (Baetghen et al. 2001).

In several cities of southern and southeastern Brazil, studies of long-term trends in air temperatures, from the beginning of the 20th century, have indicated a general warming. These trends could be attributable to increase in urbanisation or systematic warming observed in the South Atlantic since the beginning of the 1950s. In southern tropical Argentina, warming is only observed during the autumn season and in the Argentinean humid plains, warming is a result of increased urbanisation (IPCC 2001b). Changes have been detected in the zonal air circulation over Paraguay, Brazil, Uruguay and northeast Argentina. In this area, the air circulation associated with the sub-tropical Atlantic anticyclone increased after 1954.

Climate variability can influence water levels in the La Plata River. Even though it is still uncertain how global warming is linked to the behaviour of the El Niño phenomenon in this region, there is evidence of increasing flow anomalies in the La Plata River Basin during the last El Niño events. The discharge of Paraná River increased its maximum monthly values between two and six times above normal values during El Niño events that occurred in 1982-1983, 1992, 1994 and 1997-1998 (Moyano 2001). During previous El Niño events (1902-1977), the Paraná river flow was between one and two times above its normal maximum monthly values. Despite the fact that the impact of the El Niño phenomenon varies in magnitude, it was suggested that the frequency has increased in the last years.

Socio-economic impacts

Economic impacts

Economic sectors affected by flooding and water table elevation in the Basin are considerable. Damage to public and private property, loss of agricultural production and long-lasting change in agricultural, fishery and forestry productivity is significant (IPCC 2001b).

Argentina has been permanently affected by extreme flood or water shortage events. There are still doubts as to whether climate change or environmental degradation is the main cause, or whether random natural processes are to blame (World Bank 2000). The frequency of extreme events is high and the rehabilitation period is over 10 years. However, 11 events have taken place since 1957, on average one every four years, causing several deaths, infrastructure and agricultural losses, as well as serious social and economic impact (Mugetti 2002). The 1982/1983 El Niño event flooded 4 million ha and caused economic losses of about 1 800 million USD (World Bank 2000).

Together with changes in land use in the upper basin, the increase in frequency of extreme events since 1970 might be related to El Niño phenomena. Table 25 shows the relationship between peak flows and affected surface and losses in Argentina (Mugetti 2002).

Table 25 Major floods in northeast Argentina. Affected surface and economic losses.

Year	**Paraná river flow at Posadas** (m^3/s)	**Affected surface** (millions of ha)	**Economic losses** (million USD)
1966	37 885	ND	751
1977	30 081	ND	265
1982-1983	50 882	4.0	1 790
1992	48 790	3.0	905
1997-1998	33 000[1]	18.5[2]	17 502

Notes: ND = No Data. [1]Subsecretaría de Recursos Hídricos. [2]Subunidad Central de Coordinación para la Emergencia. (Source: GWP 2000)

Several studies in Argentina, Uruguay and Brazil, based on general circulation models and crop models project decreased yields for several crops (maize, wheat, barley), even when the direct effect of CO_2, fertilisation and the implementation of moderate adaptation measures at farm level are considered.

In Brazil, the drier conditions in major plantation states such as Minas Gerais, Paraná and São Paulo, that are likely to result from global warming and/or reduced water vapour transportation from the Amazon forest can be expected to reduce silvicultural yields (IPCC 2001b).

Health impacts

The risk to human health increases, particularly in relation to tropical and water-related diseases. Climatic change increases the viability of certain disease vectors and the propagation of existing ones. Extremes in the hydrological cycle, such as water shortage and flooding, could increase the risk of diarrhoea. Water shortages cause diarrhoea through poor hygiene, and flooding can pollute drinking water from watershed run-off or sewage overflow.

There is good evidence that the El Niño Southern Oscillation (ENSO) cycle is associated with increased risk of certain diseases and can affect distribution, reproduction and mortality of disease vectors. Several studies have speculated that the cholera outbreak in the early 1990s was linked with the 1992-1993 El Niño event (IPCC 2001b).

Other social and community impacts

The size of the community affected is moderate to large, since the whole population in the fluvial littoral zone in the Basin is involved. The inhabitants of the large areas affected by water table increase should also be considered. The degree of severity is quite high where people have been forced to migrate, and moderate when they are subject to temporary relocations. More often, the most vulnerable segments of the society are affected by the events.

The number of people evacuated, auto-evacuated or isolated is another good indicator of the severity of the event (Mugetti 2002). Table 26 shows the number of people in each of these categories for three different events in Argentina.

Table 26 Number of people evacuated, auto-evacuated and isolated during three major floods in northeast Argentina.

Year	1982-1983	1992	1997-1998
Number of people affected	177 035	133 106	121 348

(Source: Mugetti 2002)

Conclusions and future outlook

The IPCC Report on climate change indicates that warming will accelerate as an increase of +0.6°C in the mean annual world temperature is expected during the present century (IPCC 2001a). Even if the Kyoto Protocol is signed and effectively implemented by all participating countries, the situation will worsen. According to forecasts, climate evolution in the La Plata River Basin will be negative. Although small modifications in the total annual precipitation are expected, precipitation intensities and distribution will change, and climatic variability will increase.

Considering that the environmental impact of global change is likely to increase in the near future, an increase in costs, health problems and social and community impact is expected. It is also predicted that, as a consequence of climate changes, tropical and sub-tropical disease vectors will increase expanding to areas where the population is neither prepared nor resistant to their effects. Therefore, the future impact will be severe.

It is also recommended that regional studies should be carried out to assess and predict impact due to climate variability, through a deeper knowledge of climate and hydrological factors that define flood and drought frequency in the La Plata River Basin.

South Atlantic Drainage System

Table 27 Scoring table for South Atlantic Drainage System.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter): 0 No known impacts; 1 Slight impacts; 2 Moderate impacts; 3 Severe impacts.

The arrow indicates the likely direction of future changes: ↗ Increased impact; → No changes; ↘ Decreased impact.

South Atlantic Drainage System	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1.0* ↗	2.3 ↗	0 ↗	2.3 ↗	1.5	
Modification of stream flow	1					
Pollution of existing supplies	1					
Changes in the water table	1					
Pollution	1.4* →	2.3 →	2.0 ↘	1.0 ↘	1.5	
Microbiological pollution	1					
Eutrophication	1					
Chemical	1					
Suspended solids	2					
Solid waste	1					
Thermal	0					
Radionuclide	0					
Spills	2					
Habitat and community modification	2.0* ↗	2.3 ↗	0 →	2.0 ↗	2.2	
Loss of ecosystems	2					
Modification of ecosystems	2					
Unsustainable exploitation of fish	1.8* ↗	2.2 ↗	0 →	2.2 ↗	2.0	
Overexploitation	3					
Excessive by-catch and discards	2					
Destructive fishing practices	2					
Decreased viability of stock	0					
Impact on biological and genetic diversity	1					
Global change	0.2* →	1.4 →	0 →	1.6 ↘	0.6	
Changes in hydrological cycle	1					
Sea level change	0					
Increased UV-B radiation	1					
Changes in ocean CO_2 source/sink function	1					

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

Freshwater shortage

The impacts of freshwater shortage in the South Atlantic Drainage System were assessed as moderate. Water shortages are common features in the arid and semi-arid zones within this system. However, a decrease of spring water areas has been observed in some parts of the system and there is evidence of salinity change in some coastal lagoons. The construction and operation of reservoirs in the Limay, Neuquén and Lower Chubut rivers (inter-jurisdictional rivers) have resulted in changes in the seasonal flow pattern, which have affected the drainage of irrigated land, caused water tables to rise and become contaminated with salt and impaired the use of groundwater as a rural freshwater source. At some monitoring stations there have been indications of bacteriological contamination, hydrocarbons from oil spills and pollution of groundwater from oil industry activities.

In addition, there is evidence of salinisation at regional level in irrigated areas associated with major inter-jurisdictional rivers (Chubut, Negro, Colorado) due to rising water tables resulting from low irrigation efficiency and insufficient underground drainage capacity. In other areas where water tables are replenished by springs, there are also indications of lowering in water table as a consequence of soil compaction due to sheep overgrazing and trampling in local recharge zones. Water availability in flood meadows ("mallines") is affected by human intervention. In some places, salinisation processes due to overexploitation are impairing groundwater supply.

Economic impacts are moderate mainly because of increased water treatment costs and effects on agricultural activities. There is no readily available data describing the magnitude of the impact of this concern on human health. Low population density, the intensity of agriculture and land use in the region and the deterioration of water quality have a significant social impact on rural workers who, although not numerous, are severely affected in the long-term.

Environmental impacts

Modification of stream flow

Modification of stream flow has a slight impact on the system, manifested mainly by a reduction in the surface area of wetlands and changes in annual river flows due to dam construction and operation.

The Colhue Huapi Lake within the Senguerr River Basin is located in the province of Chubut and is suffering desiccation and desertification due to both human and natural causes. The system has become endorheic, characterised by a negative water balance over the second half of the 20th century. Due to progressive reduction in size and increased salt concentration, the zooplankton diversity has noticeably diminished. Today, the surface area of the Colhué Huapi Lake is about 1/8 of its original size due to: (i) a decrease in flow of the Senguerr River resulting from declines in the amount of rainfall and melting ice in recent years; and (ii) extraction of large amounts of water mainly for irrigation, domestic water supply and the oil industry. Previously, the Colhué Huapi Lake occasionally discharged water into the Chico River but this has ceased, likely due to the continuous increase in the area of irrigated land together with withdrawal of water for domestic supply and industrial use (Malinow et al. 2001).

Irrigation practices in the Lower Senguerr Basin involves mostly extensive grassland flooding. Controlled irrigation occurs over a considerably smaller area. Such inefficient generalised irrigation practices in the Basin are usually conducted using poor infrastructure (channels, dams, small embankments), favouring the infiltration of large water volumes and causing, as in Colonia Sarmiento, the elevation of the water table and soil salinisation. Similar practices, near the town of Alto Río Senguerr, floods the steppe plains at lower elevations which, in the summer, may represent up to 78% of the mean flow of the Senguerr River (Malinow et al. 2001). These water resource practices results in much lower input into the Colhué Huapi Lake than in the past (Figure 22).

Building and operation of dams in the Limay, Neuquén and Chubut rivers has changed the seasonal pattern of drainage as well as increased evaporation from reservoirs. The first dam in the Limay River was built in 1973 and four more dams have been built since 1983.

Changes in mean discharges, as well as in maximum and minimum discharges, due to reservoir operation are shown in Figures 23 and 24. These figures illustrate the stream flow measured at Paso Córdoba gauge that lies downstream of the confluence of Limay River and Neuquén River before and after the construction of the dam (SSRH 2000). The seasonal variability and the monthly discharge during the year have both decreased with the operation of the dam. Similar changes were observed in the Colorado River at Pichi Mahuida gauge downstream of Casa de Piedra Reservoir, as well as downstream of Florentino Ameghino Reservoir, in the Chubut River.

On the other hand, building and operation of reservoirs has increased water availability, allowing new land to be irrigated in the provinces of Neuquén, Río Negro and Chubut, which has led to an important economic development and improved situation for the farmers. However, the increase in minimum discharges in the regulated rivers has caused an elevation of the water table affecting the lowest areas in the near valleys. Elevated water

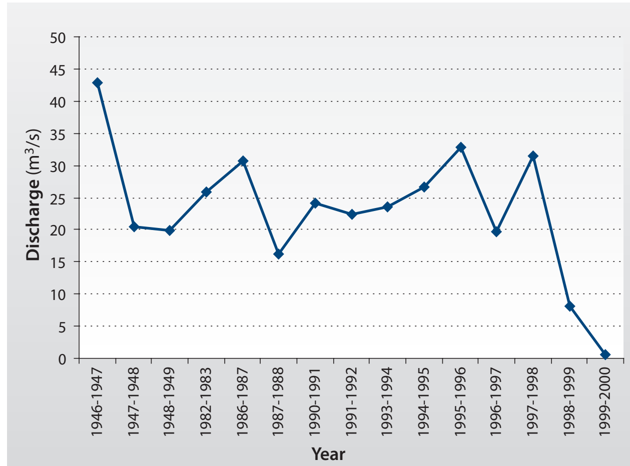

Figure 22 Annual discharge at Puente Camino Buen Pasto gauging site. Senguerr River near Colhué Huapi Lake.
(Source: SSRH-EVARSA 2000)

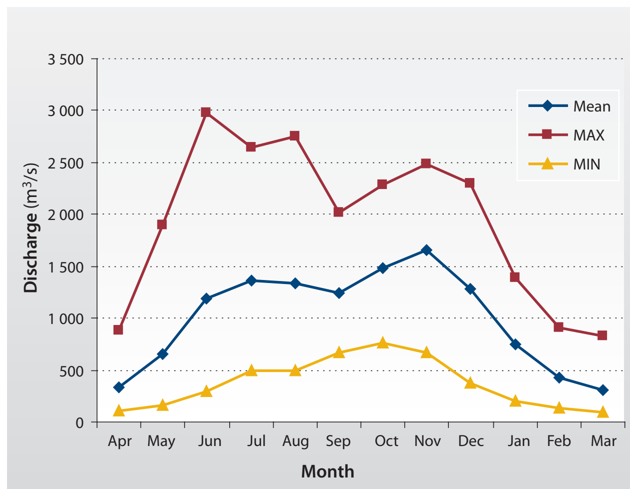

Figure 23 Discharge at Paso Cordoba gauge (province of Río Negro) before operation of Cerros Colorados System (1978).
(Source: SSRH-EVARSA 2000)

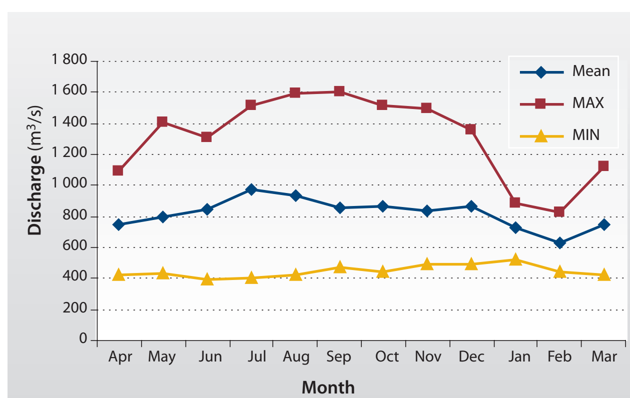

Figure 24 Discharges at Paso Cordoba gauge (province of Río Negro) after operation of Cerros Colorados System (1978).
(Source: SSRH-EVARSA 2000)

tables affect the root zone of irrigated crops (mainly apple and pear trees) by depleting them of oxygen. Some cases of soil salinisation due to poor drainage, capillary ascent and water evaporation has also been caused by the increase in water table.

Pollution of existing supplies

In the Colorado River between 1997 and 1999, a detailed assessment was conducted that examined the potential sources of pollution related to the main human activities in the Basin, such as urban discharge, agriculture, oil industry, mining, etc., and their impacts on water quality for different uses. The assessment took into account the aquatic environment in the Grande, Barracas and Colorado rivers, as well as Casa de Piedra Reservoir. Monitoring of polynuclear and aliphatic hydrocarbons, heavy metals and metalloids, agro-chemicals, as well as analysis of riverbed sediments, determined that water quality was not limiting water use. This conclusion was confirmed by complementary studies carried out in 2000 (COIRCO 2000).

In some zones of the Negro River Basin, water treatment for domestic water supply is made complicated by the presence of algae. Similar problems are found in Trelew City downstream of Florentino Ameghino Reservoir in the Chubut River Basin. There are also water treatment problems due to eutrophication in Paso Piedras Reservoir, the water supply for Bahía Blanca City. The reservoir is mesotrophic with recurrent algal blooms (more than 1 million cells/ml, varying from diatoms to filamentous cyanobacteria). Water treatment by disinfectants is not effective and the algae remain in the water supply generating trialomethanes (THM), unpleasant odours and taste. There are also risks of bacterial re-growth (Marquez 1991).

Some cases of impacted groundwater have been reported in the system. Río Gallegos City, located near the mouth of the Río Gallegos River, is supplied from both groundwater and surface water. The groundwater supply network has 30 wells. Some wells located near the estuary of the river are more affected by seawater and show an increasing chloride/bicarbonate ratio indicating seawater intrusion, and there is an increasing trend for such conditions (Baumann & Castillo 1999). In Mar del Plata City seawater intrusion affects the water supply.

Changes in water table

Groundwater is a very important resource in Patagonia since it is the only source of freshwater, for domestic, irrigation and animal (sheep raising) requirements in many areas. However, this important resource is affected by human activities. There is evidence of salinisation, pollution, and changes in water table, both increasing and decreasing.

In the province of Mendoza, 80 000 ha are irrigated by groundwater. In the northern oasis, including Mendoza City, salinisation, due to inefficient irrigation practices, and pollution, due to agro-chemical, industrial and domestic discharge, affected the first layer of the aquifer in the 1970s. The second layer of the aquifer with better water quality was then exploited, but some problems during well construction allowed infiltration from the upper polluted layer, and the wells were abandoned. Today, a third deeper layer of the aquifer is being exploited (DGI 1999).

Inefficient irrigation practices, together with lack of drainage infrastructure and poor soil drainage capacity, have resulted in elevated water tables and started a salinisation process. Such salt accumulation changes the structure and chemical properties of the soil and, as a consequence, affects the normal growth of crops. Affected areas include the lower irrigated valleys of the Colorado, Negro and Chubut rivers.

There is also evidence of lowered water tables in many areas due to overgrazing and changes in physical and chemical properties of the soil, affecting water dynamics in the soil.

Flood meadows or "mallines" are wetlands in arid regions developing in areas where there is water available for extended periods of the year. The deterioration of mallines is basically related to human activities. Quantity and quality of vegetation is decreasing due to overgrazing and increasing run-off towards the central channel of the mallines. Flow increases create a riverbed channel, operating as drainage of the mallín by lowering the water table (Figure 25). In addition, increased salt concentrations have also contributed to the deterioration of the mallines, particularly in eastern Patagonia and the coastal zones (Horne 1999).

Although the groundwater used for domestic water supply in the region is not widely affected, some local areas are affected by pollution from oil industry and overexploitation. In Río Gallegos City, located in the southern part of the province of Santa Cruz, groundwater is a very important source of water supply that has changed its quality since 1982. Overexploitation might have caused seawater intrusion changing water chemistry from bicarbonate type to chloride type indicating declines in water quality (Baumann & Castillo 1999).

Socio-economic impacts

Economic impacts

Despite large and obvious benefits, the regulation of stream flows has resulted in elevated water tables and, as a consequence, increases in the salinity of groundwater. This is due to more frequent and longer periods

Figure 25 Main gully downstream the Aguada del Sapo mallín. *(Photo: Horne 1999)*

of low water levels which determine regional drainage and also the construction of the Cerros Colorados dam. The dam acts as sediment trap reducing the quantity of sediment transported downstream. Prior to the construction of the dam, sediment transported by the river was deposited naturally along irrigation channels forming a barrier that retarded seepage of water into the ground and water table adjacent to irrigation channels. Without the natural deposition of sediment, the water has eroded the beds and banks of irrigation channels allowing water to seep into the surrounding ground elevating water tables. In addition, the lower turbidity of water downstream from the dam allows greater light penetration and, as a consequence, enabled algae to proliferate in the irrigation channels. These problems have generated losses in agricultural land use. A large part of the economic sector is affected in terms of productive capacity. Recent studies on the effects of clear water in the High Valley of the Negro River irrigation system estimated economic losses at about 225 million USD due to the absence of sediments in the last 21 years (Landricini et al. 2000).

Since agriculture is responsible of about 75% of all freshwater withdrawal for human use in Argentina, its development has enormous influence on the use of water resources. In developing countries, irrigation is expected to increase by 14% by 2030 (FAO 2002).

The cost of water supply treatment has slightly increased in some local areas related to eutrophication of water sources.

Other social and community impacts

Potential conflicts among sectors (agriculture, industry and urban water supply) may arise relating to diminishing water availability to meet different user requirements, and increasing water treatment costs.

Conclusions and future outlook

Modification of stream flows in the South Atlantic Drainage System are mainly explained by a moderate decrease of spring water observed in some zones, as well as building and operation of dams that have changed the stream flow pattern in some rivers.

Biological pollution, due to sewage effluents, and hydrocarbons, due to oil spills, are the main sources of pollution of water supplies in the system. Eutrophication is low but affects almost all the reservoirs to some extent. Both pollution and eutrophication impact on freshwater supplies.

Regarding changes in the water table, there is some evidence of salinisation in the irrigated areas and indications of lowering of water table, associated with springs in the local recharge zones. In some local places, salinisation resulting from overexploitation has degraded the quality of groundwater. However, there is no information on groundwater salinisation or lowering in water table due to overexploitation at regional level. Therefore, it is recommended that studies are conducted at a regional level to generate baseline information describing the extent and impacts of these factors.

It is anticipated that there will be a slight worsening of the present situation concerning freshwater shortage, mainly caused by further pressure on the flood meadows ("mallines"). A productive expansion of these fragile ecosystems is expected. Finally, it is assumed that some progress will be achieved in relation to the environmental regulatory framework.

Considering the predicted slight increases in freshwater shortage during the next decades, it becomes apparent that economic costs associated with increased water treatment and the restoration and replacement of supply sources will increase similarly. However, a more serious increase in health problems is expected due to lack of safe water. Social and community impact will likely also become more severe.

IMPACT Pollution

The intensive use of pesticides and fertilisers in extensive areas in the South Atlantic Drainage System has impacted on water bodies such as the Nahuel Huapi Lake (shared by the provinces of Neuquén and Río Negro) and the Pellegrini Lake, causing eutrophication of some localised areas with restricted water circulation.

Surface water pollution by oil spills has a transboundary impact at sub-national level. There is also impact on groundwater due to secondary oil recovery in the province of Santa Cruz, and impact on other sectors along the Atlantic coast, where some species have become contaminated or poisoned due to frequent oil spills. There is also evidence of some toxic spills during the transportation of high-risk material.

Discharge of thermal waters has been observed without significant impact, and there is no evidence of radionuclide impact in the South Atlantic Drainage System.

Moderate economic impacts are caused by pollution in the South Atlantic Drainage System mainly because of the increased costs of water treatment.

Environmental impacts

Microbiological pollution

Microbiological pollution exerts slight transboundary impacts in the South Atlantic Drainage System indicated by the concentration of faecal coliforms and total coliforms in water sources.

During the summer 2000-2001, the microbial content of the water from 36 recreational resorts was surveyed. According to the results, the water of 31 resorts was suitable for direct contact, while water at the remaining five, which are situated near the confluence of the Limay and Neuquén rivers and in the upper reaches of the Negro River (Neuquen and Rio Negro provinces), was unsuitable (Autoridad Interjurisdiccional de Cuenca de los Ríos Limay, Neuquén y Negro, 2001). The monitoring was carried out in the framework of the Programme of Bacteriological Control of River Beaches (Secretary of Environmental Management, Interjurisdictional Basin Authority of the Negro River) according to the criteria recommended by the Canadian guidelines on Water Quality. The bacteria *Escherichia coli*, was considered the main indicator.

The main sources of microbiological pollution in the South Atlantic Drainage System are industrial and urban discharges. Mar del Plata, Buenos Aires province, which is the main tourist city in Argentina, and Bahía Blanca city only pre-treat their effluent before it is subsequently discharged into the sea. Many cities of the provinces of Santa Cruz and Chubut, such as Puerto Deseado, Puerto Santa Cruz, Comandante Piedrabuena, Puerto San Julián and Puerto Madryn, have secondary treatment of wastewater before discharge to the sea. Finally, Río Gallegos and Comodoro Rivadavia cities discharge untreated effluent directly to the sea.

Fundación Patagonia Natural (FPN) has detected pathogens along the Atlantic seashore that have, in some cases, exceeded internationally recommended levels for recreational water use. In the Chubut River outlet, diatoms characteristic of eutrophic environments, such as *Aulacoseira granulata* and *Stephanodiscus* spp., and other harmful pathogens, such as *Alexandrium tamarense* and *Dinophysis acuminate*, and faecal coliforms have been found (Fundación Patagonia Natural 1999).

Eutrophication

In the Negro River Basin, the Interjurisdictional Basin Authority has conducted systematic monitoring of water quality since 1998. The presence of algae due to dam building and operation has caused problems in water treatment, since they are not removed by conventional treatment. A similar situation is found in the Chubut River, downstream of the Florentino Ameghino Reservoir, where there are problems in the purification process of water supplied to Trelew City.

According to the monitoring carried out in the Pellegrini Lake (Neuquen) during November 1996, the environment could be characterised as mesotrophic-eutrophic (Amalfi & Verniere 1995). Several records from 1995 indicate cyanobacterial blooms in the summer, with a predominance of *Microcystis aeruginosa* and *Anabaena spiroides* (Amalfi & Verniere 1995).

The Nahuel Huapi Lake (shared by the provinces of Neuquen and Río Negro) has been classified as ultra-oligotrophic because of the low concentrations of nitrogen, phosphorus, chlorophyll a, high transparency of the water and small phytoplankton biomass. However, some areas are characterised by restricted water circulation, presenting a different status with higher nutrient concentrations due to the discharge of point and non-point sources. This allows phytoplankton development, as occurred in summer 2000-2001, near the sewage treatment plant (Pedrozo et al. 1997).

The Ramos Mejia Reservoir in the area of El Chocón village (Neuquen) is characterised as mesotrophic (Labollita and Pedrozo 1997) with periodic algal blooms.

Serious problems of water treatment exist as a result of eutrophication in Paso Piedras Reservoir, which supplies Bahía Blanca city (Buenos Aires province). The Lake is mesotrophic and is characterised by frequent algal blooms (more than 1 million cells/ml, varying from diatoms to filamentous cyanobacteria) (Marquez 1991).

Along the Atlantic seashore, impact from eutrophication has been found in the Nuevo Gulf, since the secondary biological treatment of effluent (aerated lagoons) from Puerto Madryn City is overloaded, inefficient and does not remove nutrients.

Toxic algal blooms together with poisonings that occur through the consumption of contaminated molluscs have serious consequences for public health, and has caused deaths in the Patagonian region where at least two groups of noxious species can be found: *Alexandrium tamarense* and *A. catenell*, *Pseudonitzschia multiseries*, *P. pseudodelicatissima* and *P. australis*, and *Dinphysis acuminata* and *Prorocentrum lima*. It is therefore necessary to implement an adequate monitoring of these groups (Fundación Patagonia Natural 1999).

Chemical pollution

Oil and agricultural exploitation affect the Colorado River. In the past, oil refining industries have discharged effluents into this system. Today, farming activities in Neuquén, Río Negro and La Pampa provinces are potential sources of agro-chemical input.

In a study on chemical pollutants carried out in 1987, it was found that copper concentrations in sediments downstream oil refining industries and at the entrance to Casa de Piedra Dam (Río Negro and La Pampa provinces, Colorado River) were clearly higher than those found at other reference stations, suggesting the influence of anthropogenic activities. The same research showed that lead and chromium concentrations in the fine sediment fraction, less than 63 µm, also exceeded guidelines for freshwater organisms. Acenaphthene was detected in 7 out of 12 sampling stations. This contaminant was the only aromatic hydrocarbon that exceeded guidelines for freshwater organisms (CCREM 1987).

This study also found that mercury and selenium concentrations in fish muscle exceeded the National Service of Agro-food Health and Quality (SENASA) (Servicio Nacional de Sanidad y Calidad Agroalimentaria) edible food guidelines for human consumption in all fish species at all sampling stations. The highest mercury concentration in fish tissue was reported in silverside (*Odonthesis argentinensis*) at Desfiladero Bayo, while the highest selenium fish tissue concentration was recorded in *Perca fluviatilis* at Rio Barrancas (CCREM 1987).

Despite long-term exposure to oil and agricultural exploitation, the Colorado River system is suitable for supplying drinking water, and has no restrictions for human fish consumption or serious risks for aquatic biota (Alcade et al. 1999). Nevertheless, further studies are needed, especially to detect metal residues in fish. Sampling has not been sufficient to assess human consumption recommendations (Alcade et al. 1999).

The Patagonian coastal zone experiences slight to moderate pollution of toxic chemicals. Petrogenic hydrocarbons in sediments have reportedly the highest concentrations in oil shipping locations (Caleta Córdova, Comodoro Rivadavia and Caleta Olivia), where discharges of oil effluents and tanker ballast washing is carried out. This is especially important at Caleta Córdova where hydrocarbon concentrations are increasing. Winds and marine currents are potential transport agents of such persistent pollutants (a situation already reported in Faro Aristazábal) posing environmental risks to vulnerable coasts with great ecological sensitivity.

High concentrations of heavy metals in sediments (lead, zinc and copper) have been registered in San Antonio Bay and in San Matías Gulf. These were the only coastal areas where cadmium was found, affecting local flora and fauna, and threatening migratory species such as the birds *Calidris melanotos* and *Charadrius wilsonia*, which cross this zone during seasonal migration. High cadmium concentrations were detected in the kidney and liver of the Commerson's dolphin (*Cephalorhynchus commersonii*) and the Dusky dolphin (*Lagenorhynchus obscurus*), and in kidneys of the Kelp gull (*Larus dominicanus*). The only halogenated persistent pollutant detected in biota was pp'-DDE, which was found in the Magellanic penguin (*Spheniscus magellanicus*) and the Kelp gull, although recent studies have found significant quantities of halogenated residues in dead new-born cubs of the Sea lion (*Otaria flavescens*) suggesting that these residues are transmitted from the parent (Fundación Patagonia Natural 1999).

Suspended solids

Mining activities have caused a sharp increase in turbidity in various streams, reservoirs and marine water bodies and has altered the natural vegetation cover of extensive sedimentary areas devoted to sheep raising in southern Patagonia.

In the province of Santa Cruz, the Río Turbio mining industry discharges large quantities of solids generated by mineral carbon treatment which flush into the Gallegos River. Carbon waste at the banks of the San José and Turbio Rivers is carried by pluvial and eolic erosion and discharged into the River. The concentration of suspended solids upstream of the mining complex is 0.05 g/l reaching as high as 15.5 g/l downstream of the mine. The amount of suspended solids in the water affects aquatic life as well as its suitability for human use (Brea & Loschacoff 2000).

Wind and water erosion are additional sources of sediment. About 30% of Patagonia is suffering desertification caused primarily by overgrazing by sheep and cattle. Intensive sheep raising with high animal densities started at the beginning of the 20^{th} century which, together with the hard climate features of the region, accelerated the degradation process (SAyDS 2003). Reduction in vegetation coverage has increased run-off and soil losses and, in many cases, has affected the water bodies.

On the other hand, a decrease of suspended solids can also affect water resources and cause economic impacts. In the Negro River, there has been a considerable decrease of suspended solids after the building and operation of the Cerros Colorados System in 1978. Before the reservoir was constructed, suspended sediments, mainly clay and mud, coated irrigation channels reducing the infiltration rate and subsequent water loss. Sedimentation in the channels was 2.3 cm per year and sediment accumulation for about 50 years in the irrigated field represented almost 3% of the soil. After the dam was completed, sediments were retained in the reservoir, and the clear water discharged in the irrigation channels increased water infiltration and caused algal growth due to decreased turbidity. Such higher infiltration, which represents about 68 to 74% of the channel inflow, has raised the water table, affecting up to 66% of irrigated land (Landricini et al. 2000).

Solid waste

The analysis of information related to the contamination of water resources by solid waste indicates a negligible impact on surface water. Nevertheless, along the Patagonian Atlantic coast interference of solid waste with fishing activities has been observed.

There are some environmental impacts in the coastal area of the South Atlantic Drainage System due to solid waste disposal practices, mainly in urban areas close to the coast, where it is common to dispose solid waste in open dump sites. Some landfills located in harbour areas also receive large quantities of fishing waste, which produce offensive odours, water pollution and negative effects on the coastal landscape, tourism and recreation activities.

Regarding the Negro River, the dumping of solid waste in open sites, riverbanks and lakes generates an environmental and human health impact, mainly due to non-biodegradable waste.

Spills

Spills are closely related to chemical pollution in the South Atlantic Drainage System, both according to the nature of the pollution source, the presence of treatment facilities and the frequency of events.

In the Upper Colorado River Basin (Mendoza and Neuquén provinces), significant oil drilling activities are performed (40% of the Argentine oil production comes from this basin) and have been the cause of intermittent oil spills for quite some time. Accidental spill events since 1995, linked to oil drilling, have seriously affected the water quality of this course. One of the most serious accidents happened in early 1997 when an oil spill of 100-300 m^3 of petroleum polluted the River. The impact generated by the spill caused the closure of drinking water supply to nearby towns (more than 10 000 inhabitants were affected) and the interrupted of irrigation supply to an area of 5 000 ha. A 10 km coastal stretch was also affected (La Cuenca negra del Colorado 1997, Daniele & Natenzon 1997). Records of relevant oil spills go back to January 1992, when an oil spill (a 30 ha oil plume) from a fracture in a YPF (Yacimientos Petrolíferos Fiscales) oil pipeline at Rincón de los Sauces, affected irrigation water intakes and caused the closure of drinking water supply to Catriel and 25 de Mayo cities. In February 2002, another oil spill occurred due to overflow of two oil ponds containing chemicals, generating an avalanche of mud contaminated with hydrocarbons that entered into the Colorado River.

The Inter-jurisdictional Committee of the Colorado River Basin (COIRCO) (Comité Interjurisdiccional del Río Colorado), together with the Argentine Energy and Mining Secretary and the Oil Enterprises Group, performed a water quality survey (1997-1999) recording the concentration of PAHs (polycyclic aromatic hydrocarbons) in water, sediments and biota, particularly fish, and performing ecotoxicological bioassays (zooplankton, benthos) (COIRCO 2001). The data showed naphthalene concentrations in sediment at Casa de Piedra intakes exceeding international reference standards, and accepted conditions in the remaining sampling locations. Chronic toxicity to the amphipod *Hyalella curvispina* was found at Puesto Hernández, in the oil drilling area. PAHs were detected in the muscle tissue of various species of fish (*Odontesthes bonaerensis*, *Oncorhynchus mykiss*, *Percichthys colhuapiensis*, *Percichthys altispinnis*, *Cyprinus carpio* and *Diplomystes viedmensis*) at standard levels in the ng/g order of magnitude at two sampling sites (Desfiladero Bayo in the Colorado River and Casa de Piedra Reservoir). The obtained values indicated that it was not necessary to apply restrictions to human consumption based on the US Environmental Protection Agency risk assessment (COIRCO 2001).

On the Patagonian maritime coast, impact due to accidental spills or daily activities in coastal ports, has been observed. The most relevant accident occurred in September 1995, when approximately 30 tonnes of diesel oil were spilt, affecting 10 km of beach in the surroundings of Puerto Deseado (Santa Cruz province). Another oil spill occurred in 1991, when unidentified hydrocarbon (crude oil or fuel oil) was spilt near Valdés Peninsula (Chubut province). Due to this oil spill, approximately 1 100 penguins were covered with oil and died from hypothermia and poisoning (DRIyA 2001).

In case of pollution due to harbour activity, beaches remain affected by the presence of tar balls and birds become covered in oil. The incidents are related to operative problems in the ports and the washing of hulls and tanks (DRIyA 2001).

Socio-economic impacts

Economic impacts

Economic impacts derived from pollution in the South Atlantic Drainage System are mainly related to increased water treatment costs. Algal blooms in reservoirs and oil spills demand major economic investment for contingency measures and water treatment.

Paso Piedras Reservoir, which supplies water to Bahia Blanca, Paso Alto and other cities in the province of Buenos Aires, suffers severe eutrophication. The main problem in the reservoir is the occurrence of algal blooms during autumn and summer (Marquez 1991). Water treatment is not effective and the algae remain in water used for human consumption posing risks of bacterial re-growth and generation of THM.

In the upper basin of the Colorado River there are problems in water supply due to recurrent oil spills. These spills have especially affected irrigated agriculture in the area near Catriel (province of Rio Negro) and 25 de Mayo (province of La Pampa) cities. In an area of approximately 48 000 ha, cultivated with vegetables, alfalfa and fruits, 30% was affected by the interruption of irrigation water supply causing considerable economic losses. Spills also affected Rincón de los Sauces, a small town in the province of Neuquén. In this case, local authorities interrupted water distribution and private oil companies assumed the cost of the emergency by distributing thousands of litres of mineral water for human consumption (Daniele & Natenzon 1997).

In the oceanic component of the South Atlantic Drainage System, negative economic impact has been reported by the private sector devoted to exploitation and seafood production, since harvest and commercialisation has been prohibited due to toxic algal blooms.

Health impacts

Access to drinking water and sanitation systems are a fairly accurate indication of sanitary conditions in relation to pollution in the South Atlantic Drainage System. According to data from the 1990s, the total population supplied with drinking water was 61.2%, whereas only 31.8% of the population was connected to sewage networks (INDEC 1991). Although the census carried out in 2001 by INDEC did not specifically record the proportion of the total population supplied with drinking water and serviced by sewage networks, the proportion of the urban population with access to drinking water has increased to 79.9%, while 51.6% is connected to sewage networks (ENOHSA 2002).

Due to eutrophication and oil spills, the incidents described under economic impact also present aspects linked to human health. Since 1977, episodes of algal blooms have been commonplace in the Paso Piedras Reservoir. In the summer-autumn of 2000, a significant incident took place resulting from an *Anabaena spiroides* bloom. Between April and May, the crisis reached its maximum. The Health Department of the province of Buenos Aires deemed the water not suitable for drinking and recommended a complete suspension of the water supply (Mancini & Santoro 2000). There was long-term risk for human health due to the appearance of trihalomethanes (THMs), formed by the combination of the algae with chlorine utilised in the water treatment.

Another example of serious impact and risk to human health is the 300 000 tonnes oil spill that occurred in March 1997, which caused the interruption of drinking water supply in Rincón de los Sauces and other cities in the province of Neuquen. Local authorities declared an epidemiological alert (La Cuenca negra del Colorado 1997) due to the possibility of disease related to polluted water, such as diarrhoea. This interruption was mainly caused by hydrocarbons in the water purifying systems, which did not guarantee sanitary conditions (Daniele & Natenzon 1997).

Other social and community impacts

Algal blooms in the Paso Piedras Reservoir have caused other impacts associated with the disagreeable smell and taste of the water. The cyanobacteria *Anabaena spiroides* caused a problem due to highly disagreeable taste and smell and greenish-blue coloration of the water and the algae *Ceratium hirundinella* caused problems to the water supply system in 1997-1999, giving a brown colour and high turbidity to the water (Mancini & Santoro 2000).

In the Upper Colorado River Basin, inhabitants and officials of towns affected by successive oil spills led protests and presented lawsuits to the provincial authorities (En Neuquén protestan por los derrames de petróleo 1997). In Rincón de los Sauces, local NGOs and representatives from the Chamber of Commerce took part in the complaint (En Neuquén protestan por los derrames de petróleo 1997). Primary producers, invoking loss in soil quality, pollution of groundwater and decreases in crop yields also led protests (La Nación 1997).

Conclusions and future outlook

Pollution is considered to have moderate overall impact in the South Atlantic Drainage System. The highest environmental impact is from spills and suspended solids. Demographic pressure in the region will continue to be low and therefore the pressure on water resources will not increase significantly.

Action from environmental NGOs and increased community awareness is likely to improve the situation and result in diminished pollution loads. Major investments in the region may be carried out by large enterprise subject to international funding, which would force them to be environmentally friendly and comply with self-regulating ISO standards. Even so, some degradation is expected.

Improvements in pollution control will require major investments by the private and public sectors. Thus, improvement in terms of environmental impact will be offset by an increase of the economic impact. Health problems and other social and community impact will likely improve as a consequence of better environmental conditions.

IMPACT Habitat and community modification

The construction of reservoirs in inter-jurisdictional rivers in the South Atlantic Drainage System to regulate flow and control floods has altered seasonal flow patterns affecting the environmental conditions for most species. This includes the transformation of fast running water courses into lentic reservoir environments with longer residence times, large impounded areas and lengthy lake shores.

Areas with large productive potential, such as flood meadows ("mallines") are seriously deteriorating. About 30% of the territory between 41° N and Magallanes Strait, is affected by intense wind and water erosion processes (SAyDS 2003).

Along the ocean environment, mainly on the coast in the province of Buenos Aires, there is evidence of fragmentation of sandy foreshores, the littoral belt system and coastal fringes as a consequence of discrete urban settlements, infrastructure works, fishing and recreational beach facilities. Erosion from human origin also modifies habitats and ecosystems.

Operation of harbours and oil shipping facilities in some areas (Puerto Madryn, Caleta Cordoba, etc.) along the coast has resulted in pollution hot spots that locally affect coastal habitats and attached aquatic communities.

The main cause of community modification is however intensive fish exploitation which, together with incidental captures, discards and fishing practices, has sharply affected aquatic community structure and population dynamics at various trophic levels.

Economic and social and community impacts are moderate. No significant links between health impact and this concern have been identified.

Environmental impacts

Losses of ecosystems and ecotones

A large number of reservoirs have been built in the South Atlantic Drainage System, mainly in the Neuquén and Limay rivers (Table 28). The construction of reservoirs transforms fluvial riparian ecosystems into lentic systems with long water residence times and changes terrestrial ecosystems into aquatic systems. Approximately 44% of lotic environments along the Limay River have been transformed into lentic and semi-lentic environments.

Other ecosystems at risk due to anthropogenic activities are the flood meadows so called "mallines". The mallines are wetlands in arid and semi-arid regions. Although they represent only 4% to 8% of the provinces of Río Negro, Neuquén, Chubut and Santa Cruz, these ecosystems are quite important for the economy since they are an important resource for sheep and cattle raising. The structure and dynamics of the mallines are highly related to water availability. Alteration of the mallines features due to overgrazing, mainly by sheep,

Table 28 Main reservoirs built in the South Atlantic Drainage System.

Reservoir	River	Province	Country	Reservoir feature	
				Surface (km^2)	Residence time (years)
Arroyito	Limay	Neuquen/Río Negro	Argentina	39	0.013
Piedra del Aguila	Limay	Neuquen/Río Negro	Argentina	292	0.56
Alicurá	Limay	Neuquen/Río Negro	Argentina	67.5	0.38
E. Ramos Mexia	Limay	Neuquen/Río Negro	Argentina	816	1.17
Florentino Ameghino	Chubut	Chubut	Argentina	74	0.82
El Chañar	Neuquen	Neuquen	Argentina	10	0.004
Loma de la Lata	Neuquen	Neuquen	Argentina	409	2.83
Portezuelo Grande	Neuquen	Neuquen	Argentina	39	0.001
Planicie Banderita	Neuquen	Neuquen	Argentina	174	1.41
Casa de Piedra	Colorado	La Pampa/Río Negro	Argentina	360	1.04

(Source: SSRH 1995)

has interrupted a delicate equilibrium causing deterioration and loss of vegetation cover (Horne 1999). Some mallines that were seeded until 1975 have been degraded by overgrazing.

Most beaches on the province of Buenos Aires coast have suffered significant erosion, increased by anthropogenic activity, which has altered the coastline and also negatively affected properties and population activities. Some of these areas (e.g. beaches and coastal dunes) are particularly vulnerable to environmental stress due to the presence of coastal wetlands and their potential for service and activity development. For example, at Mar Chiquita, the beach is receding at a rate of 5 m per year at some points (Bonamy et al. 2002).

The main alteration of the physical environment on the Patagonian coast is a consequence of mining activities, urban and coastal development (harbours and roads), and degradation due to tourism activities (DRIyA 2001).

Modification of habitats or communities

The Patagonian coast is a highly important component of the Argentine marine shelf, which has a wide variety of environments and a highly productive sea. Marine resources have been under pressure from demographic and industrial growth during the last 15 years. Although such economic development has had a positive impact on provincial livelihood, it has been developed in an uncontrolled way and without infrastructure and coordinated management. Thus, biodiversity as well as sustainable exploitation of the renewable resources are seriously endangered (Fundación Patagonia Natural 1999). As a consequence of human settlement and activities, there is a modification of the marine ecosystems by degradation, fragmentation or loss of habitats (Gray 1997). Although the detrimental impacts are known, there are no quantitative estimates of such habitat modifications.

There is growing pressure on marine resources by human activities due to overextraction and the development of aquaculture activities. There is an impact on the structure of the seashore communities, mortality of fauna, and conflicts among different uses of this resource (tourism, aquaculture and fishing).

The main threats for biodiversity and, as a consequence for communities, in Patagonian are: (i) overexploitation of natural resources, mainly fisheries; (ii) pollution; (iii) introduction of alien species; (iv) loss of habitats; and (v) activities linked to tourism (FUCEMA 1999).

Physical alteration or habitat destruction of marine ecosystems occur mainly in the shallow waters off the shore due to dredging, port building, stabilisation of the coast, fishing methods, the construction of embankments and aquaculture ponds (DRIyA 2001). Harbour activities have increased in several areas such as Puerto Deseado, Caleta Olivia, Ushuaia, Comodoro Rivadavia, Bahia Camarones and Puerto Madryn (Fundación Patagonia Natural 1999).

Urban and industrial pollution is a general problem on the Patagonian coast, since liquid wastes either are inadequately treated or not treated at all. These effluents have caused eutrophication in some areas off the shore (Fundación Patagonia Natural 1999). Chemical discharges and other elements such as sediment and solid waste pollute the sea. Commercial fishing and fish industrial waste affect bird communities, benthic organisms and human population due to high BOD discharge (DRIyA 2001).

Hydrocarbons derived from petroleum show the highest concentration in the areas of oil transport. An increasing trend has been observed in Caleta Cordova in the province of Chubut. However, negative impacts on the ecosystem affects shores beyond the harbour areas, since currents and wind carry pollutants towards other more ecologically sensitive areas, generating chronic pollution that is difficult to mitigate, such as areas of industrial algal harvest (Fundación Patagonia Natural 1999).

A critical situation due to unsustainable exploitation practices is evident for marine living resources, which are subject to intense fishing activity by Argentina and Uruguay, in the Buenos Aires Coastal Ecosystem and the Argentine-Uruguayan Common Fishing Zone. An indicator of such overexploitation is the decreasing trend of total and reproductive biomass (Pérez 2000), as well as landed catch, integrated to 50% by age-2 juveniles (Renzi et al. 1999).

There is little information about the introduction of alien species. Some accidentally introduced species are the brown alga (*Undaria pinnatifida*), Asian clam (*Corbicula fluminea*) and "Dog's teeth" (*Balanus glandula*). Other intentionally introduced species for aquaculture are Brown trout (*Salmo trutta*), Rainbow trout (*Onchorhynchus mykiss*), Chinook salmon (*O. tshawystcha*), Pacific oyster (*Crassostrea gigas*), Chilean oyster (*Tiostrea chilensis*), and beavers (DRIyA 2001).

The brown alga *Undaria pinnatifida*, originally from the Japanese coast, was accidentally introduced in Puerto Madryn in the ballast water of foreign ships and has quickly spread in the Nuevo Gulf area (Casas & Piriz 1996). Sewage discharge, oil spills and waste discharged from ships and boats have probably contributed to this brown alga remaining and developing in this area (Fundación Patagonia Natural 1999).

The Asian clam was probably introduced with ballast water in the Paraná-Uruguay River system in the 1960s. The southern most area colonised is the Colorado River. South of the Colorado River the water becomes colder which inhibits propagation of the Asian clam (Cazzaniga 1997).

Tourism has also had a negative impact on the ecosystems. Motorcycles and 4x4 trucks disturb feeding and reproductive areas, such as dunes and beaches, along the coast. Such impact is more severe on the coast of the province of Buenos Aires, and only in local areas along the Patagonian coast. Another important impact from tourism is the excessive number of boats engaging in whale observation (DRIyA 2001).

Finally, a critical region where significant modification of habitats and communities has occurred is the Buenos Aires coast. This includes the main beach zone of the Atlantic coast, where the most important Buenos Aires tourist activity has developed. The historic lack of planning and territorial ordering has resulted in significant degradation of the coast line with the consequent increase of coastal erosion, which strongly affects tourist income (beach and dunes degradation, urban infrastructure damage). The advance of urbanisation has produced this situation along the coastline. Dunes, forming a natural protection against winds and tides, have been removed and/or fixed. Settlement landslide is frequent, as well as pedestrian and vehicle roadways that require refilling. Many affected municipalities are now designing or executing expensive projects to stop these processes. Another cause of degradation is associated with the unsustainable use of natural resources. In spite of severe erosion problems affecting the coastline, the sand extracting process due to construction continues (Bonamy et al. 2002).

Socio-economic impacts

Economic impacts

Climate and soil conditions make the Patagonian region extremely dependent on water resources and goods and services provided by aquatic ecosystems. Most of the population is concentrated in urban settlements near the Atlantic coast. A considerable proportion are highly dependent on ocean fisheries or live in river valleys where irrigation provides opportunities for intense economic activity.

Therefore, habitat loss and modification of the aquatic community have significant economic and social impacts on the populations concerned, particularly from the construction of dams and their influence on water tables and the availability of water for irrigation and also the exploitation of fish. Economic losses and elevated costs associated with this concern affect both public and private sectors; the latter mainly comprising small enterprise, cooperatives and individuals being the most vulnerable.

Decrease in fish yield has resulted in serious economic loss to local fishermen inducing the authorities to establish catch limits and controls to allow recovery of stocks of major commercial species. Social and community impacts are even larger due to the vulnerability of the affected sector (see Unsustainable exploitation of fish, Socio-economic impacts).

Other social and community impacts

Habitat and community modification, mainly due to overexploitation of fish, has resulted in significant social and economic problems due to the loss of employment and closing of fishing enterprises, with quite strong impact on the local community. The more the resource becomes affected, the higher likelihood of conflict among different sectors.

The loss of agricultural productivity is particularly important because it affects labour resources and results in many ranches being abandoned and the occupants emigrating to urban settlements. The effect of tourist activities also contributes to this phenomenon.

Conclusions and future outlook

Habitat and community modification is considered to have a moderate impact, having the same impact as loss of ecosystems and ecotones, and modification of structure or communities. The impact of this concern is expected to increase in the future. Although the recent trend of creating protected areas is expected to continue, degradation in other areas will continue and even increase.

Based on the expected slightly negative trend toward further habitat and community structure modification and despite efforts and improvements by the various sectors of society towards protection and restoration of the environment, it is considered that economic and social impacts directly associated with ecosystem degradation will increase. A very slight increase was predicted for both issues, while health impact was difficult to assess and not considered significant.

IMPACT Unsustainable exploitation of fish and other living resources

Hake (*Merluccius hubbsi*) is the main resource exploited in the oceanic component of the South Atlantic Drainage System. This resource is seriously affected, as it has been exploited beyond safe biological limits. In addition, incidental by-catch and discards comprises between 30 and 60% of the total catch caught in the hake fishery. Only sport fishing is carried out in inland waters.

Fishing activity generates a series of threats to biological marine diversity. Most important are overexploitation of resources, incidental by-catch and discard of organisms without commercial value (DRIyA 2001). Destructive fishing practices result from intensive trawling on the continental shelf where the sea floor is often trawled more than 10 times per fishing operation, seriously affecting the habitat. The introduction of carp and trout (of great economic importance for the region) in rivers and the cultivation of algae for the extraction of thickening agents in the Nuevo Gulf have not changed community structure.

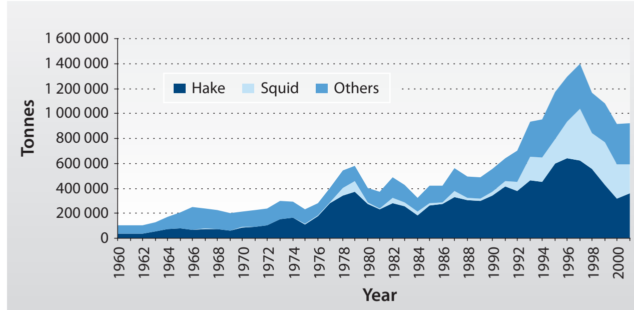

Figure 26 Fish landings in1950-2001.
(Source: DRIyA 2001)

Economic impacts were based mainly on hake overexploitation and its effects on all sectors involved in fishing activity. There are no indications of major impacts on the population as a consequence of disease or pollution. No significant links between health impacts and this concern were identified.

Environmental impacts

Overexploitation

Recent studies have found that overexploitation of fish has not only affected the Argentine hake stock, which is almost completely exhausted, but has also negatively affected marine mammals and birds and their habitats. The FAO estimates that Argentine and foreign ships are responsible for about 90% of hake fishing in the oceanic component of the South Atlantic Drainage System (FAO 2000a). Some indicators of overexploitation are (DRIyA 2001):

- Fishing effort of freezer-trawling ships has increased five-fold between 1989 and 1996;
- Fishing effort of fresh fleet has tripled between 1989 and 1996;
- Large proportion of catch is made up of juvenile and spawning fish;
- Absence of adult fish both in stocks and captures;
- Increased population mortality has effectively reduced fishing yield;
- High discards of small fish due to present fishing practices.

Fisheries in Argentina have undergone a period of accelerated growth in the last decades (Figure 26), involving mostly hake (*Merluccius hubbsi*), squid (*Illex argentinus*), Southern blue whiting (*Micromesistius australis*), Tail hake (*Macruronus magallanicus*) and prawn (*Pleoticus muelleri*). Hake stocks have been overexploited which has led to the current collapse of the population. Although the ecological consequences of this collapse have not yet been evaluated (Fundación Patagonia Natural 1999), measures to avoid the continued overexploitation of hake, such as catch limits and controls to allow recovery of stocks, have been taken. The regulatory measures have resulted in a decrease of total landings in 1998-1999 when the proportion of hake in total landings fell from 62 to 31% (Table 29). In 1999, hake, squid and southern blue whiting represented 31, 34 and 5.4 % of total landings, respectively (DRIyA 2001). Intense exploitation may have caused important changes in the structure and productivity of the aquatic ecosystems. The promotion of new fisheries tends to conceal decreases in the trophic levels of the most exploited fisheries. The abundance of the pelagic species increased due to the excessive exploitation of hake; that is why between 1993 and 1996 stocks of "Anchoita" tripled in Buenos Aires and doubled in Patagonia. Due to the fact that marine mammals and birds prey on many species of fish and crustaceans, the increase in exploitation rate generates concern for the possible competition between fishers and these predators. The disappearance of the exploited stocks causes deleteriously effects on the survival of marine mammals and birds. In addition, the selective fishing of big and old individuals changes the size and age structure of the exploited population, reducing the reproductive capacity of the population and the probability of successful recruitment (DRIyA 2001).

Table 29 Hake landings and percentage of overfishing in Argentina.

Year	Maximum permissible capture of hake (tonnes)	Hake landing (tonnes)	Overfishing (%)
1992	390	369	-5
1993	390	422.2	8
1994	390	435.8	12
1995	398	574.3	44
1996	395	589.8	49
1997	395	585.7	48
1998	289.5	458.6	58
1999	188	313.9	67
2000	130	187	44

(Source: DRIyA 2001)

Overexploitation of hake in the Mar del Plata area (province of Buenos Aires) became evident in 1997 due to increased landings (Bertolotti et al. 2001a). In 2000, the estimates of the size of the reproductive hake stock south of the 41° latitude were the smallest since 1986 (Pérez 2001). Status indicators show a critical situation; north and south stocks were overfished, total biomass decreased, reproductive biomass was lower than the biologically acceptable level and the fishery was sustained by only a few year classes (Aubone 2000, Bezzi 2000, Grupo de Evaluación Merluza 2000, Pérez 2000).

The predominance of the bivalve mollusc "Vieyra" (*Zigochlamys patagónica*) in Nuevo and San Jose gulfs has decreased and has shown signs of overexploitation in recent years (Ciocco 1996). The decline in Vieyra stocks has prompted a ban on the collection of this species (Elías 2002).

The estimated size of the Southern blue whiting population has decreased by around 77%. Decreasing average size of individuals comprising the "Gatuzo" (*Mustelus schmitti*) population, diminishing coastal density in Buenos Aires and Uruguay, and a decreasing Catch per Unit Effort (CPUE) are some signs of overexploitation (Massa et. al. 2001).

Mackerel (*Scomber japonicus*), as well as Blood corvine (*Micropogonias furnieri*) and shore ray species (Family Rajidae) biomasses have decreased in the oceanic component of the South Atlantic Drainage System since 1996. Fishing pressure on cod (*Genypterus blacodes*) stocks has increased since 1999 and is now being exploited near sustainable biological limits (Carroza et al. 2001a, Cordo 2001, Perrota & Garciarena 2001).

Excessive by-catch and discards

Trawling for prawns has high incidental by-catch rates of juveniles of commercially valuable fish species, as well as mammals such as Marine hair wolf (*Otaria flavescens*), Dark dolphin (*Lagenorhynchus obscurus*) and "Tonina overa" (*Cephalorhynchus commersonii*). Capture of hair seal has been estimated around 1 to 2% of the whole population per year in the southern part of the Chubut province (Crespo et al. 1997). The rate of incidental by-catch of the freezer and factory fleet varies between 9.9% to 24.3%, and 2.3% to 37.2% respectively (Cañete et al. 1999). The size of codfish stocks has declined since 1999 because of high levels of by-catch in hake fishing (Cordo 2001).

Vessels and commercial trawl fishing also affects penguins, albatrosses, petrels and seagulls. Albatrosses are the most vulnerable species because of their low reproductive rate and high age of maturity (DRIyA 2001).

The main target of the Argentine high seas trawling fleet is the hake (*Merluccius hubbsi*). This fleet uses non-selective nets that capture a wide variety of species, which are later either selected or discarded. In areas with high average yields of hake, accompanying species such as cod and tail hake are discarded. However, in areas with low average yields of hake (Buenos Aires seashore) the relative importance of accompanying species such as Gatuzo, codfish and Pescadilla becomes higher (Irusta et al. 2001).

Incidental captures of benthic organisms have been recorded. For example, in the shrimp fishery of the San Jorge Gulf and along the coast of Chubut, non-target macrobenthic organisms were caught in 89% of all hauls investigated (Roux 2000).

Discards produce changes in the community structure, food web and marine bed composition. Assessments carried out during 1993-1996 found that out of about 100 species caught, around 85 were thrown back as discard (21 with some commercial value). The high seas fleet discards about 25% to 30% of their catches while the coastal fleet discards are about 25% (Caille & González 1998). The fishery of Argentine prawn lands a significant by-catch of hake (Table 30).

According to official estimations, in 1990-1996 between 20 000 and 75 000 tonnes per year of young hake were discarded, representing 80-300 million fish. The majority of these discards were hake younger than 2 years old. In 1997, the prawn trawling fleet landed 5 500 tonnes of prawn and 40 000 tonnes of hake. The total discards of young hake by prawn fishing fleet was estimated at about 20 000 tonnes per year. Discards of young and adult hake from the factory fleet and fresh trawling fleet are also significant (DRIyA 2001).

Table 30 Composition by species of the secondary fishing of prawn in Argentina.

Species or group of species	Biomass (%)	Frequency (%)
Argentine hake (*Merluccius hubbsi*)	66	91
Argentine prawn (*Pleaticus muelleri*)	18	91
Anchoita (*Engraulis anchoita*)	4.8	24
Southern blue whiting (*Genyperus blacodes*)	2.2	35
Other invertrebrates	1.7	56
Skates (Rajidae)	1.6	32
Crabs (Brachyura)	1.4	53
Lobsters (*Munida* spp.)	0.88	29

(Source: Caille & González 1998)

In the factory fleet, observers verified that catches showed no relation to the factory processing capacity. There is a trend to catch much more than the amount that can be processed. There is no control over what enters the net to regulate trawl duration. In general, trawl frequency and duration are independent of the presence of raw product in the processing plant. The discard level is very high and related to variable criteria that are difficult to predict. To a large extent this is conditioned by the previous item, since bad quality fish is rejected or the processing line excessively accelerated. This is not exclusively associated with fishing gear selectivity. Failures were detected in the processing lines that can be attributed to equipment calibration and maintenance, handling and selection of specimens by operators and the quality of raw material (crushed fish that block the machinery). All those factors diminish yield and increase discard levels (Cañete et al. 2000).

Destructive fishing practices

Trawling of the sea floor has a significant impact on the benthic habitats, and its continued use could result in serious consequences - not only for the target species but also for other marine organisms. Although there are a wide variety of possible negative effects on the ecosystem, an environmental impact assessment of trawling practices in the Argentine seashore has not been carried out. In the San Jorge Gulf and along the Chubut coast, the groups most affected by trawling nets were seahorses and polychaetes (Roux & Bertuche 1998). Benthic habitats are usually trawled more than 10 times per fishing operation.

Drag is another fishing practice that could also greatly affect the marine bed. This practice is used by the vieiras fishing boats which, in San Matías Gulf between 1969 and 1972, negatively affected the marine beds as well as several species (Ciocco et al. 1998, Orensanz et al. 1991).

Impact on biological and genetic diversity

As mentioned in the section on Habitat and community modification, there is little information about the impact induced by the introduction of alien species such as the brown alga (*Undaria pinnatifida*), Asian clam (*Corbicula fluminea*), "Dog's teeth" (*Balanus glandula*) and other intentionally introduced species such as Brown trout (*Salmo trutta*), Rainbow trout (*O. mykiss*), Pacific oyster (*Crassostrea gigas*), Chilean oyster (*Tiostrea chilensis*), Chinook salmon (*Onchorhynchus tshawystcha*) and beavers.

These species might become a threat for biodiversity by excluding native species. At the same time, alien species might introduce new pathogens affecting the native species and the ecosystem negatively (DRIyA 2001).

Socio-economic impacts

Economic impacts

The moderate impacts on the South Atlantic Drainage System exerted by overexploitation of fish and other living resources are primarily caused by the overexploitation of hake. However, banning hake fishing would result in severe social problems, loss of employment and the closure of fishing enterprises, as well as affecting tourism. More weight has been assigned to frequency and duration, taking into account that impact on the local community is quite strong.

In Patagonia, 71% of fishers are employed within the factory fleet which supplies processed fish products, 18% within the fresh fish trawl fleet and 11% in the coastal fleet. The manufacturing of fish products involves both factories and cooperatives. Although the total number of people employed in the entire fishing sector decreased by about 11% between 1987 and 1996, the number of people employed within fish processing industries in Patagonia has constantly increased (about 37%) due to the construction of several fish processing factories (DRIyA 2001).

By the time hake overexploitation became evident in 1997, maximum crew employment was registered. Since 1997, employment in the fishing sector has decreased by about 22% while in 2000 alone, it decreased by about 8 to 9 % in total, 13% for the Patagonian region and 6% for Buenos Aires Region (Bertolotti et al. 2001a).

Recent estimates from the coastal fishing fleet show that landings have decreased and fishing days increased indicating a reduction in catch per sailing and a decrease in average revenue. Since profits are divided between crew members the average income per person has also decreased (Bertolotti et al. 2001b).

In 1999-2000, production, fishing days and employment of the high seas fleet decreased about 13%, 9% and 9% respectively. During the same period, for freezer and factory fleets the decreasing rates were 14%, 7% and 9% (Bertolotti et al. 2001a).

In 1999, fish export reached 809 million USD showing a decrease compared with previous years; 1 014 million USD in 1996, 887 million USD in 1997 and 923 million USD in 1998 (Figure 27). The decrease was mainly due to international and national market conditions but also reduced landings.

Other social and community impacts

The processing plants of Comodoro Rivadavia, Trelew and Rawson are mainly devoted to hake manufacturing. Due to the decrease in hake landing there has been a sharp drop in industrial input. Many plants were closed and many jobs were lost (Table 20) (Bertolotti et al. 2001b).

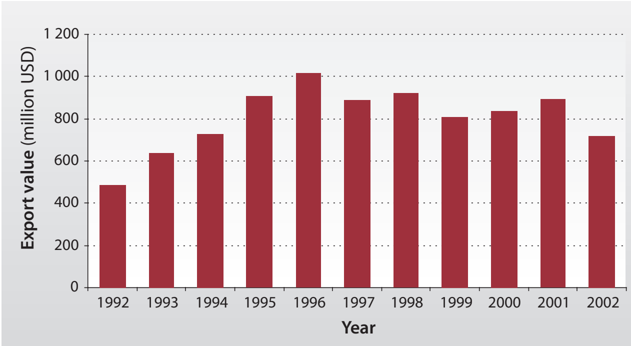

Figure 27 Argentine fish export between 1987 and 1999.
(Source: DRIyA 2001)

Of 38 established plants, only 26 were operative in 2001. Since 1998, there has been an ongoing trend towards poorer working conditions, lower incomes and even loss of work benefits such as health cover and retirement pensions.

Conclusions and future outlook

The overall impact of Unsustainable exploitation of fish and other living resources is moderate. Highly linked to the concern Habitat and community modification, intensive fish exploitation, incidental captures and discards, and fishing practices have affected aquatic community structure and population dynamics at various trophic levels.

In future, the exploitation of living resources is likely to increase. Visible results from implemented regulations are not expected in the oceanic component of the system. In continental areas, where regulations are usually not fulfilled, unsustainable exploitation is also predicted to increase.

A slight increase is expected in economic, social and community impacts exerted by unsustainable exploitation of fish, considering that this concern is expected to cause greater environmental impacts in the future.

It is estimated that fish consumption will be slightly higher than it was at the end of the 1990s, based on the assumption that total quantity consumed per person per year will remain fairly constant. A breakthrough in aquaculture (e.g. an extremely rapid spread of tilapia culture in Latin America) would be the only major reason to alter this prediction (FAO 2000b).

Global change

Global change models, mainly relating to global heating by the greenhouse effect, applied in the region, show a temperature and precipitation change for different future scenarios.

The possible after-effects of regional climatic changes, even those suggested by the most moderate scenarios, may affect among other aspects, biodiversity, coastal habitat characteristics, forest fires and production activities such as agriculture, cattle raising, hydropower generation and tourism. Therefore, it is recommended that the impact of global change in these fields should be investigated.

Changes in the hydrological cycle have been indicated by movement of the isohyets towards the west. Although ongoing research has not yet reached conclusions, there is preliminary evidence of changes affecting phytoplankton and ichthyoplankton due to increased UV-B radiation. Research is also being carried out to assess changes in ocean CO_2 source/sink function. There is no evidence of changes in sea level.

Considering the current regional climate, no significant effect on the health could be attributed to climate change. In addition, the anticipated changes in the hydrological cycle are likely to yield economic benefits to the system.

Environmental impacts

Changes in the hydrological cycle and in the ocean circulation

Between 20° and 38° S, rainfall around the Andes occurs mainly during summer. Between 38° and 48° S, rainfall around the Andes occurs mainly during winter. Southward precipitation occurs almost all year. Snow accumulates in the high parts of the Andes and melts during spring, becoming the main source of water for the rivers of the sub-system. Between the end of the 1800s and the middle of the 1970s, the sub-system has been under the influence of a declining trend in the amount of precipitation (IPCC 2001b). However, since the mid-1970s, this trend has reversed. A similar trend has been detected for stream flows in the system (IPCC 2001b).

The estimates of precipitation changes caused by the greenhouse effect show that, in summer, the semi-arid zone located in western Argentina would show a decrease of 10% in precipitation for each degree that the average global temperature increased. In winter, models show precipitation increases of 5% in the austral zone and 5-10% in northeastern Argentina, as a result of global warming. Table 31 shows these variations expressed as percentages of present value (Labraga 1998).

Table 31 Precipitation variation scenarios for the different Argentinean regions.

Region	Precipitation variation range (%)	
	Year 2030	Year 2070
Summer		
Middle-West (West of 65° and from 35° to 45° S)	-1 to -17	-2 to -42
Winter		
South (South of 45°S)	0 to +8	0 to +21

Note: The effective variation precipitation ranges (not standardised) are expressed as percentages of the actual values. (Source: Labraga 1998)

In the high altitudes of the Andes, large amounts of snow are recorded. Melting of this accumulated snow is the main cause of river run-off during spring and summer. In central and western Argentina, to the north of 37°, stream flows are normal or above normal during El Niño years. On the other hand, during cold events (La Niña), negative anomalies of rainfall and snowfall occur, with reverse consequences, including below-normal summer stream flows. For this area, the likelihood of dry conditions during La Niña are higher than wet conditions during El Niño (IPCC 2001b).

Since the 1970s, there has been a shifting in the isohyets towards the west, mainly southwest of the province of Buenos Aires and La Pampa (Sierra et al. 1994). Ocean currents have not been affected.

Increase in the UV-B radiation as a result of a reduction of the ozone layer

The impact of UV-B radiation in the region is not clear. On one hand, Patagonia is not likely to be affected by ozone layer depletion since seasonal cloudiness takes place during the few days when it might exert an influence on the region. On the other hand, preliminary research data suggests changes in phytoplankton and zooplankton communities that may be attributed to increased UV-B radiation.

Changes in ocean function as a CO_2 source/sink

There are huge doubts about this issue, although suspicions about its effects exist. Research is just starting with the installation of measuring equipment in the southern zone of the Atlantic Ocean where measuring is easier.

Socio-economic impacts

Economic impacts

Economic impacts from changes in the hydrological cycle are considered beneficial. As a result of such changes, about 1 million ha have been incorporated into production in the province of La Pampa. Given that the system is arid, increases in precipitation induce positive impact in the economic sector.

Depending on latitude, a 1° C increase in temperature would increase alfalfa yields. For the area located south of 36° S, an average increase in alfalfa yields of 50-100% is expected for most varieties (IPCC 2001b).

Other social and community impacts

The increase in productive land surface does not only improve welfare of the population directly involved in agriculture but also extends its benefits to all indirectly related sectors.

Conclusions and future outlook

In the South Atlantic Drainage System, detrimental environmental and socio-economic impacts could not be attributed to Global change. In fact, changes in the hydrological cycle are expected to yield slight socio-economic and social benefits for the region.

Considering the likely future conditions, it is probable that the overall negative environmental impact of global change will increase in the near future. This negative perspective is shown in the slight reduction of positive scores assigned to present conditions.

Phenomena like El Niño, with a great importance in the climatic variability each year, have not yet been modelled in a satisfactory way. For that reason, it is difficult to infer future El Niño behaviour in this system in the presence of an intensification of the greenhouse effect.

Priority concerns:
La Plata River Basin & South Atlantic Drainage System

All the concerns in La Plata River Basin are moderate taking into account their weighted impact; consequently the assessment did not result in a clear identification of priorities. Numerical differences were not significant enough to establish priorities among the related concerns. These priorities were finally assigned on the basis of common expert judgement and intense discussion during the GIWA workshop and further assessment of the individual scores (Annex II). The priority concerns selected were:

- Habitat and community modification
- Pollution

Despite the fact that Pollution contributes to Habitat and community modifications, a higher impact is attributed to the construction and operation of reservoirs and dams; widespread presence of invasive species like *Limnoperna fornei*; and overexploitation of fish. The main socio-economic impact comprises the cost of controlling invasive species, increased fishing effort and changes in fishing practices.

The widespread distribution and the long-term degradation caused by habitat and communities modification and pollution justified the prioritisation of these concerns over the other three considered in the GIWA Assessment.

The possibility of reverting existing dams and reservoirs is almost non-existent as there is a great dependency on the use of water resources to generate electric power, mainly in Brazil. Therefore, the transformation of lotic ecosystems into lentic ecosystems will continue. In addition, facilities constructed for species migration are not effective, and operations of dams do not always fulfil environmental requirements. Demands for water and electricity will increase in the future together with the human population and improvements in the quality of life in the region exerting greater pressures on the water resources in the basin. Also, economic and human efforts dedicated to controlling invasive species have not succeeded.

Chemical contamination is the most important issue of pollution; heavy metal pollution ubiquitous in the Basin is the main chemical pollution stress. There are also numerous indications of bacteriological contamination, and some spill events during the last five years. The main socio-economic impact is the increased costs for water treatment, and impact on tourism and recreational values.

Considering the socio-economic impact produced by the contamination of drinking water supply in the two big cities in the Basin, São Paulo in Brazil with 18 million inhabitants and Buenos Aires in Argentina with 13.5 million inhabitants, it can be inferred that pollution, directly or indirectly, affects the greatest population. At the same time, priority is based on the important economic, educational and awareness efforts of the community and necessary controls to improve environmental conditions.

In the South Atlantic Drainage System, four concerns were assessed as moderate considering their weighted impact: Habitat and community modification; Unsustainable exploitation of fish and other living resources; Pollution; and Freshwater shortage. Slight beneficial impacts can be attributed to Global change (Annex II). Nevertheless, significant numerical differences relating to the impact of the above four concerns has meant that the following can be considered a priority:

- Habitat and community modification
- Unsustainable exploitation of fish and other living resources

Taking into account the magnitude of the environment and economic impact, mainly in the oceanic component of the system, as well as the extent of impacts and the number of people involved, Habitat and community modification and Unsustainable exploitation of fish and other living resources, constitute the principal problems. The negative impacts are reversible but requires great effort, economic resources, education, awareness and political and institutional agreements.

Habitat and community modification in the continental area is mainly due to the development of reservoirs and impacts on flood meadows ("mallines"). On the other hand, in the oceanic component, overexploitation of target species, unsustainable fishing practices, as well as pollution are the most important causes of habitat and community modification. Loss of agricultural productivity, increasing fishing effort and economic losses for local fishermen constitute the main socio-economic impact.

Unsustainable exploitation of fish and other living resources in the oceanic component is particularly related to the overexploitation and incidental by-catch and discards, with consequences for habitat and community modification. Overexploitation of fish results in severe social and economic problems due to the loss of employment and the closure of fishery enterprises.

Based on the GIWA Assessment of each concern and their constituent issues in both systems, the following concerns have been prioritised for Causal chain and Policy option analyses:

- Habitat and community modification in the entire region, highly linked with Overexploitation of fish in the oceanic component of the South Atlantic Drainage System;
- Pollution in La Plata River Basin.

The links between GIWA assessed concerns for the Patagonian Shelf region as a whole resulted from the aggregation of the analysis made for La Plata River Basin and South Atlantic Drainage System (Figure 28).

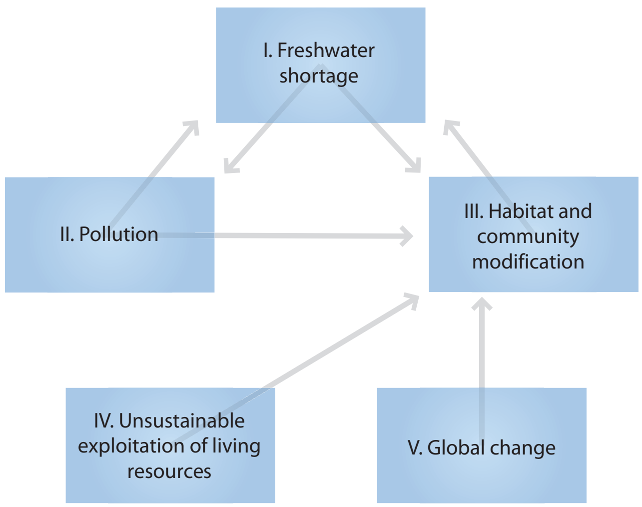

Figure 28 Links between the GIWA concerns.

Pollution of water sources has been identified as the main issue concerning water shortages in the La Plata River Basin, as well in Buenos Aires and São Pablo cities in terms of water supply. On the other hand, freshwater shortage increases the impact of pollution by decreasing the dilution capability of water bodies, as is the case in the Quareim River in the La Plata Basin during summer.

Habitat and community modification is the central concern in the Patagonian Shelf since all other concerns are linked to this. Pollution (spills and urban discharge) and unsustainable fishing practices affect aquatic habitats (overexploitation of target species and trawling), particularly marine resources and ecosystems.

In the South Atlantic Drainage System habitat modification due to anthropogenic activities aggravate natural water deficits that occur in this mostly arid region. Modification of stream flow due to the construction and operation of reservoirs of dams affects habitat and community structure throughout the entire Patagonian Shelf region.

Finally, global change will affect aquatic ecosystems and habitat and community structures through large variations in climate and changes in the water balance.

Causal chain analysis

Giangiobbe, S., González, S. and F. Pacheo

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.

Uruguay River Basin upstream of the Salto Grande Dam

The water resources of the Uruguay River Basin are shared by three countries: Argentina (provinces of Corrientes, Entre Ríos, and Misiones), Brazil (states of Rio Grande do Sul and Santa Catarina), and Uruguay.

Throughout the Basin, water resources are stressed by extensive agricultural and industrial activities. Rice cultivation, livestock production, and various other agricultural activities have caused extensive chemical and microbial pollution and eutrophication of freshwater resources. The lack of proper wastewater treatment systems in the urban and industrial centres of all three countries has exacerbated conditions further. The situation is expected to worsen unless effective pollution control measures are implemented, which will require major investments by both the public and private sectors. Pollution in the Uruguay River Basin is similar to the situation in other sub-basins of the La Plata River Basin. As a result, the causal chain analysis for pollution in the Uruguay River can be taken as a practical representation of the situation within other sub-basins of the greater La Plata River Basin.

System description

The total surface area of the Uruguay River Basin is 385 000 km^2 (ANEEL 2001). Within the Basin, the area selected for the Causal chain and Policy options analysis covers the area upstream of the Salto Grande Reservoir (Figure 29). Sections of the Basin with shared water resources include the Middle Uruguay River (Argentina and Brazil), the Lower Uruguay River (Argentina and Uruguay), the Pepiri Guazú River Basin (Argentina and Brazil), and the Cuareim River Basin (Brazil and Uruguay).

Physical and natural aspects

The Uruguay River begins at the confluence of the Pelotas and Peixe rivers, and flows into the La Plata River. In the upper reaches of the Basin, there are large topographical differences and wide variations in the riverbed slope. These characteristics continue until Santo Tomé (Argentina), where the River gradually begins to widen as it flows southwards. The River reaches a width of 1 200 m at Paso de los Libres (Corrientes, Argentina) and 1 900 m upstream of the Salto Grande Reservoir.

Rain is well distributed throughout the year, and tends to be abundant in the northern part of the Basin during summer, and the southern part of the Basin during winter. Maximum river flow occurs in winter and spring, a secondary peak occurs during summer, and minimum river flow usually occurs during April and May (OEA et al. 1992). Table 32 summarises the main hydrological parameters of the Uruguay River.

The River and its tributaries transport an estimated 17 million tonnes of sediment every year. As a result, water transparency is low. Measured visibility with a Secchi disk is roughly 20-30 cm upstream of the Argentina-Brazil border, and 10-45 cm near Colón (Entre Ríos, Argentina). The salinity of the River is low, and pH varies between 6.5 and 8 (Canevari et al. 1998). Other chemical characteristics are shown in Table 3.

Other shared water bodies include the Cuareim and Pepiri Guazú rivers. The Cuareim River is relatively short (351 km) and has a low slope. The maximum river flow of 4 653 m^3/s was registered in April 1991, in Artigas city (Cuenca del Río Cuareim 2003). The Pepiri Guazú River has a stony riverbed with 4-5m waterfalls, and contains several plunge pools and backwaters.

The Uruguay River ichthyofauna belongs to the Parano-Platense biogeographical province, but there are distinct differences between the upper and lower parts of the River. Recent research from several reservoirs in the upper river discovered certain species restricted only to this area (IPH 1998). In the middle and lower reaches, the fauna is dominated by catfish in the orders Characiformes and Siluriformes. Predators such as *Salminus* sp. and *Brycon* sp. dominate open waters, and *Hoplias malabaricus* dominate calm waters. The most common species include *Loricaria* sp., *Plecostomus* sp., *Pterodoras granulosus*, and the commercially valuable *Doras* sp. (Canevari et al. 1998).

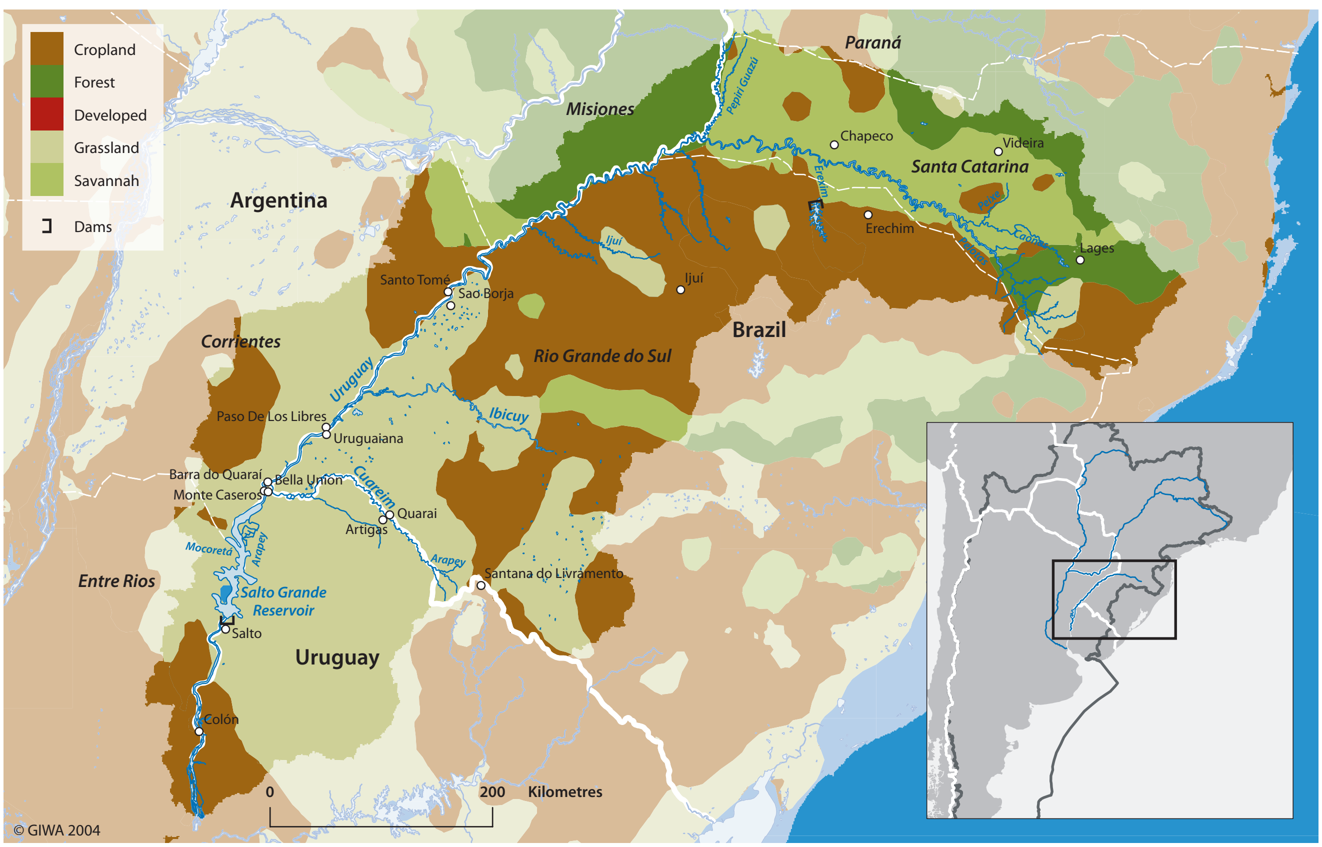

Figure 29 Uruguay River Basin.
(Source: Loveland et al. 2000)

Table 32 Main hydrological characteristics of Uruguay River.

Total length (km)	Average flow (m^3/s)	Maximum flow (m^3/s)	Minimum flow (m^3/s)
1 850	6 000	20 000	600

(Source: OEA-BID-ROU 1992)

The western part of the Uruguay River Basin contains relatively large, important wetlands. The inter-fluvial plain between the Ibicuy and Cuareim rivers is relatively flat, but there are some hills close to the Uruguay River. The landscape is dominated by grass steppes, while gallery forests are restricted to the drainage network (Canevari et al. 1998). The entire basin extends over the Guaraní Regional Aquifer, which contains an estimated stored volume of 40 000 km^3 and is the main freshwater reservoir in South America.

The main construction on the Uruguay River is the Salto Grande Dam. Constructed in 1982, this dam is a bi-national development managed by Argentina and Uruguay and primarily devoted to the generation of hydropower. Water in the Salto Grande Reservoir is also used for domestic consumption, navigation, and waste disposal (Chalar et al. 1993, Catalogo Lagos y Embalses en Argentina 2003).

Based on the average concentration of chlorophyll a in the water, the Salto Grande Reservoir can be classified as either oligotrophic or mesotrophic (Catalogo Lagos y Embalses en Argentina 2003). Since the filling of the Salto Grande Reservoir began in 1979, water quality changes have been detected due to excessive influxes of nutrients and organic matter from terrestrial systems, which has led to repeated algal blooms (Chalar et al. 1993).

In the Cuareim Basin, Brazil's São Marcos Dam has been constructed, primarily for the purpose of irrigation (ANA 2002).

Socio-economic aspects

According to data from 2000 and 2001, the population within the Basin is 4.9 million inhabitants. Of these, 69.1% live in urban areas. The major urban centres in the Basin are shown in Figure 29. These include the cities of Santo Tomé, Paso de los Libres, and Monte Caseros (Corrientes, Argentina), Lages, São Borja, and Chapecó (Santa Catarina, Brazil), and Erechim, Ijuí, Uruguaiana, Santana do Livramento and Bagé (Rio Grande do Sul, Brazil). In addition, the cities of Artigas and Bella Union (Uruguay), and Quarai and Barra do Quarai (Brazil), are located on the banks of the Cuareim River.

Table 33 shows the percentage of the total and urban population served by sewage and drinking water systems in the various jurisdictions of the Basin. Existing weaknesses in sanitary facilities are evident, especially in the provinces of Corrientes and Misiones. In Brazilian sections of the Basin, the number of people connected to a sewage system is below average in 9 out of 13 municipalities. In the urban areas of the Brazilian states, domestic and industrial effluents are often discharged without treatment. The main industrial pollution sources are located in the upper basin on the Peixe and Caonas rivers, where paper, leather and food processing industries are located in the cities of Lages, Videira, and Caçador (Santa Catarina state, Brazil) (Tucci 2001).

Table 33 Total and urban population with access to sewage system and drinking water in Uruguay River Basin.

	Total population			Urban population		
Jurisdiction[1]	Population	Sewage system (%)	Drinking water (%)	Population	Sewage system (%)	Drinking water (%)
Río Grande do Sul	10 187 798	23.1	76.6	8 317 984	32.9	92.6
Santa Catarina	5 356 360	13.7	65.4	4 217 931	23.8	89.1
Artigas	75 059	40.6	81.3	66 589	94.4	93.0
Salto	117 597	55.1	78.8	104 031	94.7	92.1
Entre Ríos	1 158 147	36.1	80.7	915 772	58.8	93.6
Corrientes	930 991	3.4	67.4	736 638	58.8	89.0
Misiones	965 522	5.3	27.3	725 151	19.4	65.7

Note: [1]Corresponding to the Brazilian States, Argentinean Provinces and Uruguayan Departments partially included in the study area.
(Source: IBGE 2000, INE 1996, INDEC 2001, ANA 2002, INE 1996, ENHOSA 1999)

In the Brazilian parts of the Basin, Human Development Index (HDI) values indicate a reasonably good socio-economic situation, despite the low percentage of sewage system coverage. Socio-economic indicators for the two states in the Brazilian portion of the Basin show that infant mortality rates are below the national average (Table 34), while the GDP and HDI in both states exceeds the national average (ANA 2002). In Uruguay, infant mortality rates are the lowest within the entire Basin; however, the Uruguayan component of the Basin is the least economically active region in Uruguay. In Argentina, no provinces in the Basin exceed the national mean HDI value of 0.884, and Corrientes province exhibits the highest infant mortality rate and the lowest HDI in all of Argentina.

Agricultural activities are widespread throughout the Basin (Figure 30), and the demand for irrigation water exerts significant pressure on water resources in some sub-basins. Rice cultivation is a significant consumer of irrigation water. In the Brazilian portion of the Basin, water demand for irrigation represents 91% of the total (ANA 2002). The Middle Uruguay contains over 440 000 ha of rice, and Rio Grande do Sul is in fact the main rice-producing state in Brazil, producing over 2.5 million tonnes of rice per year (IRGA 2002). Rice cultivation is concentrated around the Ibicuy River, where data from the 1980s has shown the demand for

Table 34 Infant mortality rate in Uruguay River Basin.

Jurisdictions[1]	Infantile mortality rate (per 1000 live births)
Santa Catarina	21.7
Rio Grande do Sul	18.1
Artigas	16.6
Salto	16.5
Misiones	21.7
Corrientes	22.9
Entre Ríos	19.5

Note: [1]Data correspond to entire jurisdictions. (Source: ANA 2002, INDEC 2000, INE 2002)

Table 35 Total cultivated area and the percentages of rice and soybean in Uruguay River Basin.

Jurisdictions[1]	Farming area (ha)	Rice (%)	Soybean (%)
Santa Catarina	1 638 686	7.7	13.4
Rio Grande do Sul	3 522 074	28.1	86.5
Artigas	29 170	85.3	ND
Salto	11 527	67.2	ND
Misiones	674 644	0.04	0.7
Corrientes	430 978	14.8	1.2
Entre Ríos	1 638 686	3.0	49.7

Notes: ND = No Data. [1]Data corresponding to entire jurisdiction.
(Source: IBGE 1999, INDEC 2002, MGAP 2000, MAGyP 2002)

irrigation water at over 13% of the average flow of the Ibicuy River (Tucci 2001). Soybean and millet have also been recently introduced in Brazil. Practices associated with the cultivation of these crops have increased soil erosion, and combined with deforestation, this has resulted in increasing concentrations of suspended sediments and significant impacts on water quality (Tucci 2001).

In the Upper Uruguay River, pig and poultry production predominates. In fact, Brazil is the seventh largest producer of pigs in the world (17.2 million animals in 1997), and the second largest poultry producer in the world (7.2 million tonnes in 2002).

Farming is also the main activity in the Argentinean provinces bordering the Uruguay River. Cattle raising and the cultivation of rice, wheat, maize, yerba mate (*Ilex paraguariensis*), tea, tobacco, soybean, and citrus fruits are all widespread. Forestry also occurs in Argentina. Rice cultivation and cattle raising are mainly concentrated in the province of Corrientes. Entre Ríos province also produces rice, grain, fodder and oleaginous fruits, and in recent years, wheat and soybean production has been replacing sunflower and maize (INDEC 2001). The province of Misiones is the primary Argentinean producer of yerba mate (*Ilex paraguariensis*).

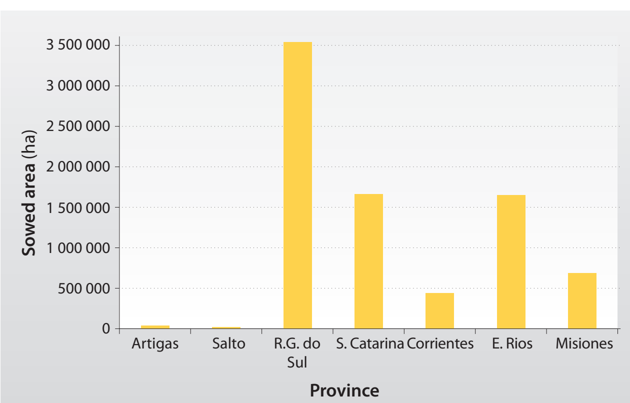

Figure 30 Sowed area by jurisdiction in the Uruguay River Basin.
(Source: IBGE 1999, INDEC 2002, MGAP 2000)

Table 35 shows the total cultivated area and the percentages of rice and soybean.

In the Uruguayan part of the Basin, the main activities are the cultivation of rice, citrus fruits, and sugar cane. The cultivation of rice near the Cuareim River in Uruguay began 25 years ago. At first, water was obtained by pumping, while later, several small reservoirs were constructed. According to the Uruguayan National Hydrographic Institute (DNH), over the period 1977-1998, 260 reservoirs with a total capacity of 309 million m^3 were constructed within the provinces of Salto and Artigas.

The Uruguay River Basin has been highly valued for hydropower generation. The estimated hydropower generation capacity of the Basin is approximately 40.5 kW/km^2, while the potential installed power has been calculated at 16 500 MW (ANA 2002). The current installed power is 2 680 MW (ANA 2002). Besides Salto Grande, only Passo Fundo Reservoir on the Erexim River is currently used to generate hydropower. In the future, the construction of several reservoirs is anticipated to solve the energy deficit of Rio Grande do Sul, which has been estimated at over 60% (Tucci 2001).

The Uruguay River Statute has been signed between Argentina and Uruguay, resulting in the formation of the Administrative Commission for the Uruguay River (CARU, Comisión Administradora del Río Uruguay), and the Cooperation Agreement for the prevention and fight against pollution. The bi-national Brazilian-Uruguayan Commission for the Cuareim/Quarai River has also been formed between Brazil and Uruguay.

Impacts

Pollution is a significant problem within the Uruguay River Basin, and is therefore the primary GIWA concern subjected to causal chain analysis. Some of the immediate causes for pollution include: inadequate treatment of point-source pollution from urban and industrial effluents (including animal slaughterhouses), agricultural practices such as weed and insect control, cropping and irrigation patterns, and tilling practices that lead to soil erosion.

Chemical pollution was assigned the highest priority due to the adverse effects caused by this type of pollution and the risks it poses to human health. Studies carried out in the reaches where water resources are shared between Uruguay and Argentina have measured many dissolved biocides and suspended materials. Concentrations of aldrin, dieldrin, hepatachlor and heptachlor epoxi often exceed recommended safe levels for drinking water (Comisión Técnica Mixta de Salto Grande 1992 and 1994, and later samplings campaigns). In addition, samples of effluents discharged along the length of the Uruguay River and its tributaries have measured phenol and metal concentrations above recommended safe limits.

In the Salto Grande Reservoir, studies conducted by the Salto Grande Joint Technical Commission (Comisión Técnica Mixta de Salto Grande) have detected a wide range of restricted organic chloride biocides in fish tissues (Leites & Bellagamba 2002). Samples of fish obtained from the Salto Grande Reservoir and the Mocoretá River (the boundary between Corrientes and Entre Ríos) found that one quarter of all fish contained pesticides such as dieldrin, endrin, endosulfan I, and endosulfan II (Leites & Bellagamba 2002).

The impacts of chemical contaminants are manifested mainly in the Upper Uruguay and its tributaries, and tend to be reduced or concealed in the Middle and Lower Uruguay River due to the processes of chemical degradation and dilution. However, in the higher trophic levels of the Middle Uruguay, persistent organic pollutants (POPs) classified as part of the so called "dirty dozen" (UNEP 2001) have been found, revealing a need for more in-depth studies.

Microbiological pollution, eutrophication, and suspended solids were all assigned to the same category as second priority. Microbiological pollution was identified as a significant problem due to measured concentrations of faecal coliforms and the presence of pathogenic organisms in the water. Published data has shown faecal coliform values in both the Ibicuí and Santa Maria rivers at over 1 000/100 ml, while on the beaches of the Ibicuí River Basin (Rio Grande del Sur, Brasil), temporary variations of over 1 000 coliforms/100 ml have been measured (FEPAM 2002). Data from 14 HIDROSUL sampling stations in the Upper Uruguay demonstrate the potential for water-transmitted diseases due to the lack of suitable wastewater treatment and the presence of urban and industrial solid wastes (Instituto de Pesquisas Hidráulicas 1998).

On a local scale, water quality is poor within reaches of the Cuareim River between Quaraí City (Rio Grande del Sur, Brazil), and Artigas City (Artigas, northern Uruguay) (Comisión del Río Cuareim 2002). Recreational swimming in the Artigas City municipal bathing site has been prohibited due to contamination by wastewater discharged by Quaraí City. Contamination by wastewater discharged by Barra do Quaraí (Rio Grande del Sur, Brazil) has also been recorded. Within the Cuareim River, a number of international conflicts have resulted from increasing demands placed on water for drinking water supply, rice irrigation, and recreational use (Comisión del Río Cuareim 2002).

In the Pepiri Guazú River, urban effluent discharges and pig and poultry breeding have contaminated the River with pathogens (ANA 2002). The magnitude of impacts associated with microbiological pollution varies along the length of the River. In general, impacts are severe in the Upper Uruguay, moderate in the Middle Uruguay, and low in the Lower Uruguay. However, throughout the Basin strong local impacts can be found in the vicinity of discharges.

Eutrophication is evident, particularly in areas where rice cultivation is common. Algal blooms occur primarily at the end of summer in small ponds and reservoirs. The frequency and intensity of algal blooms depends on both the hydrological regime and the operation of the irrigation systems. In the Salto Grande Reservoir, the explosion of blue-green algae populations has occurred with varying frequency and intensity since the development of the reservoir, and these algal blooms tend to be concentrated at the margins of the Argentinean side of the lake (Comisión Técnica Mixta de Salto Grande 1992, Comisión Técnica Mixta de Salto Grande 1994).

Monitoring of the Salto Grande Reservoir during the 1990s showed that pelagic and detrivorous species were increasing in numbers, and this has been attributed to the influx of nutrients. A progressive decline of migratory species has also been recorded (Espinach Ros, Delfino et al. 1994).

A large amount of the nutrient influx comes from the upstream cities of Bella Union (Artigas, Uruguay) and Monte Caseros (Corrientes, Argentina). If the concentration of phosphorus is used as a guideline, Salto Grande Reservoir can be classified as eutrophic; however, if the concentration of chlorophyll a is considered, the water body would be classified as oligotrophic (Comisión Técnica Mixta de Salto Grande 1992, Comisión Técnica Mixta de Salto Grande 1994).

The increased concentration of suspended solids in the Uruguay River and its tributaries is strongly related to both eutrophication and chemical pollution. Detrimental impacts of high concentrations of suspended solids include: the loss of soil, the transport of nutrients and chemical pollutants absorbed in silt and clay particles, and the disturbance of aquatic ecosystems due to habitat loss and modification. Highly turbid water also results in poor light penetration through the water column, which can limit algal growth.

Studies from Brazil estimate that rates of sediment loss in the Uruguay River Basin are between 75 to 100 tonnes/km^2/year, and measured average concentrations of suspended solids in the River are 100 mg/l, which makes this river basin one of the four most erosive regions in Brazil (Bordas et al. 1998, Empresa Brasileira de Pesquisas Agropecuarios 2002). In southwestern Brazilian sectors of the Middle Uruguay, desertification is occurring, and has intensified since the introduction of soybean monoculture in the 1980s (Suertegaray 2001). In Salto Grande Reservoir, the predicted sedimentation rate of 330 m^3/year is now estimated at 1 130 m^3/year (Irigoyen et al. 1998).

There is no data available from the Basin to quantify the economic impacts associated with the pollution of water supplies. Information on social impacts and health impacts also requires improvement.

Immediate causes

Chemical pollution

The application of biocides (herbicides and pesticides), inefficient irrigation, and the discharge of effluents are the primary immediate causes of chemical pollution in the Uruguay River.

Studies conducted by the Salto Grande Joint Technical Commission have concluded that 90% of the biocide contaminants in the Salto Grande Reservoir originate upstream of Bella Union/Monte Caseros. At more local scales, citrus farmers in Corrientes and Entre Ríos (Argentina), and in Salto (Uruguay) are also responsible for contamination. The main source of chemical contamination in the Middle and Lower Uruguay River can be traced to the application of herbicides on rice fields.

Intensive, inefficient irrigation is driven mainly by the high water availability in the area. The resulting low irrigation efficiencies permit high volumes of water contaminated with agro-chemicals to flow back into the drainage network. In the case of irrigated rice, more than half the water applied to fields returns to the hydrological system through drainage, percolation, and sub-surface flow.

The industrial and urban sectors both discharge polluted effluents into water bodies and streams. The pulp and paper, wood, and leather industries are the primary sources of chemical pollution in the Upper Uruguay's Brazilian sections (ANA 2002). In Uruguay, various small urban industries add to the problem further. Generally, there is a lack of independent treatment systems for industrial wastes; as a result, industrial effluents are often dumped into the urban collection system. An additional immediate cause originates from the inadequate disposal of urban and industrial solid wastes, which tends to leach pollutants into the hydrological system.

Microbiological pollution

The discharge of effluents (point-source pollution) is the primary immediate cause of microbiological pollution. Animal wastes (non point-source pollution) are a secondary immediate cause. Populated centres in all three countries in the study area are characterised by either inadequate wastewater treatment systems or a complete absence of treatment altogether. As a result, pathogens are rarely removed prior to the discharge of wastewater.

The state of Rio Grande do Sul in Brazil particularly lacks adequate treatment: in this state only 32% of urban effluents are collected, and only 22% of wastewater is treated, which is 12% below the Brazilian national average (IBGE 2002). However, other regions of the Basin are not performing much better. For example, Argentina's Misiones province only collects 21% of urban effluents, and Uruguay's Artigas city treats only 30% of its wastewater (Dirección Nacional de Medio Ambiente, Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente de Uruguay). Intensive breeding of poultry and pigs, in the Brazilian Upper and Middle Uruguay Basin also contribute large amounts of microbiological pollutants.

Eutrophication

Effluent discharges (point-source pollution) are the primary immediate causes of eutrophication. Additional immediate causes can be categorised as non point-source pollution, and are caused primarily by the application of fertilisers, inefficient irrigation practices, and soil erosion, as well as from animal wastes and leachate from solid wastes. Effluents discharged into streams contain nutrients from various industrial, commercial and household, wastes, including detergents. The industrial slaughter of cows, pigs, and poultry also tends to discharge effluents with high concentrations of nutrients.

The application of fertilisers (both organic and inorganic) contributes large influxes of phosphorus and nitrogen from the agricultural sector. Excess nutrients are often transported into rivers as run-off that results from inefficient irrigation practices. Rice cultivation in particular requires high rates of fertiliser application and intensive irrigation, which causes significant inputs of nutrients into rivers. From November to March, rice fields consume almost 15 000 m^3 of water per ha, and more than half of the water applied to rice fields returns to the hydrological system through drainage, percolation, and subsurface flow. As a result, rice cultivation is the primary cause of eutrophication in both the Middle Uruguay River and the beginning of the Lower Uruguay River.

Nutrients are also absorbed within silt and clay particles, and are transported into rivers by soil erosion. These mechanisms are considered as the main cause of eutrophication in the Upper Uruguay River. Animal wastes and the inadequate disposal of urban and industrial wastes provide additional nutrients that contribute to eutrophication.

Suspended solids

Soil erosion is the most important immediate cause of increased concentrations of suspended solids in rivers. The progressive deforestation of native forests and poor agricultural practices are the primary causes of soil erosion (IPH 1998). The intensive use of soil and poor land use practices has degraded and compacted soil structure and changed its' infiltration capacity, leading to high observed rates of soil erosion.

The largest influxes of suspended solids into rivers originates in the Brazilian sector of the Basin, where poor land use practices, deforestation, slash-and-burn agriculture, and heavy ploughing have all resulted in increased erosion. The mechanisation of agriculture, which began in the 1950s, further aggravated the situation. The worst extremes were reached in the 1970s, when soybean prices rose and fuelled rapid deforestation and an expansion of agriculture (IPH 1998). Recently, the urgent need to reduce soil erosion has brought about initiatives for more sustainable agricultural practices, including the introduction of direct sowing practices.

Root causes

This section first discusses root causes of pollution that are common across several economic sectors, and then proceeds to apply these root causes towards the analysis of agricultural practices and wastewater treatment systems. The end of the causal chain analysis discusses the cross-cutting theme of a lack of Integrated Water Resources Management (IWRM), and the need to establish river basin organisations. The causal chain is outlined in Figure 31.

Common root causes

Common root causes for the observed pollution of the Uruguay River Basin can be classified into five basic categories: economic, technological, legal, governance, and knowledge.

Economic

Economic root causes are also related to deficiencies in governance, law, and knowledge. The inadequate valuation of the benefits gained from environmental resources and services is a common, overarching root cause in all three countries in the Basin. Healthy rivers provide benefits to the economy (e.g. provision of fish habitat, flood control), to human health (e.g. clean drinking water, uncontaminated fish), and also indirectly to society (e.g. provision of recreational venues). These benefits are typically undervalued in policy-making and decision-making in the Uruguay Basin.

Market incentives favour short-term economic gain over long-term sustainability and environmentally friendly technologies. Because industrial chemicals and biocides can be obtained cheaply and tend to promote efficient production and competitiveness on the market, there are very large economic incentives for using these inputs. When combined with the lack of penalties for pollution, the high cost of installing wastewater treatment systems, the lack of enforcement of existing regulations, and the low cost of water due to its' high availability, this virtually ensures that industries and farmers will continue to pollute rivers.

Generally, there are no economic incentives to encourage compliance with environmental regulations. Higher operation costs associated with adherence to environmental regulations could be facilitated by tax credits or fiscal penalties ('polluter pays'), but this has not been occurring. In 2000, economic incentives and taxes were established as valid legal instruments for environmental management through Law 17 283 (Uruguay). However, such incentive policies have yet to be applied. Brazil has made the most progress towards solving this problem.

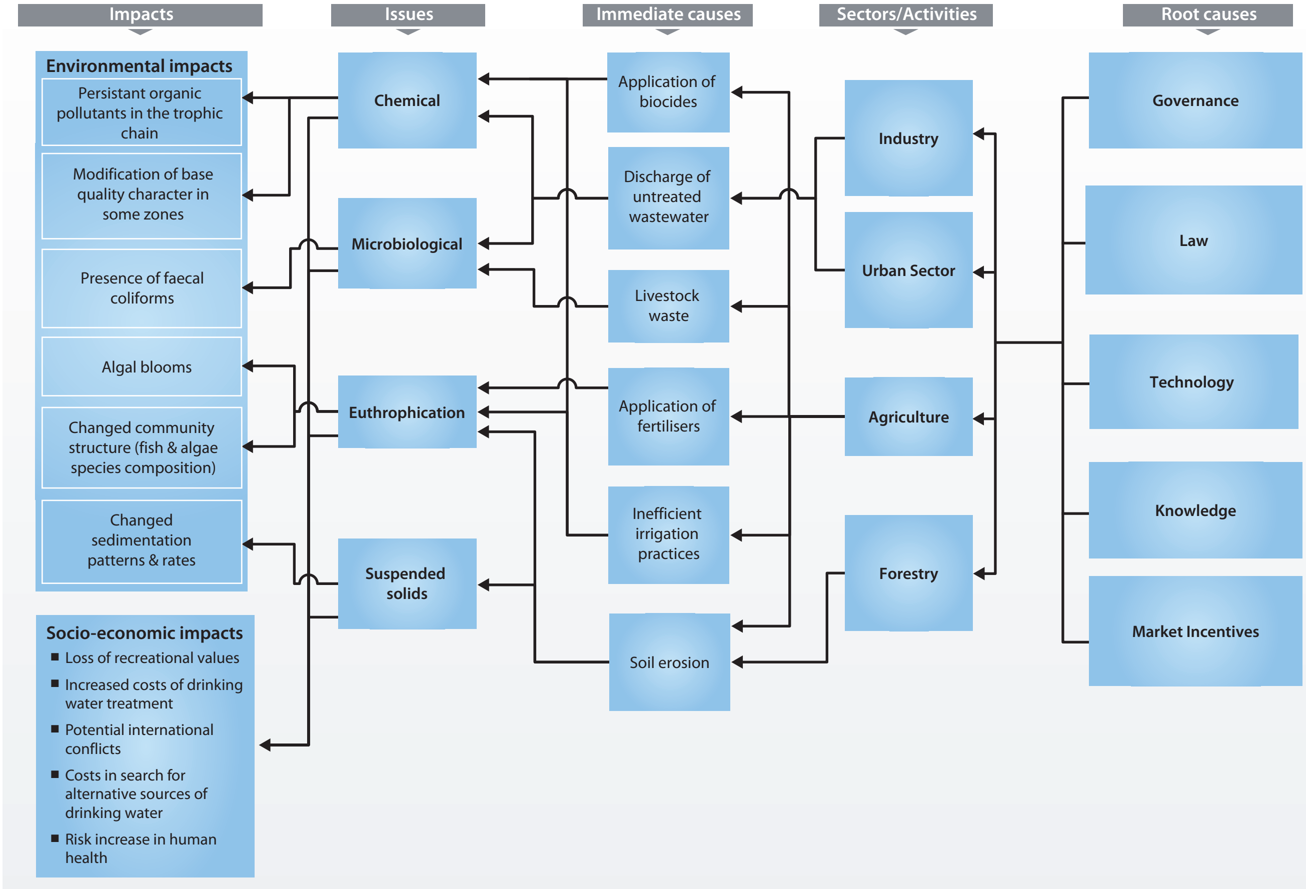

Figure 31 Causal chain diagram illustrating the causal links for Pollution in the Uruguay River Basin.

The existence of poverty also is tied in with several aspects of pollution. Most apparent is the fact that the poorest sectors of the Basin cannot finance urban wastewater treatment infrastructure. In addition, poor farmers generally do not have the means to apply environmentally friendly practices in the absence of external assistance.

Finally, it is important to highlight that in the Argentinean and Uruguayan regions of the Basin, a large proportion of the goods produced are fuelled by demands created by export markets located in Brazil.

Governance & Law

Various environmental laws and regulations have been developed in each of the three countries. Multilateral agreements have also been reached concerning water resources shared by more than one country. However, the capacity to promote conformity and fulfil agreements and policies is generally very low. As a result, the national, provincial, and state bodies responsible for environmental issues often fail to enforce decrees and laws.

For example, in Argentina, a 1997 report by AIDIS Argentina concluded that environmental legislation has been inefficient and has not achieved its intended results (World Bank Group 1999). Inefficient environmental legislation and a lack of human and financial resources to enforce environmental policies has also been reported from Uruguay and Brazil. In Uruguay, the absence of legal actions against polluters demonstrates a lack of resources assigned to enable monitoring of the effluents discharged into rivers (Dames & Moore 1999). In 1996, the budget assigned to "Dirección Nacional de Medio Ambiente" represented only 0.03% of Uruguay's national budget. In Argentina, provinces in the Uruguay River Basin allocated less than 4% of their financial resources towards water resources monitoring and management (World Bank Group 1999). Therefore, a primary reason for the observed lack of enforcement of agreements and policies are the inadequate budgets assigned to environmental assessment and environmental regulation. Due to low salaries within those institutions responsible for management, experienced personnel with the relevant technical training and competence often turn to other activities.

Mechanisms to promote participatory decision-making are often inadequate, and when they do exist they are not implemented in an effective way. The negotiation capacity and economic influence of specific groups often disproportionately influences existing power structures and contributes to the disregard of environmental legislation, and the delay of potential solutions to pollution problems.

A general lack of policy coordination across the various levels of government (national, state/provincial, local, etc.) compounds the problem further. Because environmental legislation has been developed differently in all three countries, it is difficult to achieve a coordinated approach at the basin level. Furthermore, national and regional policies for economic development are often poorly coordinated with environmental policies. In Argentina, provincial authorities are responsible for the management of natural resources, yet these provincial bodies often do not consider existing national or regional policies or agreements that are relevant to water resources management. In Uruguay, although industrial effluent discharges have been regulated since 1979 based on permissible discharge concentrations, activities responsible for producing urban and industrial solid wastes are not regulated at the national level. In Brazil, regulations related to water resources at national and state levels have advanced in recent years, but require additional fine-tuning.

Knowledge

A lack of technical studies on superficial water resources is evident in all parts of the Uruguay River Basin. Consequently, it is difficult to accurately determine the magnitude of impacts resulting from the pollution of water resources (including groundwater). The absence of data is particularly evident within the Pepiri Guazú River Basin, which makes it impossible to carry out an adequate assessment or causal chain analysis.

The general lack of awareness of environmental concerns in society exacerbates the situation further. Water is perceived as a plentiful resource that is easily able to cope with the discharge of wastes. These perceptions make it difficult to implement a tax policy for the use and contamination of water resources in the Basin. The poor commitment from society to environmental issues has led to inadequacies in urban and industrial wastewater treatment systems, with the exception of specific cases where these inadequacies have resulted in direct, highly visible impacts on public interests. The lack of vision and awareness of environmental issues among the productive workforce also delays the development and utilisation of new products that would have fewer environmental externalities.

Root causes for agricultural practices

Environmentally damaging and unsustainable agricultural practices persist throughout the Basin.

Economic

Market incentives for short-term economic gain virtually assure the continued persistence of both biocides and fertilisers due to the aggressive marketing campaigns of the agro-chemical companies and the high yields obtained when these inputs are used. Unless widespread outbreaks of biocide-resistant insect plagues or weed infestations occur, farmers are not likely to invest in environmentally-friendly practices such as the biological control of pests and weeds. Market incentives have also encouraged the existence of monocultures, such as the highly destructive soybean monocultures.

Governance & Law

Despite existing regulations, several biocides officially restricted or prohibited have been detected in water samples. This reveals that the enforcement of existing regulations pertaining to biocides is inadequate.

Knowledge & Technology

Poor access to scientific and technological knowledge and training hampers efforts to determine the environmental impacts of biocides with scientific studies. Each of the three countries has almost 600 registered agro-chemicals, and determining the impacts of all of these as well as the interactions and cumulative effects between multiple compounds requires highly skilled staff, expensive sampling campaigns, and complex analyses. Controlling the distribution and application of biocides after negative impacts are identified is also likely to be both difficult and expensive. Complicating the issue is the fact that the public and farmers are both usually unaware of the negative effects and health risks associated with the use of biocides.

Poor access to knowledge on tilling methods that would conserve soil structure and reduce soil erosion has also been an issue, although campaigns to introduce direct sowing techniques are beginning to address this problem.

There is inadequate access to technology and knowledge to improve irrigation efficiencies. When combined with the high availability and low cost of water, this effectively prevents farmers from adopting irrigation practices that would decrease their profligate use of water. As a result, agro-chemicals continue to contaminate waters when they are leached into excess run-off from farms.

Root causes for urban & industrial effluent discharges

The discharge of wastewater by the urban and industrial sectors are linked to several common root causes. In fact, industrial wastewater often enters the urban disposal system in many municipalities, which means that many policy options to address this issue should analyse both the urban and industrial sectors together as one system.

Economic

Poverty is a problem that is more applicable to the analysis of deficiencies in the treatment of urban wastewater. In the poorest areas, returns on investments made in infrastructure works and water treatment would not be amortised with tariffs collected from users.

Market incentives for wastewater treatment are generally poorly developed or completely absent. Although fees are sometimes assessed for discharging industrial effluents into urban wastewater networks, industries responsible for polluting water resources usually are not penalised. As a result, there are no economic incentives to discourage industries from dumping wastes into urban collection systems.

Governance & Law

Poor enforcement of existing regulations is a major problem that impedes the adequate treatment of wastewater. In particular, tasks associated with pollution control systems are often centralised in national or regional governments, and coordination with local governments remains highly inadequate.

The inadequate participation of stakeholders in decision-making processes makes it difficult to effectively manage pollution. The impacts of industrial pollution tend to affect many components of the environment and many components of society, yet the benefits of industrial production tend to flow only to specific groups, which is a classic case of the 'tragedy of the commons' (Hardin 1968). For example, communities downstream from wastewater discharges are usually impacted most by pollution, yet decision-makers acting at the scale necessary for improving treatment often do not incorporate the perspectives of these downstream stakeholders and do not consider the impacts that inadequate wastewater treatment will have on their interests. Efforts to avoid such tragedies requires improving governance by involving stakeholders more during decision-making and policy-making, and allocating authority at scales that enable meaningful governance to occur based on the boundaries of specific impacts (Dietz et al. 2003).

Cross-cutting root cause

Lack of Integrated Water Resources Management

Most problems related to governance are further rooted in the lack of effective mechanisms to encourage integrated water resources management. In the absence of a cross-sectoral multidisciplinary analysis of the competing interests placed on water resources, it is not possible to effectively integrate environmental, socio-economic, and developmental aspects into management (Agarwal et al. 2000).

The creation of management organisations at the river basin level (River Basin Organisations) could be the first step towards coordinating actions and improving the management of water resources. However, any decisions made by such organisations must coordinate the different levels of government involved to explicitly reflect their policies.

The Brazilian sector of the Basin has made the most progress towards achieving such integrated management. Since 1998, the National Council of Water Resources (Consejo Nacional de Recursos Hídricos) has been active at national level, and Law 9 433 and Decree 2 612 are both directly applicable. Brazil has also installed basin committees in the Uruguay River Basin. However, although Brazilian water management systems exist at the national level, effective initiatives at the state or local levels is lagging behind. In addition, there is a strong need for a greater degree of multilateral cooperation between Brazil, Argentina, and Uruguay.

A positive step was the creation of the River Cuareim Commission (CRC) by Brazil and Uruguay in 1991, which is intended to coordinate actions related to the shared Cuareim River. Furthermore, in an effort to increase public participation to assist in identifying issues within the Basin, and to achieve effective representation of the interests of Uruguayan citizens in the CRC, Uruguay created a Local Coordination Committee in 1999 (Comisión del Río Cuareim 2002).

Another positive development was the signing of the Uruguay River Statute between Argentina and Uruguay, which led to the Administrative Commission for the Uruguay River (CARU-Comisión Administradora del Río Uruguay). Argentina and Uruguay have also developed the Cooperation Agreement to help coordinate the fight against aquatic pollution.

These recent institutional developments seem to be working towards the type of nested institutions that are considered to be necessary for the comprehensive management of water resources (Dietz et al. 2003). However, to work towards Integrated Water Resources Management, there is still much room for improving the dialogue between different stakeholders in the River Basin.

Buenos Aires Coastal Ecosystem – Argentinean-Uruguayan Common Fishing Zone

The Buenos Aires Coastal Ecosystem and the Argentinean-Uruguayan Common Fishing Zone (Figure 32) was selected a as case study to illustrate the Causal chain and Policy option analyses for Habitat and community modification. There were three reasons behind this choice. First, the system is the richest marine ecosystem in the Patagonian Shelf region. Second, it is an important area from a socio-economic point of view for both Argentina and Uruguay. Finally, there are clear signs of transboundary impacts.

Transboundary impacts from Habitat and community modification in the South Atlantic Drainage System are higher in the oceanic component. According to the Assessment, the most severe impact is due to overexploitation of living resources. Within the oceanic component of the system, the northern zone is more representative since it exhibits transboundary impacts at both bi-national and sub-national levels.

The jurisdiction of the Common Fishing Zone is national for both Argentina and Uruguay, which manage their marine and fisheries resources together by means of the La Plata River Administrative Commission, as established by the 'Treaty on the La Plata River and its Maritime Front'. The jurisdiction of the Buenos Aires Coastal Ecosystem, which extends 12 nautical miles from the coast, belongs to the province of Buenos Aires, and the remainder belongs to Argentina, in agreement with the federal fishing regime.

The most significant immediate causes of ecosystem modification are: overexploitation of target species, by-catch, modification of sea bottom by fishing gear, and pollution by land sources and hydrocarbons. The first three are related to fishing activities, while the last is associated with urban development and sewage, industrial effluents, agricultural run-off, and operational spills in the maritime sector.

Root causes are directly related to the policy level at which they can be influenced (national level in Argentina and Uruguay). Both nations have appropriate legal frameworks that are generally adequate. In addition, they have signed the 'Treaty of La Plata River and its Maritime Front'. Nevertheless, the application of legal instruments remains inefficient due to a lack of control, inadequate budgets for research and management, a lack of qualified personnel, a lack of technology, and socio-cultural resistance to the introduction of new fishing techniques.

System description

Physical and natural aspects

The system that is analysed (Figure 32) comprises the Argentinean-Uruguayan Common Fishing Zone and the Buenos Aires Coastal Ecosystem. The Argentinean-Uruguayan Common Fishing Zone is bounded by the 12 nautical mile coastal limit and the 200 nautical mile arcs extending from Punta del Este (Uruguay) and Punta Rasa (Argentina). The Buenos Aires Coastal Ecosystem extends from the coast to the 50 m depth contour, and is bounded at its southern limit by the 41° latitude (San Matías Gulf - ecotone), and at its northern limit by the border between Uruguay and Brazil. The Causal chain and Policy options analyses are carried out in the portion of this aquatic system considered to fall within the boundaries of GIWA region 38.

Buenos Aires' northeast coast is the most important sediment deposition area in Argentina (Codignotto 1997). However, dune forestation, sand extraction, and urban development have all contributed towards coastal erosion. Sand extraction has changed beach profiles, while the development and forestation of dunes has caused coastal erosion by preventing sand stored in the dune from replenishing beaches (Dadon et al. 2002).

Platform waters are mainly formed by sub-Antarctic waters from the North Drake Passage, and by waters from the Malvinas Current. The waters are modified by continental discharge and ocean-atmospheric interactions. The most important continental tributaries are the La Plata and Negro rivers. Over the continental slope and in a north-south direction, the warm Brazil Current can be observed transporting

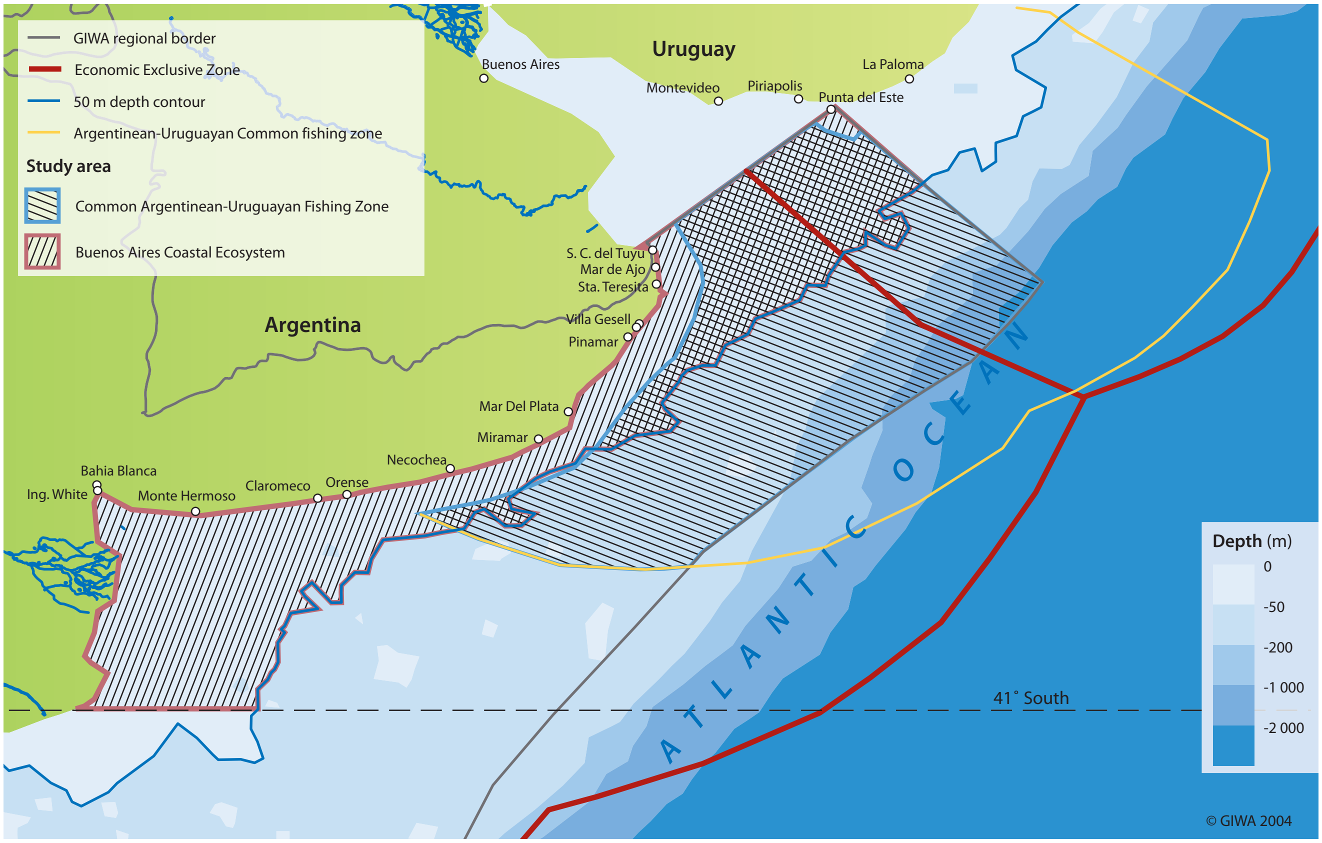

Figure 32 Buenos Aires Coastal Ecosystem and Argentinean-Uruguayan Fishing Zone and their relative location in South Atlantic Drainage System.

sub-tropical waters to 36° S-38° S, where it converges with the Malvinas Current and defines the sub-tropical confluence.

The Argentinean-Uruguayan Common Fishing Zone is an administrative area that corresponds with the environmental area of the La Plata River Maritime Front. Here, the waters discharged into the La Plata River interact with the platform waters defining a long marine front characterised by marked salinity gradients. The mixture and diffusion of salt between both systems and the drift currents, forced by the winds, govern the balance of this front. The waters resulting from these processes are those that characterise the central platform waters north of the 38° S and those that interact along the front slope with the Brazil-Malvinas confluence system.

The Buenos Aires Coastal Ecosystem corresponds with the Argentinean bio-geographical province (Lasta et al. 1998), where the cyclic influence of elements from the western area of the Brazil Current has been observed in summer. In this area, water volumes exhibiting different characteristics can be distinguished. The first is the Argentinean-Uruguayan Common Fishing Zone statutory area, which consists of an upper layer diluted by continental run-off and a bottom layer with high salinity from the intermediate platform (Lasta et al. 1998). The second is the Buenos Aires province central coastal area (between 37° S and 38° 20' S), defined by a 30 km strip with waters originating from the platform. In spring and summer, thermal tidal fronts limited to the coastal region can be observed. These fronts divide stratified outer waters and vertically mixed inner waters (Lasta et al. 1998). These fronts are areas where high concentrations of plankton and particulate material accumulate and augment productivity.

In the El Rincon area, waters are characterised by two well-defined regimes. The first is formed by platform waters flowing from the south along the mid platform current; the second corresponds to a coastal strip with waters diluted by the continental contributions of the Negro and, to a lesser extent, Colorado rivers (Carroza et al. 2001b, Lasta et al. 1998). Between these two regimes, a coastal front is defined by high salinity gradients oriented in a north-south direction. There is also a high salinity discharge from San Matías Gulf (Guerrero & Piola 1997).

The eastern limit of the Buenos Aires Coastal Ecosystem coincides with the location of the thermal front. It is a stable and diverse ecosystem that is an important area for the reproduction and breeding of many different species (Boschi et al. 2001). The fish fauna is dominated by the family Serranidae (White sea bass, Small net hake, Black small hake, "Pargo" and Black sea bass) and is part of the "Buenos Aires coastal demersal fish assemblage" (Carroza et al. 2001a). About 30 species are fished in the region, and White sea bass and Small net hake are the most important. There is also a considerable catch of shrimp and prawn (Boschi et al. 2001).

In the Argentinean-Uruguayan Common Fishing Zone, two other fisheries can be distinguished by the depth at which they are located. The inner and outer platform fishery (50-225 m) is characterised by relatively high biological potential. It consists of a group of about 38 resident species: hake, codfish, spiny dogfish, "Pintarroja", "Castañeta" and various species of sole and "Nototenias"; while the small anchovy ("Anchoita") is the most important species in the pelagic community. The second fishery is the talus deep water fishery (220-300 m), which consists of typical species from the Malvinas Current. The grenadier dominates the benthic community, and the "Polaca", Common hake, Austral hake, and Tail hake dominate the pelagic community.

At regional level, the introduction of alien species into the benthic community has been detected. The main alien species identified are *Undaria pinnatifida* and *Balanus glandula*, which have been transported to the region on the hulls of ships or in bilge water.

Pollution resulting from the dumping of sewage or industrial and agro-chemical effluents exerts pressure on the ecosystems along the Atlantic coast of Argentina and Uruguay. The so-called 'Maritime Front' of the La Plata River defines the limit of the Argentinean-Uruguayan Common Fishing Zone, and receives residual and industrial waters from both Buenos Aires and Montevideo. It is also impacted by intense maritime traffic and port activities.

Table 36 Total population and inter-census population growth of main coastal cities in selected oceanic systems.

City	Total population		Inter-census population growth (%)
	1991	2001	
Mar del Plata	512 880	541 857	5.6
Bahía Blanca	260 096	272 176	4.6
Necochea- Quequén	73 276	78 556	7.2
Mar de Ajó-San Bernardo	17 016	24 800	45.7
Miramar	19 569	24 076	23.0
Villa Gesell	15 555	21 740	39.8
Pinamar-Ostende	10 242	20 189	97.1
Santa Teresita-Mar del Tuyú	11 862	19 873	67.5
San Clemente del Tuyú	7 987	11 056	38.4
Punta del Este[1]	6 731	8 294	23.3

Note: [1]Punta del Este data from censuses of 1985 and 1996. (Source: INDEC 2001, INE 1996)

Socio-economic aspects

In Argentina, the Federal Fishing Council was created in 1998 to establish a national fishing policy. In Uruguay, there is a Law of Estate Property and Jurisdiction over living resources.

Important coastal urban centres include Mar del Plata, Bahía Blanca, Necochea (Argentina) and Punta del Este (Uruguay). Populations of the main coastal cities are presented in Table 36. The data show growth in all locations, especially in the regions north of Mar del Plata, such as Pinamar-Ostende, Santa Teresita-Mar del Tuyú, and Mar de Ajo-San Bernardo (Figure 32). These seaside resorts grew at a very intense pace during the second half of the 20th century, and are one of the most dynamic regions in the country.

The main ports in the province of Buenos Aires are Mar del Plata, Necochea-Quequén, Ingeniero White and Bahía Blanca. Table 37 shows the total catch landed at these ports during the 1990s. The main Uruguayan ports that receive catches from the fleet operating in the Argentinean-Uruguayan Common Fishing Zone include Montevideo, Piriápolis and La Paloma (Table 38).

Table 37 Fish landing in the main ports of Buenos Aires province, Argentina 1991-2000.

Port	Catchment by year (tonnes)									
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Bahía Blanca	18 200	8 54	20 641	1 862	2 674	23 681	26 630	21 415	11 446	9 803
Ingeniero White	36 256	18 563	32 694	19 576	20 631	ND	ND	ND	ND	ND
Mar del Plata	301 867	300 837	313 111	323 034	439 811	473 814	442 009	346 286	16 547	20 950
Necochea-Quequén	20 950	37 598	25 574	21 757	32 128	28 109	43 758	38 848	41 374	32 184
Total	377 273	365 551	392 019	366 229	495 243	525 604	512 398	406 549	69 367	62 937

(Source: SAGPyA Dirección Nacional de Pesca y Acuicultura 2002)

Table 38 Fish landings in the main Uruguayan ports.

Port	Landing by year (tonnes)	
	2000	2001
La Paloma	3 169	3 084
Piriápolis	461	566
Montevideo	109 780	96 595

(Source: DINARA 2003)

The most important coastal species unloaded in the Buenos Aires Coastal Ecosystem between 1986 and 1999 included White sea bass, small net hake, "Gatuzo", Sole, and "Palo". After 1992, there has been an increase in the species unloaded as "coastal assort" (Carroza et al. 2001a). Figure 33 illustrates the average landings of each of the main species in the coastal fishery between 1992 and 1999.

Argentina and Uruguay share the north hake stock. Data describing the catches of deep-sea species in ports in the province of Buenos Aires between 1986 and 1992 show the importance of Common hake. Cod and squid follow with a lower percentage. Common hake is also the dominant species caught by the Uruguayan fleet in the Argentinean-Uruguayan Common Fishing Zone. Other important species unloaded in Uruguayan ports include Sea bass, "pescadilla" (Striped weakfish), and squid (Figure 34).

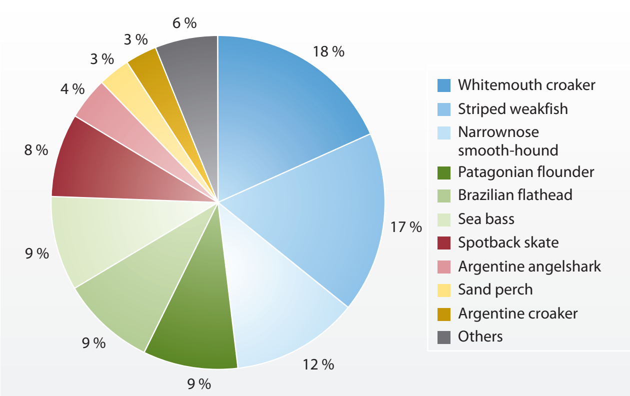

Figure 33 Average landings of main species in the Buenos Aires Coastal Ecosystem,1992-1999.
(Source: Carozza et al. 2001)

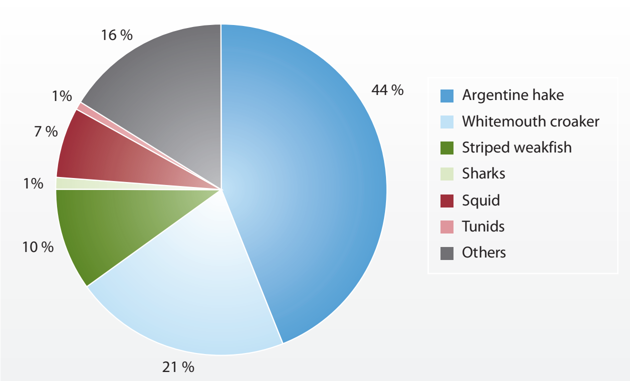

Figure 34 Average landings of main species unloaded in Uruguayan ports, 1992-1999.
(Source: INE 2002)

The most recent stock assessments seem to indicate overexploitation. In addition, many small hake and a number of other species are accidentally caught while bottom trawling for hake. The Maritime Front Technical Commission regulates fishing in the Argentinean-Uruguayan Common Fishing Zone. This commission determines the hake catch quota for both countries, sets fishing gear restrictions, and has prohibited fishing in some areas. This has resulted in decreased landings of hake, especially from 1991 (Figure 35).

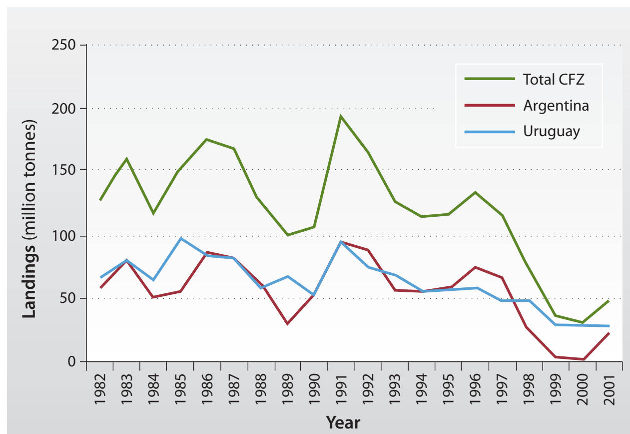

Figure 35 Hake landings in the Common Fishing Zone.
(Source: Dirección Nacional de Resursos Acuáticos 2003)

In the Buenos Aires Coastal Ecosystem and the Argentinean-Uruguayan Common Fishing Zone, three fleet types operate: roads or estuary, coastal, and high sea. Table 39 shows the trend in landings from the three fleet types between 1992 and 1999 in ports located in Buenos Aires province. The table shows that the coastal fleet have contributed between 40 to 60% of total annual catches.

The fishing industry in the province of Buenos Aires plays an important role in relation to the rest of the country. For example, 71% of fish processing plants have been established in this province. Almost all of the industrial fishing activities (96%) are located in the port of Mar del Plata, with the exception of the dry salting process, which takes place in Necochea, Quequén and other areas (Bertolotti et al. 2001b).

Between 1982 and 1996, the number of operating plants was stable, with the port of Mar del Plata contributing 80% of the production.

Table 39 Landing by type of fleet in Buenos Aires province ports, Argentina.

Year	Landing by type of fleet (%)		
	Estuary	Coastal	High sea
1992	36.27	42.00	21.73
1993	20.96	50.32	28.72
1994	22.41	50.76	26.83
1995	20.81	51.06	28.13
1996	16.33	51.59	32.09
1997	14.60	49.75	14.60
1998	6.33	53.07	40.60
1999	13.78	55.99	30.23

(Source: Carroza et al. 2001)

Mar del Plata is also the most important fish supplier for the Argentinean domestic market, with percentages varying from 90% of sales in 1993 to 85% in 1997 (Bertolotti et al. 2001b).

Fish-farming is not yet a fully developed activity in Argentina and Uruguay. According to data from the FAO, in 2000, Argentina produced 1 784 tonnes of aquaculture products, and Uruguay produced 85 tonnes (DINARA 2003). The Japanese oyster (*Crossostrea gigas*), which was accidentally introduced to the areas of Bahía Blanca and San Blas, is commercially exploited in the Buenos Aires Coastal Ecosystem. This species later formed a natural shoal, from which mature individuals were selected in order to obtain artificial seed in laboratories (SAGPyA 2003).

Tourism in the province of Buenos Aires is focused on the Buenos Aires Tourist Corridor ("Corredor Turistico Bonaerense"), which extends 1 300 km between Punta Rasa on the San Antonio Cape and the mouth of the Negro River, and receives 7.5 million tourists per year (Dadon et al. 2002). In the Corridor, Mar del Plata is the most visited tourist city in Argentina (about 3 million visitors a year). The development of seaside resorts has caused coastal erosion, pollution, biodiversity changes and pressure on drinking water supplies (Dadon et al. 2002).

Along the Uruguayan coast, Punta del Este is the second largest tourist destination in Uruguay, and received between 0.5 to 0.6 million tourists in 1999-2001 (INE 2002). The beaches are very popular in summer and suffer various impacts related to sand extraction (dune removal) and pollution resulting from the discharge of domestic sewage (OEA 1992, BID et al. 1992).

Causal model and links

With the aim of identifying the root causes of major transboundary environmental and socio-economic impacts, this report focused on those issues with the highest relative impact within the selected major concern, according to the best available information and the presence of indicators. The most significant immediate causes were those related to the unsustainable exploitation of living marine resources, which has also been linked to habitat and community modification. Indicators supporting this hypothesis have included: progressive decreases in biomass, depletion of fishery resources, excessive by-catch, and mortality of specimens from higher trophic levels due to interactions with fisheries. In both countries, this is directly related to the implementation of development policies for the fishing sector that were devoid of sustainability criteria.

Presently, it is difficult to assign priorities according to the magnitude of impacts of various anthropogenic activities in the area, due to the lack of interdisciplinary studies that describe the impacts on a regional scale. Nevertheless, the following order of priority for transboundary impacts has been suggested:

1. Overexploitation, by-catch, and modification of the sea bottom by fishing activities;
2. Pollution from shipping activities;
3 Coastal habitat destruction by urban development, mining, and navigation;
4. Introduction of alien species, particularly from aquaculture.

It is important to highlight the expected contributions from the "Strategic Action Plan for the Environmental Protection of the La Plata River and its Maritime Front" Project (FREPLATA-GEF-UNDP), which includes these issues and is currently in progress. In the "Environmental Diagnosis" 1998 Form, there is a full compilation of available bibliographic information and research projects in the La Plata River - Common Fishing Zone and neighbouring systems (coastal systems of both countries). The conclusion was that there is insufficient baseline data describing the various ecological characteristics of the region and that the scarcity of interdisciplinary projects has hindered the understanding of the ecological processes of the area.

To offer an integrated view of the area, a Causal chain analysis was conducted including all the major immediate causes responsible for habitat and community modification. A preliminary cause checklist has been prepared and sorted according to priorities. This list will either be corroborated or rectified with contributions from the "Environmental Protection of the La Plata River and is Maritime Front"

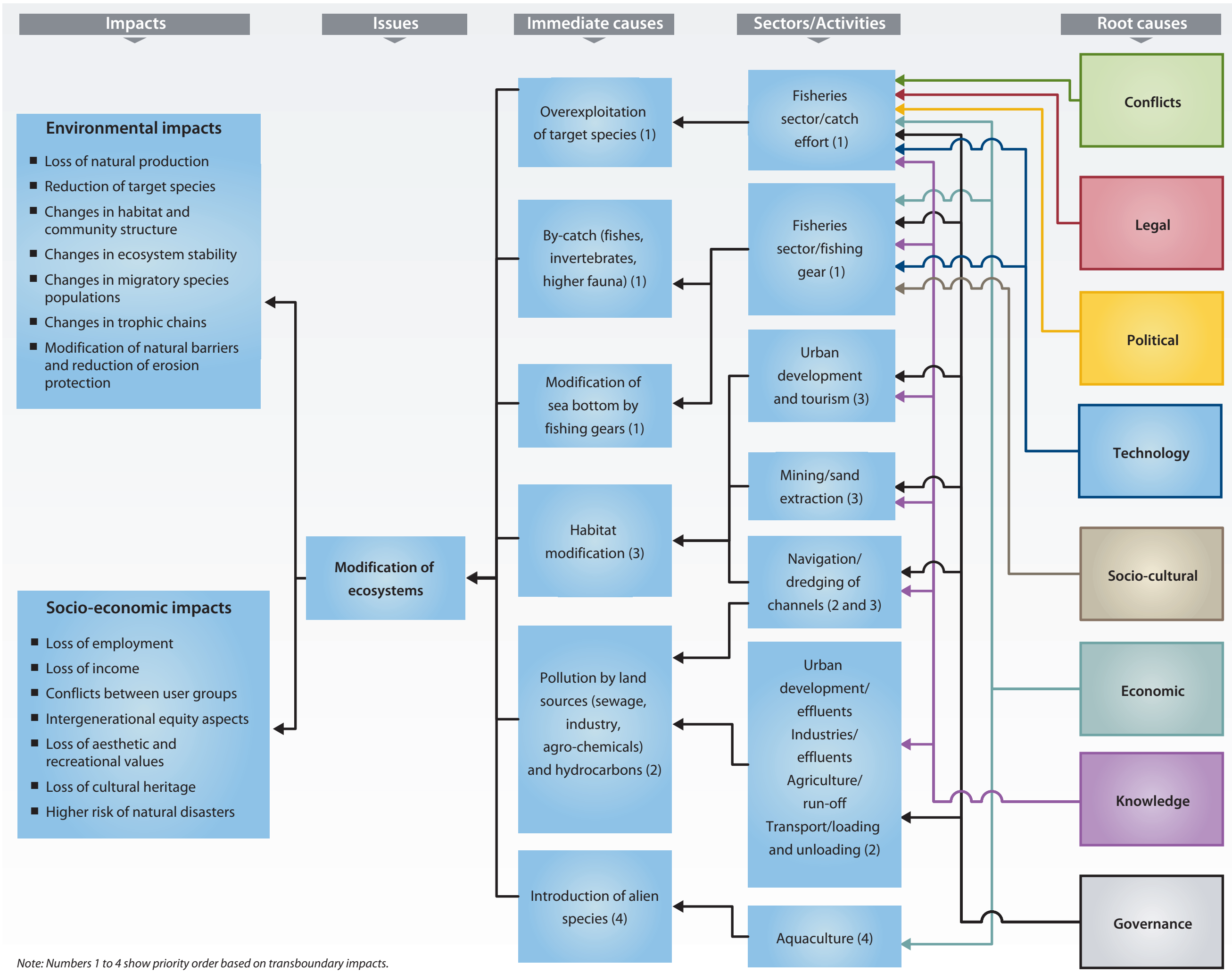

Figure 36 Causal chain diagram illustrating the causal links for Habitat and community modification in the Buenos Aires Coastal Ecosystem – Argentinean-Uruguayan Common Fishing Zone.

Project. However, policy option analysis will be carried out only for the issue and immediate causes identified as Priority 1 according to transboundary environmental and socio-economic impacts. The causal chain is outlined in Figure 36.

Impacts of overexploitation

Marine living resources are subject to intense fishing pressures within both countries, producing a critical situation due to unsustainable exploitation. The overexploitation of target species (assigned Priority 1) was noted. The fishing sector was identified as responsible and the specific activity addressed was the level of fishing effort.

For the northern stock of Argentinean hake (*Merluccius hubbsi*), fishing effort approximately doubled from 1989 to 1998, and eventually declined in 2000 due to the restrictive measures imposed on this resource by Argentina (Irusta 2002). Total biomass and reproductive biomass for this species both decreased drastically over the period 1986-1999 (INIDEP 2000). Landed catch integrated to 50% by age-2 juveniles also decreased rapidly over this period (Renzi et al. 1999). Catch per Unit Effort (CPUE) has been reduced drastically by 72% (Irusta 2002). Total effort has also dropped, particularly in 2000 due to the imposition of restrictive management measures (Irusta 2002).

In the multi-species coastal fishery, the overall trend from 1992-1999 indicates decreased catches, despite the increase in fishing effort (hours) (Figure 37) (Massa et al. 2000). After 1997, there are sharp decreases in total landings due to lower Whitemouth croaker (*Micropogonias furnieri*) catch and an increase in the proportion of "Skates" landed (Massa et al. 2000). For Whitemouth croaker, the main target species for both countries, significant declines in landings have occurred, and the

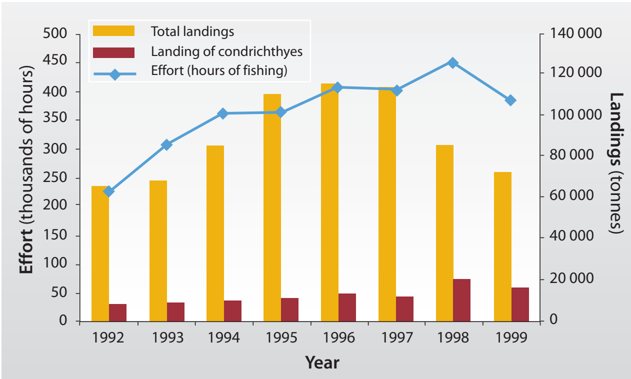

Figure 37 Effort, total landings and landing of condrichthyes from the coastal fleet of Buenos Aires and Uruguay.
(Source: Massa et al. 2000)

conservation status of this resource is a matter of controversy for both countries. The biomass for most species of bony fish targeted in the multi-species coastal fishery have also shown decreasing trends (INIDEP Coastal Project 2003).

A decrease in mean density of fish belonging to the group Condrichthyes have also been observed, with a reduction in the distribution of Electric ray (*Discopyge tschudii*), Elephant fish (*Callorhynchus callorhynchus*) and Tope shark (*Galeorhinus galeus*) (Massa et al. 2000).

Impacts of by-catch

The proportion of by-catch and discards (assigned Priority 1) are presumably high in this area due to the indiscriminate use of fishing gear (bottom trawl-net) and the high local exploitation dynamics. Although there is only one report assessing discard rates of the Argentinean ice-chiller and freezer fleets during 1998 (Cañete et al. 1999), it suggests that discards vary according to latitude, depth, season and fleet type. Therefore, permanent monitoring over several seasons is needed to estimate the impact of discards on biotic communities. Discard rates for coastal fisheries have not been estimated, although fisheries scientists constantly stress the need for additional studies to assess the effectiveness of various management alternatives. For instance, some species historically discarded in Argentina, such as *Myliobatis* spp., are possibly "keystone species" that exert significantly greater effects on ecosystems than suggested by their abundance (Power et al. 1996).

There are reports on incidental catches of marine mammals of the following species: La Plata dolphin (*Pontoporia blainvillei*) by Argentinean and Uruguayan artisan coastal fisheries, Dusky dolphin (*Lagenorhynchus obscurus*) in fisheries for Argentinean anchovy, Burmeister's porpoise (*Phocoena spinipinnis*) in Buenos Aires coastal fisheries, Common dolphin (*Delphinus delphis*) in fisheries for Argentinean anchovy, and the Southern sea lion (*Otaria flavescens*) within both coastal and offshore bottom trawl-nets. These species are included in different categories in appendices and lists from CITES and IUCN and CMS (Convention of Migratory Species) (Cané et al. 1999).

There are also reports of accidental catches of albatrosses, petrels, shearwaters, cormorants and seagulls in the Buenos Aires coastal and offshore fishing grounds. Green turtles and false carey have also been accidentally caught in coastal fishing grounds, particularly in the northern area of the Buenos Aires province (Cané et al. 1999).

Impacts of destructive fishing practices

The type of fishing gear used and the intensity of bottom trawl operations significantly modifies benthic communities and the sea bottom (assigned Priority 1). However, further research is required to determine the extent to which this affects ecosystem dynamics and long-term productivity.

Impacts of pollution

The intense maritime traffic, especially in the Common Fishing Zone, is a potential source of pollution and also requires continuous dredging of access waterways to harbours. In turn, this has direct impacts on habitats and associated communities. In this area, there are no designated navigation routes.

Along the Atlantic coast of both countries, there are reports of contamination by industrial, urban, and agro-chemical sources, as well as oil pollution (assigned Priority 2). Pollution by sewage effluents (urban development/effluent discharge) occurs in the main coastal urban centres, such as Mar del Plata, Bahía Blanca, and Punta del Este. Contamination by industrial effluents (industries/effluent discharge) is also present in these locations. Both countries engage in intense agricultural activities (agriculture/agricultural run-offs) in continental areas, which leads to the contamination of the Buenos Aires Coastal Ecosystem with fertilisers and agro-chemicals transported by rivers or as direct run-off. Oil contamination has also been reported (transport/charge and discharge) due to accidental spills, run-off and spillage in oil station operations, leaks during refilling and unloading, tank washing, and bilge water (Formulation of the Strategic Action Plan for the Environmental Protection of the La Plata River and its Maritime Front 1998).

Impacts of modification of coastal habitats

Immediate causes of habitat modification (assigned Priority 3) include urban development, tourism, and mining in the coastal areas of Buenos Aires province (Argentina) and Uruguay. These activities damage ecosystems on the coastal margin, contribute to habitat loss or modification, coastal erosion, and a higher risk of natural disasters. Harbour or pier construction, sand dune immobilisation, rain outlets, and sand extraction are activities that have altered the natural balance of beaches and subsequently caused the loss of aesthetic and recreational values.

Impacts of introduction of alien species

The introduction of alien species was assigned Priority 4. There has been a notable increase in the abundance of Pacific oysters (*Crassostrea gigas*) in the south of the Buenos Aires Province (Argentina), with differing opinions on the impact of this species on the ecosystem. Currently, there is no evidence that the introduction of this alien species has had negative impacts on marine ecosystems.

Root causes

Root causes related to overexploitation of target species

The influence of international markets was identified as one of the most relevant root causes related to overexploitation. For Argentina, there are some legal aspects related to the presence of vessels with unlimited fishing licenses, as well as aspects related to governance, such as the failure to regulate fishing effort in the Buenos Aires Coastal Ecosystem (Consejo Federal Pesquero 2001). Within both countries, these trends are reinforced by failures in the control and surveillance systems, and a lack of budget for an adequate assessment of the Buenos Aires Coastal Ecosystem.

In addition, within both countries, failures were identified in data management, and a general lack of knowledge concerning biological and socio-economic aspects of fisheries. The most important political root causes are disagreements between Argentina and Uruguay related to the administration of shared marine resources. Lack of expert advice was also identified as a technological root cause.

Economic

One of the most relevant root causes associated with overexploitation in both countries is the presence of important international markets. The Brazilian and European market for hake fillet is one example. In Argentina, the opening of Asian markets for Whitemouth croaker during 1992 contributed to the overexploitation of this species. In the same way, the opening of the European and Asian markets for the group of "rays" produced a significant increase in catches, estimated at 30 000 tonnes (Argentinean fishing statistics). Argentina is included within the countries that intensively exploit these resources (Rose 1996).

Markets (both countries): "Without the participation of all pertinent markets, programmes of fishery conservation do not have any possibility of success. The powerful international convention existing nowadays for the protection of endangered species could help in the future to enforce conservation measures, but for now it lacks experience" (Le Blanc 2003). This paragraph summarises to a certain extent how little states can do at the local level to influence international fish markets.

Entrepreneurial profit (Argentina): In Argentina, the decrease in abundance of traditional fishing resources, mainly Argentinean hake (*Merluccius hubbsi*), has resulted in a shift by part of the fleet to the coastal sector in search of profitable catches. This is associated with the unlimited nature of fishing licences with respect to areas or species, which favours the movement of fleets to different areas in search of profitable catches.

Legal

Unlimited fishing licences (Argentina): Most of the Argentinean fishing fleet have fishing licences that do not restrict them to specific fishing areas or target species. This allows boats to focus on different target species or fishing grounds to locate profitable catches that fulfil market demands (entrepreneurial profit).

Governance

Failure of fisheries regulations for the Buenos Aires Coastal Ecosystem (both countries): Unlimited fishing licences in Argentina has encouraged unsustainable fisheries when new markets for coastal species were opened up. This situation produced an increased fishing effort in the area, and caused the overexploitation of several species, such as several species of cartilaginous fish and Whitemouth croaker (Figures 37 and 38). With the aim of limiting fishing effort in the area, the National Institute of Fisheries Research and Development (Instituto Nacional de Investigación y Desarrollo Pesquero, INIDEP) proposed to manage the Buenos Aires Coastal Ecosystem as a unit based on ecological and technological criteria, and limiting access to vessels under 25-30 m in length. However, this could not be implemented due to a lack of consensus within Argentina's Federal Fishing Council. This demonstrates that there is a lack of political support for unpopular decisions, which constitutes the basis for fisheries management. Governments exhibit a lack of political leadership when they seek short-term solutions and postpone difficult management decisions due to fears of economic and social consequences. It is important to note that although Uruguay

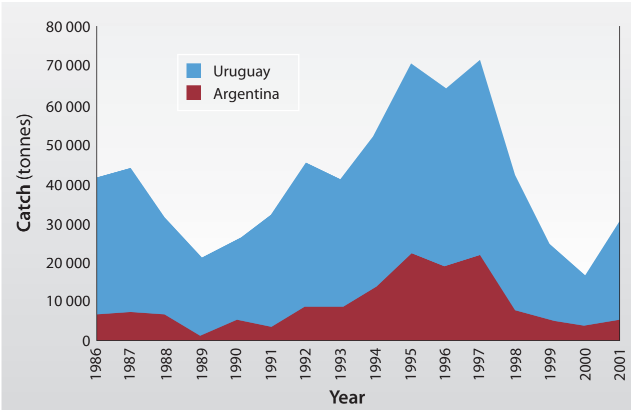

Figure 38 Catch of Whitemouth croaker (*Micropogonias furnieri*) from the Argentinean and Uruguayan fleets at the Common Fishing Zone.
(Source: JICA-INIDEP 2002)

has a fishing licence system that differentiates between fleet types, its fishing capacity would seem to be far higher than the actual fishery resources.

Failures in control systems (both countries): Coast guard, on-board and land-based fishing inspectors have failed in their duties with respect to managing the Buenos Aires Coastal Ecosystem. These agencies have not guaranteed compliance with existing regulations such as minimum landed sizes, total length restrictions in different areas, and no-take zones banning fishing. On-board and land-based control systems lack suitable, qualified personnel to carry out such functions.

Failures in data management: Fishing statistics are not compatible between the Argentinean provincial, Argentinean national, and Uruguay jurisdictions.

Lack of budget: assigned by both countries to adequately assess the Buenos Aires Coastal Ecosystem and the Buenos Aires mid-shelf Ecosystem relates to the lack of research assessment cruises in both systems (Knowledge).

Knowledge

There is a serious lack of knowledge of the biology of demersal offshore and coastal species. When research campaigns are carried out, they are usually designed to assess stock sizes of Argentinean hake, Whitemouth croaker, and Stripped weak fish (Consejo Federal Pesquero 2001). The failure to conduct comprehensive stock assessments is directly related to governance and a lack of funds assigned for this purpose, which negatively affects the quality of scientific information and hampers the design of effective management strategies.

For example, in the multi-species fishery, cartilaginous fishes can be taken as a specific case study. Generally, these species are overexploited due to their biological characteristics and high market demand. International instruments, including CITES (Convention for the International Trade on Endangered Species of Wild Flora and Fauna), and the CBD (Convention on Biological Diversity) are relevant for managing these species, and an increasing number of sharks, rays and chimeras are being added to the World Conservation Union's Red List (2000). Many species on this Red List are currently being caught by the fishing fleet in the Argentinean Shelf, and yet many basic aspects of their biology remain unknown.

There are also weaknesses in the collection process of statistical data in both countries, especially for cartilaginous fish. Current research and management does not distinguish between resources with different degrees of vulnerability and different levels of exploitation. In addition, there is a vast historical record of catch under-declaration in both countries, which negatively affects the quality of scientific information and makes it difficult for relevant authorities to plan and carry out specific management measures.

For many species in the "coastal mixture", basic biological and population parameters remain unknown, which makes it difficult to design and implement specific management measures that would reduce overexploitation (Consejo Federal Pesquero 2001). For example, if the location of spawning grounds could be determined, fishing could be banned in these critical areas to ensure both successful reproduction and protection of juveniles.

Political/Conflicts

There is a lack of agreement between Argentina and Uruguay in certain aspects of administering shared resources. Organisations from both countries have different opinions on the conservation status of Whitemouth croaker, which makes it difficult to reach agreements on annual maximum allowable catches (MAC) for this species. Technical delegations have also failed to reach agreements regarding quotas for Argentinean anchovy (*Engraulis anchoita*). The countries do not share a common control system, and there are no agreements concerning the creation of common on-board fishery monitoring systems. Furthermore, the existence of important differences in criteria and objectives within both countries prevents the efficient management of marine resources.

Technological

Lack of expert advice in multi-species fisheries: On this particular subject, there is no experience either in Argentina or in Uruguay. Therefore, it is essential to address this concern with proposals for the sustainable management of complex multi-species fisheries.

Root causes related to incidental catches (by-catch and higher fauna)

Economic

Market: Incidental catches of fish and invertebrates are sometimes discarded because they have very low market values. A good case study is provided by the cartilaginous fishes. Most of the species in this group have historically been discarded because of their low economic value. However, as of 1994, Whitemouth croaker stocks decreased, and new European and Asian markets for rays opened up, which created alternative export markets for the coastal fleet.

Important species such as notothenians, hawkfish (*Cheilodactylus bergi*) and blackbelly rosefish (*Helicolenus dactylopterus*) are part of the discarded by-catch in the hake fishery, but these could constitute alternative products because of their abundance and quality. Considering the depletion of stocks of species that have traditionally been caught in the area, both countries will have to formulate active policies in the future to develop new markets for species that have not yet been exploited.

Technological

Use of non-selective fishing gear (trawl-net): Both countries should encourage research into technology to improve the selectivity of fishing gears, and should conduct an adequate technical analysis for each type of gear. This technological problem is also related to ineffective governance processes, such as a lack of coordination between academic knowledge, public opinion, law, and the attitudes and behaviour of fishermen. The fishing sector is also quite rigid to any changes to their traditional fishing systems and resist the introduction of new gear types.

Knowledge

Lack of studies on incidental catches, by-catch, and discards: The proportion of by-catch discarded from the multi-species coastal fishery has not been quantified. In the case of "coastal mixed" fishery, where all species are subject to the same fishing effort, less abundant species can become locally extinct, even though dominant species will be capable of enduring fishing pressures (Camhi et al. 1998). By-catch species may be indirectly more vulnerable than target species since they are poorly monitored and signs of catch decline and collapse are not noted in assessments (Camhi et al. 1998). This underlines the importance of reporting discards from each fishery. Regarding the offshore fleet, the large spatial and temporal variations observed in discarded species requires improvements in long-term monitoring programmes.

Lack of monitoring plans to allow adequate assessments of incidental catches of higher fauna (i.e. seabirds). The Argentinean-Uruguayan Common Fishing Zone contains many important natural resources, including migratory species of global importance that deserve special attention (FREPLATA 1999). It is also important to mention that in the case of marine birds, Argentina is seeking to ratify the "International Agreement for the Conservation of Albatrosses and Petrels", as there are important nesting and feeding centres for these species on the Argentinean Shelf.

Governance

Inadequate integration of environmental aspects in public policies: There is a general lack of policies to encourage the study of the impacts fishing activities have on biodiversity. This is related to the lack of policies to increase the selectivity of fishing gears.

Lack of adequate systems to control on-board discards: Fishing logs only sporadically include discards. When inspection systems are present, they are inefficient. A legal framework exists, but it is not implemented.

Lack of budget: A programme of on-board observers to monitor the proportion of accidental catches and discards cannot be implemented without adequate funding.

Socio-cultural

Tradition: Unwillingness from the fishing sector to change their traditional fishing gear - they do not use statutory selectivity devices. This is aggravated by failures in control systems.

Root causes related to modification of the sea floor by destructive fishing practices

The use of inappropriate fishing gear is related to the technological root cause use of non-selective fishing gear for catch purposes (bottom trawl-nets). Resistance towards the adoption of selective fishing gears occurs primarily because of socio-cultural traditions. In addition, authorities lack the ability to control the types of fishing gear used, and the knowledge of the impacts of fishing on the ecosystem is very poor due to the lack of research on ecosystem biodiversity and the absence of programmes to monitor by-catch (Mizrahi et al. 2000, Fundación Vida Silvestre Argentina and Asociación Ornitológica del Plata 2003).

Included in the most relevant root causes is a dearth of knowledge, since no data exists to describe the impacts of fishing on benthic communities, due to the lack of policies encouraging this type of research.

Table 40 Summary of root causes related to modification of the sea floor by destructive fishing practices.

Root cause	Argentina	Uruguay
Economic	Markets	
	Entrepreneurial profit	-
Legal	Unlimited fishing licenses	-
Governance	Failures in the management (Buenos Aires Coastal Ecosystem and Argentinean-Uruguayan Common Fishing Zone)	
	Failures in control and surveillance systems	
	Lack of assigned budgets for adequate monitoring and assessment	
	Inadequate integration of environmental aspects in public policies	
Political	Conflicts	
	Lack of agreement between the two countries on matters related to the administration of certain shared resources	
Knowledge	Inadequate knowledge of some coastal and shelf species and of ecosystems in general	
	Unreliable statistical information	
	Lack of studies of incidental capture of by-catch species and higher fauna	
	Lack of studies of fishing impact on the sea bottom	
Technological	Lack of expert advice	
	Indiscriminate fishing gear	
Socio-cultural	Traditions	
	Resistance of the fishing sector to change traditional fishing methods	

Economic, Legal and Governance root causes related to the use of destructive fishing practices overlap with those related to Overexploitation. Root causes related to destructive fishing practices are summarised in Table 40.

Root causes related to pollution

Concerning pollution related to maritime traffic, a root cause associated with governance can be identified: the inadequate integration of environmental aspects in public policies due to a lack of planning of navigation routes (Acha et al. 1998).

Root causes related to pollution by industry, agriculture and urban development, include governance factors such as the inadequate integration of environmental aspects in public policies, low budgets assigned to management, and a lack of bi-national instruments and cooperation mechanisms for pollution control and prevention (Formulation of the Strategic Action Plan for the Environmental Protection of the La Plata River and its Maritime Front 1998). There are also gaps in knowledge, including insufficient knowledge on the ecology of the region, and limited knowledge on pollutants and their effects on ecological systems (Formulation of the Strategic Action Plan for the Environmental Protection of the La Plata River and its Maritime Front 1998).

Policy option analysis is not carried out for Pollution.

Root causes related to modification of coastal habitats

For both countries, a root cause associated with governance is the inadequate integration of environmental aspects in public policies, and the absence of considerations of coastal vulnerability within urban and tourist development planning (OEA 1992, Isla et al. 1998). A lack of coordination between executive and scientific organisations has also been determined (Acha et al. 1998, Isla et al. 1998). Within the area of knowledge, inadequate access to information was identified, which prevents the translation of research results into management tools (Acha et al. 1998).

Policy option analysis is not carried out for Habitat modification.

Conclusions

The most important conclusion from the Causal chain analysis is that policies aimed at protecting biodiversity are scarce, and overexploitation, by-catch and modification of the sea bottom by fishing gear are both widespread in spite of efforts from both countries within administrative and scientific areas to manage fisheries and control fishing (i.e. defining maximum sustainable catches, implementing fishing ban areas for target species, enforcing minimum landed sizes, etc.). Consequently, fisheries in the area are judged to be unsustainable.

The lack of baseline studies (biodiversity, trophic relationships, oceanography etc.) to describe the ecosystem restricts the incorporation of environmental concerns into management processes. The ability to achieve this goal will depend on advances in the scientific knowledge of the marine ecosystem in general and the interaction of fish populations with other ecosystem components in particular.

Considering the strong transboundary ecosystem relationships within the area, achieving these goals should take into account the national research policies of Argentina and Uruguay and integrate these into bilateral policies. Data collection and management should also be improved. These issues are especially interesting when we consider that resources are being exploited by jurisdictions with different legal and administrative characteristics.

Both countries have developed an appropriate legal framework, including the 'Treaty of La Plata River and its Maritime Front'. Nevertheless, issues related to governance (control, research policies, budgetary policies, lack of qualified personnel) do not permit the efficient application of these legal instruments.

The Buenos Aires coastal ecosystem contains the main reproductive area and nursery grounds of many coastal and shelf species, and is therefore of great biological importance. As a result, securing a rational, long-term management plan for the area should be a high priority.

According to indicators, such as Catch per Unit Effort, the Argentinean hake fishery and its by-catch already requires a recovery strategy. This strategy should lead to technical improvements that increase the selectivity of fishing gear and achieve reductions in fishing effort.

The development of a permanent monitoring system for the sustainability of this fishery is also essential, since fishery impacts on the ecosystem, including by-catch, depletion of higher fauna, and the alteration of the sea bottom and its associated benthic communities are unknown. This is important not only from the environmental viewpoint but also as a tool to identify under-exploited species that are potentially of commercial interest. Technological studies to reorient the fishing activities by diversifying product types should also be carried out in parallel.

Regarding other anthropogenic activities with impacts on the ecosystem, it is important to note contributions expected from the FREPLATA "Strategic Action Plan for the Environmental Protection of the La Plata River and its Maritime Front" project. The goal is to develop and approve a Transboundary Diagnostic Analysis to fill relevant information gaps, and to supply key data and instruments for the development of a Strategic Action Plan for the prevention and mitigation of transboundary environmental problems in the La Plata River and its Maritime Front. This Strategic Action Plan will include policy proposals, legal and institutional frameworks, and the prioritisation of investments for the La Plata River and its Maritime Front.

Policy options

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This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

Uruguay River Basin upstream of the Salto Grande Dam

Definition the of problem

The causal chain analysis carried out for pollution in the Uruguay River Basin identified the most significant immediate causes, sectors and activities, and the root causes of problems related to pollution and the deterioration of the quality of water resources in the basin. Intensive land use, coupled with agricultural practices designed to increase productivity, have increased the concentration of chemical substances, nutrients, and suspended solids in the rivers. The presence of pathogenic organisms in some parts of the River Basin results from failure to comply with regulations related to wastewater discharges, as well as from poultry and pig production. The lack of urban wastewater treatment also increases the concentration of nutrients. It is expected that the absence of policies governing the operation of dams for irrigation purposes during low water periods will generate conflicts over water use, which will increase the problem of poor water quality in sub-basins such as Cuareim River Basin, where water resources are shared by Brazil and Uruguay.

The analysis revealed that the impacts of pollution result from root causes which can be categorised as follows:

- Economic;
- Technological;
- Legal;
- Governance;
- Knowledge.

More specific root causes include:

- Lack of a framework for Integrated Water Resources Management;
- Lack of stakeholder participation (Governance and Legal root causes);
- Inadequate valuation of goods and services (Economic, Governance and Knowledge root causes);
- Unsustainable agricultural practices (Knowledge, Technological and Legal root causes);
- Inadequate budget of institutions in charge of management, which causes the lack of enforcement of existing agreements and policies (Economic, Legal and Governance root causes);
- Poor dissemination of scientific and technological knowledge and training (Knowledge & Technological root causes);
- Market incentives (Economic root cause);
- Poverty (Economic root cause).

The economic and technological causes of pollution in the Uruguay River Basin are strongly linked to activities in the urban, industrial, and agricultural sectors. In the urban areas, significant discharges of urban and industrial wastewater are the primary causes of pollution. In rural areas, the excessive use of fertilisers and herbicides, particularly on rice and soy crops, soil erosion, and industrial and agricultural effluent discharges are the primary causes of pollution.

Even though pollution originating from urban areas and poultry and pig production exert the greatest influences on the Basin, these activities are generally restricted to the Upper Uruguay River. Although decision-making will require the involvement of stakeholders from each of the three countries sharing the Basin, national, state or municipal authorities in Brazil will have to make very important decisions to reduce future pollution and mitigate the impacts of existing problems.

Chemical pollution due to the use of biocides is most significant in the Lower Uruguay River. In this case, Argentina and Uruguay must develop and implement policies linked to agricultural practices. In the Lower Uruguay River, eutrophication is a major pollution issue, and nutrients originate from within the entire basin. Furthermore, in the Salto Grande Reservoir, backwater conditions favour the accumulation of sediments and the nutrients they carry.

It should be highlighted that possible options for intervention at the basin level cannot be implemented by only one country. In order to address issues related to governance and knowledge, particularly the harmonisation of laws, coordination of policies, exchange of information, resolution of conflicts, and engagement in territorial planning discussions, appropriate transboundary instruments with the capacity to implement management strategies at the sub-basin level must first be created. Although new ideas and approaches are emerging, transboundary issues are usually not considered in the social, political and economic decision-making culture of the region. Therefore, it is necessary to introduce new ways of governance and management to incorporate these perspectives.

Construction of policy options

The following section presents a list of potential policy options for preliminary evaluation, and is based on several different criteria, including efficiency, effectiveness, equity, political feasibility, and application capacity. Based on the results of this preliminary evaluation, several potential policy options will then be recommended.

Policy options for Integrated Water Resources Management

Governance

- Coordinate inter-ministerial/inter-territorial policies. This implies a real change in policy formulation and implementation. Argentina, for instance, has created different coordination instruments among the provinces, such as the Federal Council of Environment, and the Federal Water Council.
- Initiate basin management mechanisms with an integrated transboundary approach that include and extend the scope of existing organisations (e.g. the Administrative Commission for the Uruguay River, CARU). An important step could be to establish working groups with technical coordination roles according to specific topics related to the management of both the quality and quantity of water. An integrated basin institution involving Argentina, Brazil and Uruguay could be created, or CARU could be extended to include the management of the Uruguay River between Argentina and Brazil. Alternatively, CARU could be transformed into a basin institution that involves all three countries.
- Implement mechanisms that secure the participation and support of a wide variety of stakeholders, especially stakeholders from civil society and from the private sector. Actors such as NGOs and the private sector should be incorporated into discussions that promote new links between regional and local governments. Brazil's basin committees are working in this direction and could be a good start as a mechanism for social participation.
- Establish local working teams that involve the private sector, NGOs, and the public, to facilitate both the systematic evaluation

of environmental problems, and the implementation of effective solutions. These teams could be used to build knowledge, strengthen human resource capabilities, and overcome the lack of enforcement of policies and agreements caused by inadequate institutional budgets. Although such mechanisms should be strengthened throughout the Uruguay River Basin, they require special attention in Uruguay, which currently has made the least progress towards developing effective basin organisations.

Legal

- Control water use and water pollution through the imposition of taxes. The funds generated from such a policy could be used to ensure management capacity and the enforcement of compliance with recognised standards. Brazilian laws have established a fee system for the use of water, as well as economic incentives for non-polluters. The same type of system should now be developed in Argentina and Uruguay.
- Establish land use regulations that address diffuse and point sources of pollution. To reduce the likelihood that water supplies important to neighbouring or downstream communities are contaminated by pollution, critical areas to protect the quality of water could be defined near key boundaries between nations, states, or communities. The low cost of marginal land next to populated centres could be used to construct artificial wetlands that filter and control the movement of pollution through the hydrological system.
- Coordinate and harmonise water quality standards throughout the Uruguay River. Locations with existing transboundary conflicts or the potential for future conflicts should be targeted first.
- Harmonise legal tools among all three countries concerning Integrated Water Resources Management, as well as other comprehensive frameworks for managing natural resources with integrated approaches.

Economic

- Strengthen and coordinate financial mechanisms between the public and private sectors.
- Create economic incentives for non-polluters.

Policy options for wastewater treatment

- Construct and maintain wastewater treatment infrastructure on the Middle and Upper Uruguay River. In order to achieve this goal, financial support must be obtained from both public (national and international) and private sources.
- Tertiary treatment of wastewater should be pursued. However, special attention should be paid to final effluent disinfecting systems, since the elimination of pathogens with chlorinated disinfectants could produce secondary compounds with significant impacts on biota.
- When deciding upon the method and location for the disposal of sludge that results from the wastewater treatment process, a wide range of stakeholders should be consulted.

Policy options for agricultural practices

- Impose levies on high water consumption or the excessive use of biocides.
- Implement legal mechanisms to control the use of biocides, including the establishment of penalties.
- Introduce the 'polluter-pays' legal concept in Argentina and Uruguay to create market incentives for non-polluters.
- Carry out systematic campaigns to promote awareness among farmers and the public concerning the risks associated with the use of pesticides and herbicides (biocides).
- Carry out pilot studies on alternative methods of pest and weed control.
- Educate and train farmers on more sustainable agricultural practices that improve irrigation efficiency and decrease the amount of biocides applied to fields.
- Educate and train farmers on more sustainable agricultural practices that conserve soil structure and decrease soil erosion, such as direct sowing' techniques, which can significantly decrease the rate of soil erosion (IPH 1998).
- Conduct educational campaigns to raise awareness and engage stakeholders, including teachers, students, farmers, industries, and national, regional and local governments.
- Introduce technologies for the treatment and reuse of effluents that originate from livestock production, especially in the Upper Uruguay Basin. This could be facilitated through credits or subsidies.

Performance of selected policy options

Policy option 1: Improve wastewater treatment by strengthening and coordinating financial mechanisms between the public and private sectors

The lack of municipal wastewater treatment systems in the main urban centres of the sub-basin, especially in the poorest municipalities, is a basic problem that must be addressed. Wastewater treatment facilities should be constructed, and existing facilities should operate effectively.

According to regulations, governments at different levels should assume the costs of wastewater treatment. However, current practices of data aggregation makes it difficult to compare poverty indicators at the municipal level. The data that does exist indicates that basic sanitation needs are not being met, and financial resources should be sought to address this deficiency. Various funding mechanisms or other innovative approaches, such as the establishment of a special international fund, should be examined to ensure the most effective and expeditious transfer of environmentally sound technologies to developing countries (UNCED 1992).

Wastewater treatment systems could be financed either by government funds or by the private sector (concessionaire of the service). However, the re-payment capacity of the inhabitants is a problem. When this problem occurs within Brazilian municipalities of the Uruguay River Basin, this has ramifications for the whole basin, since all other areas are downstream from Brazil.

The operational costs of wastewater treatment facilities could be met by a mixed system of costs paid by water supply users according to their ability to pay, combined with public budgets through transparent subsidies. In accordance with the United Nations Millennium Declaration (United Nations 2000), bilateral and multilateral donors should increase financial and technical assistance to meet the wastewater treatment needs of developing countries. To access different financial mechanisms at the international and national levels, the construction of wastewater treatment facilities requires the formulation of plans that contain clear goals and investment evaluations.

Instrument: Construction of infrastructure for urban development/ wastewater treatment systems.

Efficacy: The policy option has a high efficacy to solve the pollution problem.

Efficiency: The likelihood of accomplishing goals depends on the availability of funds from regional (states, provinces, departments) and local governments (municipalities).

Equity: This action would have a deep impact on equity, as it would substantially improve the environment and the quality of life, especially in poor municipalities.

Political feasibility: Undoubtedly, both the municipalities and their authorities are allies. There is no evidence of previous efforts made by national governmental actors to solve this problem. If financial resources were obtained, stakeholders would approve the construction of infrastructure.

Implementation capacity: Local capacity to manage/administrate the entrepreneurship is uncertain. Human resources from outside the municipalities involved will probably be required.

Policy option 2: Promote the adoption of sustainable agricultural practices

This policy option could be addressed taking a basin-wide or sub-basin approach. Relevant information on alternative herbicides and fertilisers is not publicly available. There is generally very little information about products currently in use or their alternatives. However, their impact on the cost of rice per hectare can be estimated as less than 10% of the total and there are alternatives to traditionally used fertilisers and biocides. The establishment of policies that promote the use of environmentally appropriate alternatives to agro-chemicals, as well as tighter controls on water use, both seem to be viable policy options. Programmes promoting direct sowing technology have also proved to be useful for reducing soil erosion in the Upper Uruguay Basin (IPH 1998).

Instrument: Enforcement of regulations for water use, and regulations governing the use of fertilisers and herbicides (including 'polluter pay').

Efficacy: The policy option has high efficacy for achieving rational use of water resources and decreasing pollution levels. This measure would raise awareness among producers, citizens and decision-makers of the causal links between the condition of the environment and agricultural and livestock production, and would encourage the adoption of agricultural methods that are more likely to be sustainable.

Efficiency: Producers who adopt sustainable technologies will eventually absorb the costs. However, costs will not be above 10% of the total investment. The success of this policy depends on the attitudes of the lobbies representing the agricultural and livestock sectors and the support of governmental authorities (not shown until now).

Equity: Responsibility for environmental degradation is linked to the obligation to pay for it or change products, which tends to generate social and environmental equity.

Political feasibility: Non-polluting producers as well as the population in general will support the idea. However, it would certainly be necessary to deal with lobbies and pressures from the entrepreneurial sector in order to carry out this policy. Also, from a cultural point of view, the main interest of local populations is economic growth irrespective of environmental costs. Soy and rice production are undoubtedly polluting activities and alternative sustainable methods of production are not yet available. It is evident that all producers will be strongly against this option.

Implementation capacity: Initial identification of the polluters and the development of effective mechanisms are both required prior to the implementation of any economic tools. Public sector capacities should also be strengthened in order to make this policy feasible. To carry out this measure, national governments must be supported to achieve agreements with producer organisations.

Policy option 3: Carry out systematic campaigns of environmental awareness and education

It should be highlighted that there is a great lack of knowledge in the Basin concerning links between the economy, the environment, human health, and legal aspects of environmental management. Furthermore, efforts towards education and public awareness of environmental issues are central on the agenda. At the policy option level, it is necessary for the public to acknowledge that water resources are valuable and that their appropriate management is desirable.

Instrument: Environmental Education Programmes tailored for specific stakeholders and problems.

Efficacy: This policy option has high efficacy in terms of process sustainability.

Efficiency: Difficulties in carrying out this policy are foreseen if differences between actors are not considered. Different education modalities should be used according to target actors; further research is necessary.

Equity: This option promotes equity among stakeholders through raised awareness and the wide dissemination of information.

Political feasibility: The support and opposition to this option will depend on how environmental education is carried out. If education fosters development it will find allies. However, if the educational approach closes the way to production and development upon the grounds of a healthy environment, it will surely fail and it will not find enough support to justify a massive programme. The balance achieved among actors involved in education is essential to secure support and disseminate knowledge of more sustainable methods of production.

Implementation capacity: Alliances with the social, economic and educational sector must be sought in order to carry out the educational campaign. An innovative education programme should be based on specific and multidisciplinary courses. However, courses are generally too technical, or are based on an environmental approach that does not consider sustainable development. The agreements obtained and the diversity of people responsible for education is essential for the success of the environmental education policy.

Policy option 4: Treat and/or reuse wastes originating from livestock production

This policy option relates to previous options. It is difficult to build wastewater treatment systems for the small and medium-scale rural production of poultry and pigs. Therefore policy options should be linked to the industrialisation phase.

Instrument: Incorporating environmental considerations in the industrialisation of pig and poultry production. Industries that comply with environmental policies and treat or reuse wastewater could benefit from subsidies, and those that do not meet requirements could be penalised by sanctions.

Efficacy: This policy option has medium efficacy for reducing water pollution levels.

Efficiency: The success of this option depends on the attitude of lobbies associated with the production sector and the support of government authorities (not shown until now).

Equity: This measure favours equity, as sanction mechanisms would transfer financial resources to the community from polluters, in order to efficiently implement environmental policies.

Political feasibility: As in the previous policy, the majority of politicians and all social actors will be allies. Nevertheless, fears generated by economic and political lobbies, and statements about the potential negative impacts these measures will have on employment are certain to appear.

Implementation capacity: The policy's success will depend on the capacity of local, regional and national governments. The presence or absence of conflict in the implementation of policies will depend on the negotiation capacities of the production sector.

Policy option 5: Create basin management mechanisms with a transboundary and integrated approach, that includes and extends the scope of existing institutions

Some aspects to be considered with these types of initiatives include:

- Overlapping competencies and administrative and institutional fragmentation. The co-existence of competence in supra-national, national, territorial, and local governments can often lead to conflict. When faced with new basin management mechanisms, it is necessary to generate new ways of governance that include all stakeholders and management agencies.
- Cooperation between different public bodies. Mechanisms should be established that promote inter-state cooperation at various levels and in different fields of expertise. The existing administrative fragmentation is a difficult problem to solve. However, participation by all governmental actors through the appropriate administrative and management bodies should be promoted.
- The participation of local stakeholders is crucial. Territorial actors, including individuals representing provinces, states, small communities, NGOs, farmers, local governments and industries, are often competent and knowledgeable. Consequently, mechanisms that incorporate their opinions during both the planning and implementation of policies can help lead to policies that are comprehensive, equitable, and implementable.
- Although transboundary cooperation is an essential component of sustainable river basin management, historical and cultural factors have not promoted the necessary cooperation among countries within the river basin.

Instrument: A new institutional order to support the basin's governance or a Basin Agency will be created based on existing institutions. The structure of this institution would be based on national governmental levels, with the participation of local government, and a consideration of the opinions of local stakeholders.

Efficacy: The policy option has high efficacy for managing transboundary water resources.

Efficiency: The successful implementation of this option depends on the willingness of existing institutions (i.e. CARU) to harmonise and transform their roles and goals. Social legitimisation and respect of the laws will depend heavily on how well the opinions and knowledge of regional social and economic actors are included.

Equity: This option fosters equity as it encourages more participation and commitment in the decision-making process.

Political feasibility: The local governments and the main economic and social actors will be allies in the suggested policy. There would certainly be opposition from national governments, as the delegation of power on supra-national mechanisms will present resistance. There are already a few institutions working on the generation of management mechanisms with a transboundary approach, which can serve as embryonic basin authorities.

Implementation capacity: Human and legal resources will be required for the new institutional mechanism proposed for basin management. The development of a network of connections and trust among the different actors involved is also needed. The policy definition in the stated terms - negotiation, environment and mutual trust - is the key to efficiently manage the challenges and appears to be the only way to deal with the area's challenges in terms of development and environment in the medium and long-term.

Final considerations

To avoid the duplication of actions and/or conflicting objectives, the development and implementation of the policy options discussed above should be integrated with existing programmes, including: Environmental Protection of the Rio de la Plata and its Maritime Front, Pollution Prevention and Control and Habitat Restoration (Argentina and Uruguay), and Environmental Protection and Sustainable Integrated Management of the Guaraní Aquifer (Argentina, Brazil, Paraguay and Uruguay).

The causal chain and policy option analyses focused on identifying the most significant root causes of problems stemming from pollution in the Uruguay River Basin, and considered possible options to mitigate them. In recommending suitable policy options, priority has been given to those instruments whose effectiveness can be assessed in the short-term (pollution reduction measures, construction of infrastructure), as well as others that would have an impact in the short to medium-term (related to new ways of governance and environmental education).

In addition, options that recognise and address the links between production development policies and environmental problems have also been suggested. This is particularly relevant for those aspects related to rice and soy production in the Middle Basin, as well as those related to poultry and pig production in the Upper Basin.

Finally, it is important to bear in mind that all measures proposed can be effective in relatively short time frames, provided that relevant political measures are taken, and some advances have been made by the three countries involved in this direction. This, added to the creation of an institutional framework to improve basin governance, would guarantee big chances of success for decreasing pollution in the Basin.

Buenos Aires Coastal Ecosystem – Argentinean-Uruguayan Common Fishing Zone

Definition of the problem

The most important immediate causes of habitat and community modification, from a transboundary point of view, include the unsustainable exploitation of marine living resources, and pollution and habitat degradation associated with shipping activities. Transboundary impacts include the depletion of fish biomass, excessive by-catch, depletion of fauna in higher trophic levels, and habitat degradation. These impacts validate the perception of widespread unsustainable exploitation of marine living resources, and habitat and community modification within the Buenos Aires Coastal Ecosystem, as well as the Argentinean-Uruguayan Common Fishing Zone (Zona Común de Pesca, ZCP). With respect to pollution and habitat change due to shipping activities, the poor state of knowledge on the environmental and socio-economic impacts of these issues does not permit valid policy options to be developed for these issues.

Living marine resources are subjected to intense fishing pressure by both countries (Argentina and Uruguay), and currently are in a critical situation due to unsustainable exploitation practices, such as overexploitation of target species, incidental by-catch, and modification of the sea floor. Fisheries throughout the area involve mismatches between coastal and marine ecosystems on the one hand, and the institutions and markets on the other.

Fisheries should be managed sustainable to ensure that living resources are not depleted, which is analogous to spending income while ensuring that the standing stock of capital remains intact. If the resource extraction rate is higher than the renewal rate, the price of resources tends to increase as they approach depletion, fishing effort increases in response to these market forces, and wealth availability typically decreases.

Many coastal countries face problems similar to those found in this area. Fish stocks are usually regarded as a common property resource, and fisheries are often characterised by inadequate management, levels of fishing effort that prevent the sustainable reproduction of fish stocks, intensive exploitation of only a few species, high levels of by-catch, and fishing practices that contribute to habitat degradation (Pauly 2002).

Argentina and Uruguay have appropriate internal legal frameworks and coherent bilateral regulations through the 'La Plata River Treaty and its Maritime Front'. Nonetheless, root causes associated with governance, policy, and knowledge prevent legal instruments from being applied in an effective manner.

This section presents potential policy options to address the major root causes presented in the causal chain analysis. In addition, policy options to promote improvements in technology that consider socio-cultural factors are also analysed. The importance of knowledge availability is also recognised as an essential component to ensure that adequate capacity exists for making management decisions and implementing policies.

Buenos Aires Coastal Ecosystem

The Argentinean fishing sector operates as a highly complex open system that interchanges goods and products with other economic systems, demands production factors, satisfies direct and indirect needs of the community, and influences the natural and social environments.

The Fisheries Economic System (FEP) is comprised of a complex set of rules, customs and institutions that regulate the behaviour of fishers based on resource availability. The fisheries economic system includes the primary (fishing), secondary (industrial), and tertiary (services) sectors related to fisheries, and a complex set of rules, customs, and institutions to regulate the behaviour of actors within this system. The FEP requires production factor inputs, including resources, capital, and working capacity, which affects levels of employment according to fishery cycles of higher and lower production. The fisheries sector is characterised by high-risk investments due to the degree of uncertainty associated with yields and the difficulty of fulfilling investments, which tends to lead to overcapitalisation in the long-term. Outputs of the fishery system include: employment, income generated from the sale of catches (wages, salaries and benefits for workers and entrepreneurs), invested capital revenues, fisheries resource rent (in licensing fees, etc.), and important sources of food and protein. Fisheries development should be regulated according to criteria that promotes long-term sustainability. Criteria for fisheries sustainability should consider environmental, economic, social and political factors.

Common Fishing Zone (Argentina-Uruguay)

The FES of the Common Fishing Zone is composed of three sectors: primary (fishing activities), secondary (industrial and processing activities) and tertiary (local and foreign markets and sale of products). The theoretical framework within which potential policy options have been proposed focuses on the different sectors involved in fishing, and considers several interrelated factors, including the health of stocks and species targeted by each country's fleet, the amount of fish caught by fishing fleets, the fish processing industry, and finally, markets selling processed fish products. The performance of fisheries can be described by analyzing each economic sector. It is also possible to evaluate the possible impacts of different exploitation strategies and construct scenarios of foreseeable consequences.

Construction of policy options

Policy options developed included existing planned policy actions as well as ideas not yet discussed in traditional forums. Potential policy options were evaluated according to several criteria (efficiency, effectiveness, equity, political feasibility, and application capacity). Only those that were feasible or that would be expected to yield tangible results were advanced as recommended policy options. Proposed policy options are categorised within one of two geographical areas: the Argentina-Buenos Aires Coastal Ecosystem, and the Common Fishing Zone (ZCP Argentina-Uruguay). Policy options in each of these jurisdictions are presented in relation to prioritised immediate causes and relevant root causes.

Policy options for the Buenos Aires Coastal Ecosystem

Governance

Many aspects of the overexploitation of target species, by-catch, and habitat modification are associated with governance root causes. Environmental considerations are often not adequately integrated within public policies, there is a general lack of integrated coastal zone management plans, a lack of coordination between different institutions and different levels of government, and inadequate budget allocations for a thorough assessment of the Buenos Aires Coastal Ecosystem.

It should also be mentioned that there have been numerous efforts (research, development and monitoring), on administrative, scientific, and entrepreneurial fronts, to develop guidelines that would regulate the sustainable exploitation of ecosystems and their natural resources. State research institutes and universities carry out research and development activities to advise policy-makers, authorities, producers, and entrepreneurs. The administrative sector has on numerous occasions resolved to integrate ecosystem coordination and management. Nevertheless, there is a trend towards the formulation and application of short-term policies, which remain poorly integrated with global policies of structural type (national policies for sustainable exploitation of natural resources, environmental conservation, etc.).

There should be a distinction between aspects of governance incorporated in 'state policies' and those included in 'government policies'. State policies are structural and their design and execution involves long-term application independent of the current elected government. Government policies are based on the political orientation of the government in power, and require design and execution characterised by flexibility, opportunity, and short-term application.

Policy options related to governance could include:

- Delimit boundaries for the coastal area, and enforce restrictions for vessels operating within the defined area. For instance, access should be restricted to vessels under 25 m in length and inshore of the 50 m depth contour between the latitudes 34° S and 42° S.
- Regulate fishing effort in Argentina and respect historical rights acquired by vessels that traditionally have operated in the area. These include the smallest fishing boats (painted yellow), which operate mostly from Mar del Plata, Necochea and Bahia Blanca.
- Adopt stronger unification criteria in fisheries policies between the national, state and Buenos Aires provincial governments.
- Link fisheries development to national programmes for preserving the marine environment.
- Reorient research policies to reconcile research and development issues with state policies.
- Optimise national, provincial, and state budget allocations to fisheries management agencies.
- Develop a mechanism to finance long-term research aimed at achieving the sustainable management of natural resources.
- Coordinate and share research information obtained by different projects at the national (e.g. SECyT, INIDEP, NGOs) and international levels, in order to optimise results and maximise existing sources of funding. Implement specific actions to mitigate the impacts of fishing on biodiversity.

- Optimise communication systems among scientists, administrators and managers to facilitate the application of scientific results to fisheries management.
- Improve the capacity of land-based and on-board fisheries inspectors to undertake control and monitoring activities.
- Reformulate existing mono-specific fisheries management systems that do not recognise the importance of interactions between species (predator-prey equilibrium), and that do not assess the capacity of the ecosystem to recover from fishing activities (ecosystem resilience, population viability, etc.).
- Review the obligations of the Secretariat of Agriculture, Livestock, Fisheries and Food (SAGPyA), which is the national fisheries application authority, and the Federal Fishing Council (CFP).
- Include within the "Pluriannual National Plan" of the National System of Science and Technology (SECyT) a National Programme of Preservation of the Marine Environment that considers different development policies. Within this programme, the following national priorities should be included:
  - Identification, characterisation and delimitation of marine ecosystems.
  - Promoting awareness of the importance of top predators (i.e. cartilaginous fishes, marine mammals) in marine ecosystems, and their roles in controlling prey populations.
  - Implementation of actions aimed at reducing the number of incidental catches of cartilaginous fishes, mammals and marine birds, especially those most threatened. The goal should be to maintain the number of accidental captures below levels that will affect the health and continued existence of those populations.

Knowledge & Technology

The overexploitation of target species is often caused by inadequate scientific knowledge on coastal and shelf species, and unreliable fisheries statistics. The management of multi-species coastal fisheries is a particular challenge. In any multi-species fishery where all species are subject to the same fishing effort and death rates per catch, less abundant species risk extinction, even if dominant species are able to persist (Mussik 1997, Camhi et al. 1998). Likewise, species included in by-catch might be indirectly more vulnerable than target species because their abundance is poorly monitored and signs of declining catches may go undetected (Camhi et al. 1998).

Therefore, in the absence of basic technical standards and guidelines for sustainable exploitation, managing a multi-species fishery involves taking precautions to protect the more vulnerable species, such as cartilaginous fishes. In addition, it is essential to monitor stock (volume) indices obtained from commercial fleets, as well as those gathered from specific assessments of the abundance of species affected by multi-species fisheries.

The goal should be to develop an adequate "model" to ensure the sustainable exploitation of both fish stocks and the ecosystem. This requires high-quality data that describes the current conditions of the fishery and ecosystem, and predicts changes to fish stocks and the condition of the environment as a result of fishing activities. The causal chain analysis identified inadequacies in data management, lack of biological knowledge for some species, and lack of knowledge of the impacts of fishing on the ecosystem as significant contributors to the inadequate management of fisheries resources. The failure to obtain the specific knowledge required to manage fish resources sustainable is directly attributable to the lack of research policies to encourage the investigation of the ecological consequences of fisheries.

It will be the responsibility of the science and technology sectors as well as academics to raise awareness and to advise authorities on the benefits of focusing on more long-term global policies, rather than the current focus on short-term policies which are poorly integrated.

Suggested specific policy options related to knowledge include:

- Continue efforts to analyse existing fisheries data (catches, landings, exports, domestic sales, etc.), and obtain additional data in order to manage fisheries resources appropriately;
- Promote studies that investigate the impacts that fishing gear has on the sea floor and benthic communities;
- Involve fishermen in the development of selective fishing gears;
- Restructure the scientific research conducted on fisheries and fish stocks to focus on investigating the impacts of fishing, and monitoring the condition of the marine ecosystem;
- Increase the number of qualified technical staff in institutions responsible for fisheries administration;
- Increase the knowledge of local scientists and managers to regulate multi-species fisheries by obtaining practical advice and assistance from experts concerning the management of such systems;
- Improve monitoring of the most vulnerable species within fishing grounds.

In order to carry out several of these policies, the main problem is that resources are partly shared with Uruguay in the Common Fishing Zone. Since a management system established by the Technical Commission of Maritime Front (Comisión Técnica Mixta del Frente Marítimo, COFREMAR) already exists, some policy options would not be fully viable under the current institutional framework.

Economic

Market performance (associated with resource exploitation) and entrepreneurial profit (achieved by market operators) were identified as economic root causes. However, the international economic environment, as well as the national market system and their operators are highly influential, and as a result, policies for addressing economic root causes seem to have low feasibility.

Nonetheless, initiatives to promote new exploitation strategies and influence markets and economic factors, could be promoted, including:

- Develop new fisheries products, based on clear scientific assessments;
- Establish a promotional organisation associated with the Argentinean Ministry of Foreign Affairs, to strongly influence the private sector and promote the diversification and acceptance of non-traditional fish products.

Policy options for the Argentinean-Uruguayan Common Fishing Zone

The overexploitation of target species, by-catch, and habitat destruction are caused by failures in regulatory frameworks, inadequate budgetary allocations for ecosystem management, and disagreement between Argentina and Uruguay on matters such as the management of shared resources (Governance). There is also a lack of scientific data on many coastal and continental shelf species, and unreliable statistics (Knowledge).

Governance

Suggested policy options to address governance problems include:

- Joint regulation of fishing activities by both Argentina and Uruguay. In this respect, a positive step has been to define marine protected areas and promote fishing gears that selectively target desired species (Mizrahi et al. 2000).

If joint regulations are considered unfeasible, it would be appropriate to:

- Institute compatible fisheries management regulations (Argentina-Uruguay) where each country retains the freedom to develop its own fishery exploitation model but the overall objectives and principles of each model are consistent.
- Carry out studies investigating the selectivity of various fishing gears to support management regulations (minimising by-catch, safeguarding biodiversity and the habitat).
- Joint assessments of the condition of resources by both Argentina and Uruguay. This would help enable the collection of more reliable scientific data. Continuity in bilateral research programmes is necessary for these assessments to occur.

If joint assessments are not possible, an alternative could be to:

- Evaluate the state of resources separately, but maintain common protocols for collecting and analysing data on factors such as catches of different species, landings, by-catch, exports, domestic sales, and imports. This would help to assimilate all of the information required for fisheries research and management.

Knowledge

- Carry out studies to investigate the selectivity of various fishing gears, in order to support management regulations that would aim to minimise by-catch and safeguard biodiversity and habitats.
- Expand research on species being discarded as by-catch.
- Involve fishermen in research and development to increase the selectivity of fishing gears and devices.
- Disseminate information throughout communities to foster public awareness about goods and services related to ocean ecosystems and the importance of proper management.
- Launch educational campaigns among the general population in order to discourage consumption of products based on living resources and species that face extinction and/or whose exploitation is incompatible with an ecosystem-based approach.
- Promote the exchange of data and knowledge among regional organisations, such as common research units and workshops (Argentina, Uruguay and Brazil) to identify shared resources. These activities should complement existing tools that specifically deal with fisheries, including the Río de la Plata Treaty (Tratado del Río de La Plata, TRP) and the Comisión Técnica del Frente Marítimo (CTFM). Other vehicles for information dissemination and participation include seminars and discussion forums.

Identification of recommended policy options

Since root causes of overexploitation are diverse, they require management policies based on a set of multiple and complex actions and tools, to be applied simultaneously.

Actions recommended for the Buenos Aires Coastal Ecosystem

- Zone coastal waters to permit only small traditional vessels in certain areas (Governance).
- Optimise criteria for national and local budget allocations to institutions in charge of management (Governance).
- Refocus research policies according to state objectives regarding research and development (Governance).

- Establish a mechanism for financing long-term Research and Development (R&D) in order to achieve sustainable exploitation of fish resources (Governance).
- Integrate research data from different projects at the national (SECYT, INIDEP, and NGOs) and international levels (Governance).
- In conjunction with other development policies, develop a programme that promotes the preservation of the marine environment within Argentina's science and technology system (SCYT) (Governance).
- Involve fishermen in the development of technologies that increase selectivity of fishing practices, gears and devices (Knowledge & Technology, Governance).
- Standardise the collection and analysis of fisheries statistics, including catches, landings, exports, imports, and local sales, in order to assimilate the information required for adequate fisheries research and management (Knowledge).
- Disseminate information throughout communities to foster public awareness about goods and services related to oceanic ecosystems and the importance of proper management (Knowledge).
- Launch educational campaigns among the general population to discourage consumption of products based on living resources and species that are at risk of extinction and/or whose exploitation is incompatible with an ecosystem approach (Knowledge).

Actions recommended for the Argentinean-Uruguayan Common Fishing Zone

- Institute compatible fisheries management regulations between Argentina and Uruguay. Each country would retain the freedom to develop its own fisheries exploitation models, but the overall objectives and principles of each model would be consistent (Governance, Knowledge).
- Jointly assess the condition of resources and procure more reliable scientific data. This requires continuity in bilateral research programmes (Governance, Knowledge).
- Standardise the collection and analysis of information (catch, unloading, exports, imports, local sales), in order to assimilate information required for fisheries research and management (Governance, Knowledge).
- Carry out studies to investigate the selectivity of various fishing gears, to support management regulations aimed at minimising by-catch and safeguarding biodiversity and habitats (Knowledge, Technology).
- Expand research on species that inhabit similar environments as target species and are being discarded as by-catch (Knowledge).
- Promote the exchange of data and knowledge among regional organisations, such as common research units and workshops (Argentina, Uruguay, Brazil), in order to identify shared resources (Knowledge).

Performance of selected policy options

Selection of assessment criteria for policy options

Policy options proposed to mitigate the overexploitation of fish species will be assessed using available economic and social indicators (mentioned in the Causal chain analysis, Causal model and links). Indicators include the abundance of different species, catch (in tonnes per square nautical mile and/or operative unit), maximum catch per tide (i.e. between high waters), and the number of people employed in the fishing fleet and in fish processing plants. The choice of these indicators is justified for the following reasons:

- They are considered useful for the socio-economic assessment described in the causal chain analysis;
- They illustrate the magnitude of impacts on the ecosystem;
- They are obtained using a known method and are easily available.

Analysing the effectiveness of options for preventing the overexploitation of target species by changing conditions related to root causes of governance, knowledge, technology, and socio-cultural elements requires repeated monitoring of key indicators to determine whether proposed actions are achieving desired objectives. In addition, potential detrimental impacts of proposed policy options should also be identified and analysed.

Policy option 1: Regulating fishing effort in Buenos Aires Coastal Ecosystem

Effectiveness: A policy that limits fishing effort to levels that reflect the estimated annual ecosystem surplus of 80 000 tonnes would be likely to produce an increase in the standing stock biomass of inshore species along the coast of the province of Buenos Aires (Carroza et al. 2001a). Future monitoring of changes in the stock sizes of species could be used to indicate the effectiveness of actions. In connection with the successful enforcement of actions, adverse or collateral effects must be taken into account, particularly negative socio-economic impacts on the private sector (primary, secondary, and tertiary), such as those suffered by fishing operators who are excluded from certain fishing grounds (those with ships longer than 25 m).

Efficiency: The benefits derived from conservation and management are likely to build up over time, as these measures promote their long-term availability. However, in order to achieve the sustainable use of natural resources, considerable proportions of management budgets will have to be spent on monitoring and enforcement.

Equity: By preserving the ecosystem and ensuring it does not become irreversibly degraded, this would benefit everyone in the community over longer time scales. Over short time frames, operators of fishing boats shorter than 25 m, and traditional crafts sailing from the provincial ports of Buenos Aires, would directly benefit from this policy. However, the operators of ships longer than 25 m, which would be excluded from certain zones, and the land-based operations that depend on the fish caught by these larger vessels, are the groups that would stand to lose the most from this proposed option.

Furthermore, these operators would not be entitled to compensation under the current circumstances. Implementing this option is also likely to incur political costs on certain administrators and managers. However, when considering the total costs and benefits over longer time scales, sustainable management of fisheries using an ecosystem approach seems to be fully justified. Monitoring economic indicators will enable quantitative and qualitative appraisals of the impacts of the proposed option.

Political feasibility: Excluded sectors will always be opponents and may present obstacles and block enforcement. There is also a tendency towards a stubborn bureaucracy and economic and social forces that wish to maintain the status quo. These forces include political, business and union lobbies.

Implementation feasibility: Resources (human, financial, technological, and legal) are not considered sufficient for implementing the proposed option. In today's Argentina, a lack of professionalism among managers and poor leadership among politicians are seen as the main stumbling blocks. However, scientific, academic and research groups may eventually convince officials of the pressing need to exploit natural resources in a sustainable manner. However, the political will for this is currently deemed to be weak.

Policy option 2: Enhance governance and knowledge in Buenos Aires Coastal Ecosystem

Effectiveness: The objective is to strengthen institutional capacities in research, education and outreach, and enforcement, in order to propose and apply regulatory measures. Education and outreach are tied in with governance, as this will help to foster increasing awareness among fishers on the need for sustainable exploitation of the ecosystem, will build up an understanding and trust of scientific research among fishers, and will help promote conformity with regulations.

In order to achieve this objective, a key factor will be the institutional strengthening of the National Institute of Fisheries Research and Development (INIDEP). This includes employing temporary personnel full-time, increasing the budget of the institution by 25%, guaranteeing funding for research ships and campaigns, funding projects related to monitoring and control, reinstating the 12% cut from the budget in 2002, and incrementally building a 20% increase for research, while continuing current projects with at least 10 professionals in the first two years of field work.

Adverse and collateral effects: No direct risks are associated with the implementation of this option. However, there may be obstacles such as bureaucracy, red-tape, lack of planning, cultural or traditional limitations, and rising financial costs.

Efficiency: Benefits derived from conservation and management will accrue as these measures promote optimum exploitation of resources and ensure the long-term availability of resources. However, to achieve sustainable use of natural resources, a considerable proportion of management budgets must be spent on monitoring and enforcement.

Equity: Preservation of the ecosystem will benefit many stakeholders and the community. In addition, operators of smaller ships shorter than 25 m and traditional craft sailing from Buenos Aires provincial ports will also benefit directly. Operators of ships longer than 25 m, which will be excluded from the proposed coastal area, and the land-based operations that depend on the fish caught by these larger vessels will be the losers in the proposed option. Furthermore, under current circumstances, these operators would not be entitled to compensation. Certain administrators and managers may incur political costs from the implementation of this option. Losses and gains are fully justified in terms of the rational exploitation of resources and the ecosystem approach to managing fishing grounds. Monitoring of economic indicators will enable quantitative and qualitative appraisal of the impacts of the proposed option.

Political feasibility: Excluded interests will be hostile to the implementation of this option and might present obstacles to enforcement. In addition, stubborn bureaucracy and other economic or social interests, such as political, business and union lobbies, may also hinder the implementation of this option. Management capabilities and resources (human, financial, technological, legal) are not considered sufficient to implement the proposed option. However, the implementation of programmes to enhance the capacity of managers would yield medium and long-term benefits. Unfortunately though, political will is, at present, insufficient to ensure the success of this option.

Policy option 3: Overcome technological restraints and conflicts arising from socio-cultural traits in Buenos Aires Coastal Ecosystem

Effectiveness: The objectives are:

- To incorporate equipment, best practices, and technological developments that increase the selectivity of various fishing gears into fisher's practical and operative knowledge.
- To generate awareness among the general population on the importance of sustainable management of marine ecosystems.

The first objective could be achieved through the implementation of research projects on selective fishing by scientists or technicians at the INIDEP. Such initiatives should involve coastal fishers, preferably from the cooperative that gathers most small ships along the Buenos Aires shores. The second objective could be achieved through the implementation of public awareness campaigns, using television, radio and newspapers that disseminate information that describes the value of marine resources, ecosystem services, and endangered species. It would be expected that such a campaign would reduce the consumption of products produced in environmentally damaging ways, and would generate acceptance of management interventions that promote the sustainable use of marine resources.

Adverse and collateral effects: No definite hindrances are apparent. However, there may be some unforeseen obstacles caused by the cultural traditions of fishermen, which must be taken into account and treated tactfully. If not, their natural mistrust and aversion to change will prevent them from supporting managers openly, even if they usually cooperate with scientists and technicians in developing devices for selective fishing. Also, political bureaucracy and the costs associated with implementation, monitoring and enforcement may slow down actions.

Efficiency: Expected outcomes are the adoption of selective fishing practices and gears and the development of pro-environmental behaviour among all parties concerned with the sustainable exploitation of resources. Such attitudes will be perpetuated as long as stakeholders continue to be included in the development process. Projected economic and financial costs can be allocated to education and dissemination, research and development, administration, monitoring, and enforcement. It could also be divided between immediate and longer-term costs.

Equity: All members of society are winners in the long-term if ecosystem conservation can be achieved. If there are any losers over the short-term, this will be wholly justified by the sustainable use of sea resources, and an ecosystem-based approach to approach to the management of fishing grounds. Monitoring of socio-economic indicators, such as the number of selective devices in use, their degree of acceptance among fishermen, and the success of current educational campaigns, will provide quantitative and qualitative information to describe the impacts of proposed options.

Political feasibility: A stubborn administrative bureaucracy might limit the effectiveness of this option, although this type of intervention is generally accepted and is considered by most social groups as favourable. Moreover, politicians that promote such actions present a good image and, as a consequence, secure widespread approval.

Implementation feasibility: Economic resources required for advertising, public awareness and community education campaigns are usually high. Considering Argentina's current situation, the likelihood of diverting funds from the existing scarce budgets towards areas considered less essential to people's bare needs is not very high.

Policy option 4: Address political questions, governance and state of knowledge in the Argentinean-Uruguayan Common Fishing Zone

Effectiveness: The objectives are:

- To maintain and strengthen institutional capabilities in both countries.
- To advocate and implement measures to manage ecosystems sustainable.
- To standardise data collection and analysis in the Common Fishing Zone (FAO 1995).

The success of the proposed option could be measured through the number of joint projects implemented, as well as by establishing agreements for standardising data collection and analysis within both countries. The initiation of projects to investigate selective fishing practices in the area would also be a measure of success.

Adverse or collateral effects: There are no apparent risks associated with the implementation of this option. The obstacles are bureaucracy, lack of long-term plans, problems associated with the standardisation of data collection and handling procedures, and political pressure in both countries.

Efficiency: Expected benefits would be derived from the long-term sustainable exploitation of resources and the minimisation of risks that fishing and other extractive activities will cause ecosystems to collapse. Estimated costs include the time required by teams of qualified scientists, as well as policies to define types of actions and draft a long-term ”continuity strategy”. Furthermore, these costs would have to be added to the management, monitoring and enforcement costs.

Equity: In general, the populations of Argentina and Uruguay will emerge as winners from sustainable exploitation in the Common Fishing Zone. In the medium-term, operators whose fishing activity would be limited if both countries initiate conservation measures simultaneously might suffer losses. As with other proposed policy options, gains and losses result from implementation of basic environmentally sound resource management principles. Advantages would be derived from the sustainable exploitation of natural resources and the application of an ecosystem-based approach to fisheries management. Monitoring of socio-economic indicators will provide quantitative and qualitative data that describe the impacts of the proposed option. In addition, monitoring and enforcement will provide continuity.

Political feasibility: The bureaucracies and foreign offices of both countries negotiate to prevent or deal with international conflicts. Therefore, negotiation and implementation are likely to be very slow processes. However, the implementation of the proposed option is deemed to be highly feasible.

Implementation feasibility: Scientific and technical knowledge is adequate for offering advice to both governments. However, Argentina and Uruguay are both undergoing deep economic and financial crises, which may delay the implementation of proposed options.

Conclusions and recommendations

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GIWA region 38 Patagonian Shelf, comprises the entire La Plata River Basin, a major part of the Argentinean continental territory and a small part of the Chilean basins that drain into the South Atlantic Ocean. The marine component encompasses the Patagonian Shelf Large Marine Ecosystem, and the coastal shelf regions of Argentina and part of the Uruguay.

Given the significant differences in terms of biophysical and socio-economic characteristics, the Assessment was carried out separately for two systems: the La Plata River Basin and the South Atlantic Drainage System.

La Plata River Basin

Because all of the GIWA concerns in the La Plata River Basin were assessed as causing moderate impacts, there was no clear list of priorities among the concerns. However, after intense discussions and further assessments of individual scores, two concerns were identified as top priorities: Habitat and community modification, and Pollution.

The impacts of Freshwater shortage in the La Plata River Basin were assessed as moderate. Although freshwater supply aggregated at basin level greatly exceeds demand, the temporal and spatial distribution of flow is uneven, and water quality by degradation is progressively decreasing the usability of supplies.

With respect to groundwater, evidence suggests that domestic, industrial, and agricultural activities have contaminated aquifers, that water tables are receding due to the overexploitation of groundwater, and that overexploitation of aquifers has caused salinisation of certain aquifers.

Intensive water extraction in shared basins is showing evidence of significant declines in discharge, which is projected to increase in the future. Shortages in many locations have already been observed, and problems of water shortage are likely to become increasingly common.

The modification of water sources around major cities, the rising costs of water treatment, and the high cost of restoring degraded water sources stand out as pressing socio-economic issues that could potentially initiate conflicts at both sub-national and regional levels.

In addition, there are significant information gaps concerning socio-economic impacts associated with freshwater supply shortages, which makes it difficult to fully assess present and future impacts of freshwater shortages. It is recommended that further regional studies should be conducted to address this apparent paucity of information.

Although increasing attention will be paid to the control of pollution from urban and industrial sources, population growth, urbanisation and economic limitations will make it difficult to significantly increase wastewater treatment. Therefore, water sources will continue to be degraded, while the demand for water from various sectors will continue to increase. These issues are expected to intensify during the next decade, but will be abated over longer time frames. Therefore, it is likely that future impacts of Freshwater shortage in the La Plata River Basin will continue to be moderate.

The impacts of Pollution in the La Plata River Basin were assessed as moderate. There is evidence of microbiological pollution, eutrophication, chemical pollution, suspended solids, and oil spills. Solid waste, thermal pollution, and radionuclides have a much lower impact.

Microbiological contamination is mainly a problem in the vicinity of cities, due to the general lack of sewage treatment. Although impacts caused by microbial contamination of rivers are mostly restricted to sub-national levels, in some cases impacts extend beyond national borders and have transboundary implications. In addition, eutrophication in localised areas of large international reservoirs is evident.

Chemical pollution by heavy metals is widespread in the Basin due to the limited treatment of industrial wastes and the revamping of industrial processes. High fish mortality has been observed near effluent discharges. In addition, the application of biocides is a common agricultural practice in the Basin, and when combined with inefficient irrigation practices, waters become contaminated with biocides. Waste discharges from mining activities are also present in the Upper Pilcomayo River Basin.

In addition, land use changes (i.e. deforestation of humid areas) and unsustainable agricultural practices have resulted in soil erosion that has greatly increased the turbidity of water supplies. Concentrations of suspended sediments are particularly high in the Bermejo and Pilcomayo rivers, although a large proportion of these sediments have been generated through natural processes of soil erosion. Although the overall proportion of sediments generated by anthropogenic activities is low, it remains considerable and there are significant transboundary impacts. Sediments can also play key roles in transporting other pollutants downstream. However, regional studies to quantify the relative impact of sediments from various sources have been very limited, which should be addressed in further studies.

Occasionally, significant spills of oil or toxic chemicals occur in the La Plata and Iguazú rivers. Of particular importance was the heavy metal spill from a mine tailings pond near the Pilcomayo River, which exerted severe transboundary impacts. Considering that mining activities in the Basin are significant, and considering that 30 small mines discharge their effluents directly into the River without treatment or regulation, it is recommended that studies of the impacts of these discharges should be conducted in the future.

Although there is a lack of quantitative regional data, it was possible to determine that pollution is causing severe socio-economic impacts in the La Plata River Basin due to increasing costs of water treatment (especially in large metropolitan areas), increasing costs of emergency clean-ups in the case of spills, declining fish sales linked with microbiological and chemical pollution, increasing costs of fishing, and losses in property values. In addition, the health of the population in the system is being affected by pollution. The lack of adequate water treatment and sanitation systems promotes the spread of water-borne diseases. The discharge of effluents from industries and mines presents health risks. Oil spills and microbiological pollution has damaged protected areas, affected biodiversity, and caused the closure of some beaches, which has caused losses of tourism, recreation, and aesthetic values.

Government actions, the activities of environmental NGOs, enhanced community awareness and commitment, and increased self-regulating behaviour of industries (International Organisation for Standardisation - ISO standards) are expected to improve the pollution situation in the future, but in the long term only slight improvements are expected to occur.

The impacts of Habitat and community modification on the La Plata River Basin were assessed as moderate. The construction of reservoirs for hydropower generation has caused modifications to several types of fluvial and riparian ecosystems. The construction of a large number of reservoirs in the main reaches of rivers and their tributaries has transformed fluvial lotic systems into lentic or semi-lentic ecosystems. Reservoir cascades in the main international rivers (Paraná River) and their tributaries have altered habitats and interrupted system continuity, affecting community structure and the population dynamics of migratory species with considerable biological and commercial value. Migratory routes of fish species have been disturbed, flow regulation has affected species that use downstream floodplains for spawning, and there have been records of fish mortality due gas supersaturation caused by dam operations. In addition, riparian river ecotones have been turned into lake ecotones, and terrestrial habitats have been submerged.

Urbanisation has also resulted in the loss of certain aquatic ecosystems types. The development of large urban settlements along the river banks (e.g. São Paulo, Posadas and Encarnación), and the coastal belt of the Lower Paraná River and the La Plata River has destroyed riparian habitats.

The loss of habitats due to heavy pollution exerts sub-national transboundary impacts.

Accidentally introduced alien species of Asiatic origin, such as *Limnoperna fortunei* and *Corbicula fluminea,* have dispersed throughout a large part of the La Plata River Basin. The methods and extent of dispersal (Argentina, Brazil, Paraguay and Uruguay) have resulted in severe impacts with transboundary characteristics.

Also evident is the increase in abundance of carp in the inner La Plata River, Paraná, and Uruguay rivers. The introduction of tilapia in many reservoirs and lakes in the sub-tropical areas is well known. As a consequence, these ecosystems have exhibited species exclusion and changes in food webs.

Moderate economic, social and other community impacts are evident mainly in relation to the decline of fishing and, to some extent, the hunting of commercially valuable species. As a consequence, impacts are highest on fishing, sporting, and tourism activities. Additionally, there are direct costs associated with controlling invasive species and restoring habitats, and indirect costs associated with the loss of educational and scientific values. The issue of intergenerational inequity is also an important issue that should be studied and incorporated into regional plans and programmes. There are no indications that habitat modifications have any direct impacts on human health. The expected trend in habitat modification is a moderate deterioration between now and the year 2020.

The Unsustainable exploitation of fish and other living resources was also assessed as moderate within the La Plata River Basin, which contains major inland commercial and recreational fisheries. Overexploitation, pollution (including eutrophication), and the construction and operation of reservoirs are the primary causes of anthropogenic impacts on fisheries, and there are significant transboundary influences at multi-national and sub-national levels. There is also evidence of decreased viability of fish stocks due to pollution, although these effects tend to be insignificant at the regional level. The introduction of alien species can have detrimental effects on transboundary aquatic ecosystems, due to species exclusions changes to the food web structure, and altered community structure and dynamics. Although the fishing sector is relatively small, impacts on the national economy and society are significant. In addition, there are food security issues for artisanal fishers.

In the future, a moderate increase in the impact of fisheries is foreseen. However, existing impacts of fisheries are likely to remain stable if regulations are successfully implemented.

Local experts differ in opinion regarding the magnitude of overexploitation, particularly within the Argentinean section of the Paraná River. Therefore, it is a priority for this issue to be resolved in the future by research that determines the status of fish stocks in the entire basin.

The impacts of Global change were also assessed as moderate. This was based primarily on the consideration of the effects of anomalous rainfall and stream flow patterns during El Niño phenomena, and the recent increase in the intensity of these events. There is no evidence of either changes in sea level, increases in UV-B radiation or changes in CO_2 dissolution.

Economic sectors are affected primarily by flooding and the elevation of water tables. Damage to public and private properties, losses to agricultural production, and long-lasting changes to the productivity of natural resource systems (agriculture, forestry, fisheries) are significant. Climate change also poses increasing risks to human health, particularly due to new disease vectors for tropical and water-related diseases.

In the future, it is expected that the magnitude of the impacts of global change will increase slightly, particularly in the La Plata River Basin which has proved to be a sensitive area to climatic phenomena. The environmental impacts of global change are likely to cause increases in the economic, social, community, and health impacts. Regional studies should be carried out to assess and predict the impacts of both climate variability and climate change, and to obtain a deeper knowledge of climatological and hydrological factors that determine flood and drought frequencies in the La Plata River Basin.

A Causal chain analysis and Policy options analysis for Pollution has been conducted, using the Uruguay River Basin as a case study, and several policy options have been identified to mitigate or address this priority issue.

South Atlantic Drainage System

On the basis of the assessment in the South Atlantic Drainage System, the major concerns and their constituent issues were grouped into three categories. The impacts of Habitat and community modification and Unsustainable exploitation of fish and other living resources were assessed as moderate. The impacts of Freshwater shortage and Pollution were also assessed as moderate, but were considered to be significantly less severe than those of the previous two concerns. Finally, the impacts of Global change were actually predicted to be slightly beneficial to the system as a whole. Based on these assigned scores, the following concerns were prioritised:

- Habitat and community modification in the marine component, which is strongly linked to Unsustainable exploitation of fish and other living resources.

The impacts of Freshwater shortage were assessed as moderate. A measurable decrease of spring water in some locations provides evidence of stream flow modification. In addition, there have been indications of microbiological contamination, hydrocarbons from oil spills, and pollution of groundwater from the oil industry, which affect existing sources. The impacts of eutrophication are generally low but widespread, and affect almost every reservoir in the system.

Evidence of salinisation in irrigated areas and indications of falling water tables associated with springs in localised recharge zones support impact scores assigned to the issue of changes in water tables. However, there is not enough information on groundwater salinisation or changes in water tables to reliably assess impacts at the regional level. Therefore, it is recommended to carry out studies to assess the condition of groundwater resources throughout the entire region. There is also evidence that suggests that water tables associated with springs ("mallines"), have been affected and have started to recede. Consequently, it is recommended that existing studies being conducted on mallines should be supported in the future.

Health problems due to the lack of safe water are expected to increase rapidly in the future, along with related social and community impacts. In addition, economic costs associated with water treatment, restoration of supply sources, or exploitation of more costly new sources, will increase slightly in the coming decades.

At present, Pollution has only a slight impact on the system caused by the moderate impacts exerted by suspended solids and spills and the small impacts resulting from microbiological and chemical pollution, eutrophication, and solid wastes.

Industrial and urban discharges, especially in Bahía Blanca and Rio Gallegos cities, are the primary sources of microbiological pollution in the region. There is evidence of eutrophication in some reservoirs, and increases in the turbidity in various streams, reservoirs and marine water bodies due to increasing concentrations of suspended solids. The impacts of chemical pollution are limited and tend to be restricted to local scales. Hydrocarbons from oil fields and harbours are the main chemical pollutants in both the continental and oceanic waters of the South Atlantic Drainage System.

The interference of solid waste with fishing activities is observed all along the Patagonian Atlantic coast, but has a negligible impact on surface waters due to the limited extent of the problem. Frequent pollution of surface waters in the Colorado River caused by oil spills has degraded the quality of water, and has affected irrigation and drinking water supply in this semi-arid region. In the province of Santa Cruz and other areas along the Atlantic coast, pollution of groundwater is caused by secondary recovery of oil.

Action from environmental NGOs and increased community awareness will tend to improve the situation and will diminish pollution loads. It is thought that major investments in the region will be carried out by large enterprises subject to international funding, which will force environmentally friendly behaviour and compliance with self-regulating International Organisation for Standardisation - ISO standards. Demographic pressures in the region will continue to be low and therefore pollution of water resources is not expected to increase significantly, which provides a positive outlook for the future.

The overall impact of Habitat and community modification was assessed as moderate. Impacts are caused mainly by the construction and operation of dams, the fragmentation of sandy foreshores, changes to the littoral belt system and coastal fringes due to localised urbanisation and the construction of recreational beach facilities. In addition, fisheries activities and the degradation of water springs near sheep and cattle raising areas are other issues that are linked with habitat modification.

The modification of ecosystem and ecotones results mainly from the overexploitation of fish populations, and the operation of harbours and oil shipping facilities in some areas along the coast have resulted in pollution 'hot spots' which locally affect coastal habitats and associated aquatic communities. The main cause of community modification is the intensive exploitation of fish, which, when combined with incidental captures, discards, and other fishing practices, has significantly affected aquatic community structure and population dynamics of species at various trophic levels.

Unsustainable exploitation of fish and other living resources was assessed as moderate. Fishing practices, including intensive fish exploitation, incidental captures, and discards, have affected the population dynamics of species at various trophic levels, altered food webs, and changed the structure of the community. As a result, this concern is clearly linked to Habitat and community modification.

Severe impacts due to overexploitation occur mainly in the marine component of the system, particularly concerning fishing for hake, which is seriously affected due to exploitation beyond safe biological limits.

Incidental by-catch and discards amount to approximately 30-60% of fish production in the hake fishery, and destructive fishing practices as a result of trawling methods used in marine areas have a significant impact on benthic habitats. The sea floor is often trawled more than 10 times per fishing operation, seriously affecting the benthic habitat. In addition, the overexploitation of the hake fishery results in social and economic problems due to employment losses and the bankruptcy of fishing enterprises. The exploitation of living resources within both marine and inland fisheries is expected to increase, unless tangible results from implemented regulations take place in the near future.

Global change was assessed as having no negative impacts on the system. Positive impacts from changes in the hydrological cycle and in the oceanic circulation have been identified based on shifts in the isohyets towards the west, and there is no evidence of sea level changes. However, increased UV-B radiation has had slight impacts given some evidence of changes to phytoplankton and ichthyoplankton. Changes in ocean CO_2 source/sink function is also estimated to be slight, although further research is being carried out.

In the future, it is considered that the overall negative environmental impact of global change will increase, resulting in higher costs and negative social and community impacts.

A Causal chain analysis and Policy options analysis for Habitat and community modification has been conducted, using the Buenos Aires Coastal Ecosystem and Argentinean-Uruguayan Common Fishing Zone as a case study, and several policy options have been identified to mitigate or address this priority issue.

Further research recommended for the Patagonian Shelf region

Considering the lack of available information it is recommended that the following projects are conducted within the Patagonian Shelf region:

- Baseline studies for land use regulation based on indicators of anthropogenic activities with transboundary impacts, taking into account point and diffuse sources of pollution in the Uruguay River Basin. Such studies should be complemented with harmonisation of legal frameworks.
- Regional study on sediment generation and transport in the La Plata River Basin aimed at identifying the critical areas as regards human impact. Outcomes should be presented in a GIS environment.
- Regional studies to assess and predict impacts due to climate variability obtained through a deeper knowledge of climate and hydrological factors that define flood and drought frequency in the La Plata River Basin.
- Regional studies on salinisation and receding water tables in the South Atlantic Drainage System identifying the anthropogenic causes of these problems.
- In-depth studies on fauna associated with species targeted in the fisheries of the region and those incidentally exploited.

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Annexes

Annex I
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Annex II
Detailed scoring tables: La Plata River Basin

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	1	40	Freshwater shortage	1.4
2. Pollution of existing supplies	2	40		
3. Changes in the water table	1	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	2	40
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	2	30
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	1	40
Degree of severity	Minimum Severe 0 1 2 3	1	30
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	30
Weight average score for Health impacts		**1.6**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	1	40
Degree of severity	Minimum Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	30
Weight average score for Other social and community impacts		**1.9**	

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	2	20	Pollution	1.9
5. Eutrophication	2	20		
6. Chemical	2	20		
7. Suspended solids	2	15		
8. Solid wastes	1	5		
9. Thermal	1	5		
10. Radionuclide	0	0		
11. Spills	2	15		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	3	40
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	3	30
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	30
Weight average score for Economic impacts		**3.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	1	40
Degree of severity	Minimum Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**1.6**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	2	30
Degree of severity	Minimum Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	3	30
Weight average score for Other social and community impacts		**2.3**	

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	3	50	Habitat and community modification	2.5
13.Modification of ecosystems or ecotones, including community structure and/or species composition	2	50		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	40
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	30
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	33
Degree of severity	Minimum – Severe 0 1 2 3	0	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	33
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	40
Degree of severity	Minimum – Severe 0 1 2 3	1	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	30
Weight average score for Other social and community impacts		**2.0**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	2	30	Unsustainable exploitation of fish	1.5
15. Excessive by-catch and discards	1	15		
16. Destructive fishing practices	1	15		
17. Decreased viability of stock through pollution and disease	1	20		
18. Impact on biological and genetic diversity	2	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	1	20
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	40
Weight average score for Economic impacts		**2.2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	33
Degree of severity	Minimum – Severe 0 1 2 3	0	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	33
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	20
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	40
Weight average score for Other social and community impacts		**2.2**	

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	40	Global change	0.8
20. Sea level change	0	20		
21. Increased UV-B radiation as a result of ozone depletion	0	20		
22. Changes in ocean CO_2 source/sink function	0	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	33
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	33
Weight average score for Economic impacts		**2.7**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	30
Degree of severity	Minimum – Severe 0 1 2 3	3	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	30
Weight average score for Health impacts		**2.4**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	33
Degree of severity	Minimum – Severe 0 1 2 3	2	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33
Weight average score for Other social and community impacts		**2.0**	

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts: Environmental score		Economic score		Human health score		Social and community score		Overall score
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.4	2.0	2.0	2.0	1.6	2.0	1.9	2.5	**1.9**
Pollution	1.9	1.6	3.0	3.0	1.6	1.5	2.3	2.0	**2.1**
Habitat and community modification	2.5	3.0	2.0	2.5	0	0	2.0	2.5	**1.8**
Unsustainable exploitation of fish and other living resources	1.5	2.0	2.2	2.5	0	0	2.2	2.5	**1.6**
Global change	0.8	2.0	2.7	3.0	2.4	3.0	2.0	2.5	**2.3**

If the results in this table were not giving a clear prioritisation, the scores were weighted by assigning different relative importance to present/future and environmental/socio-economic impacts in the following way:

Weight averaged environmental and socio-economic impacts of each GIWA concern

Present (%) (i)	Future (%) (j)	Total (%)
60	40	100

Environmental (k)	Economic (l)	Health (m)	Other social and community impacts (n)	Total (%)
50	15	20	15	100

Concern	Types of impacts: Time weight averaged Environmental score (o)	Time weight averaged Economic score (p)	Time weight averaged Human health score (q)	Time weight averaged Social and community score (r)	Time weight averaged overall score
	(a)x(i)+(b)x(j)	(c)x(i)+(d)x(j)	(e)x(i)+(f)x(j)	(g)x(i)+(h)x(j)	(o)x(k)+(p)x(l)+(q)x(m)+(r)x(n)
Freshwater shortage	1.6	2.0	1.8	2.1	**1.8**
Pollution	1.6	3.0	1.6	2.2	**1.9**
Habitat and community modification	2.7	2.2	0	2.2	**2.0**
Unsustainable exploitation of fish and other living resources	1.7	2.3	0	2.3	**1.6**
Global change	1.3	2.8	2.6	2.2	**1.9**

Detailed scoring tables: South Atlantic Drainage System

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	1	30	Freshwater shortage	1.0
2. Pollution of existing supplies	1	30		
3. Changes in the water table	1	40		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	2	40
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	30
Weight average score for Economic impacts		**2.3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	0	33
Degree of severity	Minimum – Severe (0 1 2 3)	0	33
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	0	33
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	2	30
Degree of severity	Minimum – Severe (0 1 2 3)	2	40
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	30
Weight average score for Other social and community impacts		**2.3**	

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	1	10	Pollution	1.4
5. Eutrophication	1	20		
6. Chemical	1	20		
7. Suspended solids	2	15		
8. Solid wastes	1	15		
9. Thermal	0	0		
10. Radionuclide	0	0		
11. Spills	2	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	2	30
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	2	40
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	30
Weight average score for Economic impacts		**2.3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	2	40
Degree of severity	Minimum – Severe (0 1 2 3)	1	30
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	30
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	1	40
Degree of severity	Minimum – Severe (0 1 2 3)	1	30
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	1	30
Weight average score for Other social and community impacts		**1.0**	

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	2	60	Habitat and community modification	2.0
13.Modification of ecosystems or ecotones, including community structure and/or species composition	2	40		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small 0 1 2 3 Very large	2	30
Degree of impact (cost, output changes etc.)	Minimum 0 1 2 3 Severe	2	40
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	3	30
Weight average score for Economic impacts		**2.3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small 0 1 2 3 Very large	0	33
Degree of severity	Minimum 0 1 2 3 Severe	0	33
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	0	33
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small 0 1 2 3 Very large	1	30
Degree of severity	Minimum 0 1 2 3 Severe	2	40
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	3	30
Weight average score for Other social and community impacts		**2.0**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	25	Unsustainable exploitation of fish	1.8
15. Excessive by-catch and discards	2	25		
16. Destructive fishing practices	2	20		
17. Decreased viability of stock through pollution and disease	0	10		
18. Impact on biological and genetic diversity	1	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small 0 1 2 3 Very large	1	20
Degree of impact (cost, output changes etc.)	Minimum 0 1 2 3 Severe	2	40
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	3	40
Weight average score for Economic impacts		**2.2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small 0 1 2 3 Very large	0	33
Degree of severity	Minimum 0 1 2 3 Severe	0	33
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	0	33
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small 0 1 2 3 Very large	1	20
Degree of severity	Minimum 0 1 2 3 Severe	2	40
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	3	40
Weight average score for Other social and community impacts		**2.2**	

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	+1	60	Global change	+0.2
20. Sea level change	0	0		
21. Increased UV-B radiation as a result of ozone depletion	1	20		
22. Changes in ocean CO_2 source/sink function	1	20		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small — Very large 0 1 2 3	+1	20
Degree of impact (cost, output changes etc.)	Minimum — Severe 0 1 2 3	+1	40
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	40
Weight average score for Economic impacts		**+1.4**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small — Very large 0 1 2 3	0	33
Degree of severity	Minimum — Severe 0 1 2 3	0	33
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	0	33
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small — Very large 0 1 2 3	+1	33
Degree of severity	Minimum — Severe 0 1 2 3	2	33
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	33
Weight average score for Other social and community impacts		**+1.6**	

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.0	1.2	2.3	2.5	0	1.0	2.3	2.5	**1.6**
Pollution	1.4	1.0	2.3	2.5	2.0	1.5	1.0	1.0	**1.6**
Habitat and community modification	2.0	3.0	2.0	3.0	0	0	2.0	3.0	**1.9**
Unsustainable exploitation of fish and other living resources	1.8	2.4	2.2	2.5	0	0	2.2	2.5	**1.7**
Global change	+0.2	0	+1.4	+1.0	0	0	+1.7	+1.0	**+0.7**

If the results in this table were not giving a clear prioritisation, the scores were weighted by assigning different relative importance to present/future and environmental/socio-economic impacts in the following way:

Weight averaged environmental and socio-economic impacts of each GIWA concern

Present (%) (i)	Future (%) (j)	Total (%)
60	40	100

Environmental (k)	Economic (l)	Health (m)	Other social and community impacts (n)	Total (%)
50	15	20	15	100

Concern	Types of impacts				
	Time weight averaged Environmental score (o)	Time weight averaged Economic score (p)	Time weight averaged Human health score (q)	Time weight averaged Social and community score (r)	Time weight averaged overall score
	(a)x(i)+(b)x(j)	(c)x(i)+(d)x(j)	(e)x(i)+(f)x(j)	(g)x(i)+(h)x(j)	(o)x(k)+(p)x(l)+(q)x(m)+(r)x(n)
Freshwater shortage	1.0	2.4	0.4	2.4	**1.5**
Pollution	1.2	2.4	1.8	1.0	**1.5**
Habitat and community modification	2.4	2.4	0	2.4	**2.2**
Unsustainable exploitation of fish and other living resources	2.0	2.3	0	2.3	**2.0**
Global change	+0.1	+1.2	0	+1.4	**+0.6**

Annex III
Detailed assessment worksheets for causal chain analysis

Worksheet 1a: Description of indicators or quantitative information substantiating links between Issue and Immediate cause in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: MICROBIOLOGICAL / Immediate cause: DISCHARGE OF UNTREATED WASTEWATER & LIVESTOCK WASTE							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Faecal coliforms	Report	Uruguay River Basin, Brazil	2002	Reports from national agencies	Public, Portuguese	FEPAM Fundación Estadual de Protección Ambiental Enrique Luis Roessles de Río Grande del Sur, Brazil, Internet	Bacteriological samples from permanent stations.
Evaluation of existing data	Report	Upper Uruguay	1998	Publications from universities	Available if requested, Portuguese	IPH Instituto de Pesquisas Hidráulicas, Brazil	Data assessment by Ing. Carlos Tucci.
Description of river basin problems	Report	Cuareim River Basin	2003	Reports from national agencies	Public, Spanish	Comisión Río Cuareim, Internet	Bacteriological samples.
Water resources national plan	Report	Uruguay Basin, Brazil	2003	Reports from national agencies	Public, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Description of existing wastewater treatment plants.
Statistics of wastewater collection and treatment systems	Report	Uruguay Basin, Brazil	2003	Reports from national agencies	Public, Portuguese	IBGE Instituto Brasilero de Geografía Estadística, Brazil, Internet	Sewerage network and wastewater treatment data.
Province activities, basic data	Report	Misiones Province, Argentina	2002	Reports from national agencies	Public, Spanish	Ministerio de Economía, Argentina, Internet	Basic data.
Percentages of wastewater collection and treatment systems	Data table	Artigas City, Uruguay	2003	Unpublished	Not available	OSE Obras Sanitarias del Estado, Uruguay	Calculations by OSE technical personnel.
Data on final disposal of effluents	Report	Upper and Middle Uruguay, Brazil	2002	Reports from national agencies	Public, Portuguese	FEPAM, Internet	River basin activities, description and type of final disposal of effluents.

Worksheet 1b: Description of indicators or quantitative information substantiating links between Issue and Immediate cause in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: EUTROPHICATION / Immediate cause: INEFFICIENT IRRIGATION PRACTICES & RUN-OFF							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Statistics on algal blooms in reservoirs	Interview	Uruguayan rice zone	2003	Unpublished	Not available	SAMAN S.A. Arrozales Nacionales, Uruguay, Ing. Angel Cabral, Jefe del Departamento de Riego de SAMAN	Description of algal bloom events.
Statistics on algal blooms in reservoirs	Report	Salto Grande Reservoir	1978 - 1994	Reports from international agencies	Available if requested from CTMSG, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande	Description of algal bloom events during the study period.
Nutrient concentrations, description of sources	Report	Salto Grande Reservoir	1992-1997	Reports from international agencies	Available if requested from CTMSG, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande	Phosphorus and chlorophyll concentrations.
Area cultivated with rice per municipality	Report	Middle Uruguay and Cuareim River, Brazil	2002	Publications from private organisations	Public, Portuguese	IRGA Instituto Riograndense do Arroz, Brazil, Internet	Cultivated or seeded area.
Farmed area per department	Report	Uruguayan Sector	2002	Reports from national agencies	Available if requested, Spanish	MGAP Ministerio de Ganadería Agricultura y Pesca, Uruguay; MGAP and other organisations' libraries	Seeded area.
Volume of reservoirs	Report	Uruguay	2000	Reports from national agencies	Available if requested, Spanish	MTOP Ministerio de Trasporte y Obras Públicas, Uruguay; MTOP and other organisations' libraries	Existing water inlet and available volumes in reservoirs.
Farmed area	Report	Corrientes province	2001	Reports from national agencies	Public, Spanish	INTA Instituto Nacional de Tecnología, Agropecuara, Internet	Cultivated area.

Worksheet 1c: Description of indicators or quantitative information substantiating links between Issue and Immediate cause in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: CHEMICAL / Immediate cause: APPLICATION OF BIOCIDES & DISCHARGE OF UNTREATED WASTEWATER							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Pesticide concentrations	Report	Uruguayan - Argentinean shared sector	1992	Reports from international agencies	Public, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande	Water quality sampling at Salto Grande Reservoir.
Pesticide concentrations	Report	Uruguayan - Argentinean shared sector	1994	Reports from international agencies	Available if requested, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande	Water quality sampling at Salto Grande Reservoir.
Pesticide concentrations	Data table	Uruguayan - Argentinean shared sector	1994	Reports from international agencies	Available if requested, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande	Water quality sampling at Salto Grande Reservoir.
Pesticide concentrations in tissues	Report	Salto Grande Lake	2002	Reports from international agencies	Available if requested, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande; CARU Comisión Administradora del Río Uruguay	Organic chloride biocides in fish.
Provinces developed activities, basic data	Report	Uruguay River Basin at Entre Rios Province	2000	Reports from national agencies	Available if requested, Spanish	Ministerio de Economía, Argentina, Internet	Data on activities.
Cultivated areas	Report	Uruguayan sector	2002	Reports from national agencies	Available if requested, Spanish	MGAP Ministerio de Ganadería Agricultura y Pesca, Uruguay; MGAP and other organisms libraries	Seeded area.
Industrial activities	Report	Upper Uruguay	2003	Reports from national agencies	Public, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Description of existing industrial activities.
Industrial activities	Data table	Uruguayan sector	2003	Reports from national agencies	Available if requested, Spanish	DINAMA Dirección Nacional de Medio Ambiente, Uruguay	Type of existing industries. Production and final discharge data.

Worksheet 1d: Description of indicators or quantitative information substantiating links between Issue and Immediate cause in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: SUSPENDED SOLIDS / Immediate cause: SOIL EROSION							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Details of sedimentation processes	Report	Uruguay River Basin, Brazil	2001	Publications from universities	Public	Projeto arenização no Rio Grande do Sul, Brazil: gênese, dinâmica e espacialização, Brazil, Internet	Sedimentation processes and vulnerability data.
Data on sedimentation rates	Report	Uruguay Basin	-	Reports from international agencies	Available for technicians	GIWA Regional assessment, La Plata River Basin	Sedimentation data at Salto Grande Reservoir.
Description and evaluation of soil erosion processes	Report	Brazilian sector of Uruguay River Basin	1998	Publications from universities	Available if requested	IPH Instituto de Pesquisas Hidráulicas, Brazil	Evaluation of farming practices.

Worksheet 2a: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: MICROBIOLOGICAL / Immediate cause: DISCHARGE OF UNTREATED WASTEWATER / Sector: AGRICULTURE & URBAN SECTOR							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Description of urban effluent treatment systems	Report	Uruguay River Basin, Brazilian Sector	2003	Reports from national agencies	Available, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Urban wastewater discharges with unsuitable disinfection.
Description of river basin activities and final disposal of effluents	Report	Uruguay River Basin, Brazilian Sector	2003	Reports from national agencies	Available, Portuguese	FEPAM Rio Grande del Sur, Brazil, Internet	Urban wastewater discharges with unsuitable disinfection.
Description of river basin activities and final disposal of effluents	Report	Uruguay River Basin, Brazilian Sector	1998	Publications from universities	Available, Portuguese	IPH Instituto de Pesquisas Hidráulicas, Brazil, Internet	Urban wastewater discharges with unsuitable disinfection.
Artigas city treatment systems data	Data table	Artigas City, Uruguay	2003	Unpublished	Not available	OSE Obras Sanitarias del Estado, Uruguay, OSE.	Urban wastewater discharges with unsuitable disinfection.
Misiones and Corrientes provinces sewerage data	Report	Argentina	1999	Reports from international agencies	Available, Spanish	World Bank, Water Resources Management in Argentina, Economic and Financial Aspects, Argentina, Internet	Urban wastewater discharges with unsuitable disinfection.
Data of Brazil swine production	Report	Uruguay River Basin, Brazilian Sector	-	Publications from private organisations	Available, Portuguese	ACSURS, Associação do Rio Grande do Sul Criadores de Suínos, Brazil, Internet	Urban wastewater discharges with unsuitable disinfection.
Sewerage information national system, Data of sewerage systems in Rio Grande del Sur and Santa Catarina municipalities, Brazil	Reports	Brazil	-	Reports from national agencies	Available, Portuguese	FUNASA Fundacao Nacional de Saude, Brazil, Internet	Urban wastewater discharges with unsuitable disinfection.
Province sewerage data	Data table	Misiones Province, Argentina	2003	Reports from national agencies	Available, Portuguese	IMAS Instituto Misionero del Agua y Saneamiento, Argentina, Internet	Urban wastewater discharges with unsuitable disinfection
Data on contamination caused by swine breeding	Paper	Santa Catarina, Brazil	2000	Reports from national agencies	Available, Portuguese	Producao de suínos no Brazil: impacto ambientais y sustentabilidade, Internet	Supply resources contamination caused by swine wastewater discharges with unsuitable disinfection.
Contamination data caused by swine breeding at Peixe River	Technical Communication	Santa Catarina, Brazil	2002	Reports from national agencies	Available, Portuguese	EMBRAPA Empresa Brasileira de Pesquisas Agropecuarias, Brazil, Internet	Contamination data caused by swine breeding in Peixe River Basin.

Worksheet 2b: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue:EUTROPHICATION / Immediate cause: INEFFICIENT IRRIGATION PRACTICES / Sector: AGRICULTURE & URBAN SECTOR							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Description of urban effluent treatment systems	Report	Uruguay River Basin, Brazilian Sector	2003	Reports from national agencies	Available, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Wastewater discharges with high nutrient concentrations.
Description of river basin activities and final disposal of effluents	Report	Uruguay River Basin, Brazilian Sector	2003	Reports from national agencies	Available, Portuguese	FEPAM, Rio Grande del Sur, Brazil, Internet	Wastewater discharges with high nutrient concentrations.
Description of river basin activities and final disposal of effluents	Report	Uruguay River Basin, Brazilian Sector	1998	Publications from universities	Available, Portuguese	IPH Instituto de Pesquisas Hidráulicas, Brazil,Internet	Wastewater discharges with high nutrient concentrations.
Artigas city treatment systems data	Data table	Artigas City, Uruguay	2003	Unpublished	Not available	OSE Obras Sanitarias del Estado, Uruguay	Wastewater discharges with high nutrient concentrations.
Artigas department sewerage data	Report	Argentina	1999	Reports from international agencies	Available, Spanish	World Bank, Water Resources Management in Argentina, Economic and Financial Aspects, Argentina, Internet	Wastewater discharges with high nutrient concentrations.
Data on Brazil swine production	Report	Uruguay River Basin, Brazilian Sector	Not available	Publications from private organisations	Available, Portuguese	ACSURS Associação do Rio Grande do Sul Criadores de Suínos, Brazil, Internet	Wastewater discharges with high nutrient concentrations.
Sewerage information national system, data of sewerage systems in Rio Grande del Sur and Santa Catarina municipalities, Brazil	Reports	Brazil	Not available	Reports from national agencies	Available, Portuguese	FUNASA Fundacao Nacional de Saude, Brazil, Internet	Wastewater discharges with high nutrient concentrations.
Sewerage data, Misiones	Data Table	Misiones Province, Argentina	2003	Reports from national agencies	Available, Portuguese	IMAS Instituto Misionero del Agua y Saneamiento, Argentina, Internet	Wastewater discharges with high nutrient concentrations.
Data on contamination caused by swine breeding	Paper	Santa Catarina, Brazil	2000	Reports from national agencies	Available, Portuguese	Producao de suínos no Brazil: impacto ambientais y sustentabilidade, Internet	Wastewater discharges with high nutrient concentrations.
Data on contamination caused by swine breeding in Peixe River	Technical Communication	Santa Catarina, Brazil	2002	Reports from national agencies	Available, Portuguese	EMBRAPA Empresa Brasileira de Pesquisas Agropecuarias, Brazil, Internet	Wastewater discharges with high nutrient concentrations.

Worksheet 2c: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue:EUTROPHICATION / Immediate cause: RUN-OFF & RAINWATER / Sector: AGRICULTURE							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Description of agriculture in the area	Report	Uruguay River Basin, Brazilian Sector	2003	Reports from national agencies	Available, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Fertiliser uses, run-off, increase in nutrient contribution.
Description of river basin activities and final disposal of effluents	Report	Uruguay River Basin, Brazilian Sector	2003	Reports from national agencies	Available, Portuguese	FEPAM, Rio Grande del Sur, Brazil, Internet	Fertiliser uses, run-off, increase in nutrient contribution.
Description of river basin activities	Report	Uruguay River Basin, Brazilian Sector	1998	Publications from universities	Available, Portuguese	IPH Instituto de Pesquisas Hidráulicas, Brazil, Internet	Fertiliser uses, run-off, increase in nutrient contribution.
Cultivated or seeded area	Report	Middle Uruguay and Cuareim River, Brazil	2002	Publications from private organisation	Public, Portuguese	IRGA Instituto Riograndense do Arroz, Brazil, Internet	Rice cultivated area, fertiliser uses, increase in nutrient contribution.
Seeded area	Report	Uruguayan Sector	2002	Reports from national agencies	Available if requested, Spanish	MGAP Ministerio de Ganadería Agricultura y Pesca, Uruguay; MGAP and other organisms libraries	Rice cultivated area, fertiliser uses, increase in nutrient contribution.
Existing water inlet and available volumes in reservoirs	Report	Uruguay	2000	Reports from national agencies	Available if requested, Spanish	MTOP Ministerio de Trasporte y Obras Públicas, Uruguay; MTOP and other organisms libraries	Farming area, calculation.
Cultivated area	Report	Corrientes Province	2001	Reports from national agencies	Public, Spanish	INTA Instituto Nacional de Tecnología, Agropecuaria, Internet	Farming area, calculation.
Description of cultivated area	Report	Misiones, Entre Rios and Corrientes Provinces, Argentina	2002	Reports from national agencies	Public, Spanish	Ministerio de Economía, Argentina, Internet	Farming area, calculation.
Environmental impacts, cultivated area, irrigation methodologies	Paper	Rio Grande do Sul, Brazil	2002	Reports from national agencies	Public, Portuguese	O licenciamento ambiental dos produtores de arroz no Rio Grande do Sul, Brazil, Internet	Rice cultivated are, fertiliser uses, increase in nutrient contribution.

Worksheet 2d: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue:CHEMICAL / Immediate cause: APPLICATION OF BIOCIDES/ Sector: AGRICULTURE							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Problem description	Problem description	Uruguay River Basin, Brazil	2002	Reports from National Agencies	Public, Portuguese	FEPAM, Internet	Intensive use of agro-chemicals in farming.
Problem description	Report	Uruguay River Basin, Brazil	1998	Publications from Universities	Public, Portuguese	IPH Instituto de Pesquisas Hidráulicas, Brazil, IPH	Intensive use of agro-chemicals in farming.
Problem description	Report	Uruguay River Basin, Brazil	2003	Reports from National Agencies	Public, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Intensive use of agro-chemicals in farming.
Herbicides use per state, Brazil	Paper	Brazil	2002	Reports from National Agencies	Public, Portuguese	Comitê de Meio Ambiente, Sociedade Brasileira da Ciência das Plantas Daninhas, Uso de Herbicidas no Brasil, Internet	Intensive use of herbicides in Brazilian states.
Water quality technical studies at Salto Grande Reservoir	Report	Uruguayan-Argentinean shared sector	1992	Reports from International Agencies	Public, Spanish	CTMSG Comisión Técnica Mixta de Salto Grande; CARU Comisión Administradora del Río Uruguay	Agro-chemical origin at Salto Grande Reservoir.

Worksheet 2e: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue:CHEMICAL / Immediate cause: DISCHARGE OF UNTREATED WASTEWATER/ Sector: INDUSTRY AND URBAN SECTOR							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Problem description	Problem description	Uruguay River Basin, Brazil	2002	Reports from national agencies	Public, Portuguese	FEPAM, Internet	Type of industries.
Problem description	Report	Uruguay River Basin, Brazil	1998	Publications from universities	Public, Portuguese	IPH Instituto de Pesquisas Hidraulicas, IPH	Type of industries.
Problem description	Report	Uruguay River Basin, Brazil	2003	Reports from national agencies	Public, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Type of industries and their impacts.

Worksheet 2f: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue:SUSPENDED SOLIDS / Immediate cause: SOIL EROSION/ Sector: FORESTRY & AGRICULTURE							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Problem description	Problem description	Uruguay River Basin, Brazil	2002	Reports from National Agencies	Public, Portuguese	FEPAM, Internet	Historical studies of land occupation and soil working methods.
Problem description	Report	Uruguay River Basin, Brazil	1998	Reports from National Agencies	Public, Portuguese	IPH Instituto de Pesquisas Hidraulicas	Comparison of soil working techniques and contribution rates.
Problem description	Report	Uruguay River Basin, Brazil	2003	Reports from National Agencies	Public, Portuguese	ANA Agencia Nacional del Agua, Brazil, Internet	Soil vulnerability and associated costs.

Worksheet 3a: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: MICROBIOLOGICAL / Immediate cause: DISCHARGE OF UNTREATED WASTEWATER / Sector: INDUSTRY & URBAN								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Inadequate valuation of environmental goods and services.	Laws, decrees and regulations.	Report	Uruguay	2003	Reports from national agencies	Available, Spanish	Dirección Nacional de Medio Ambiente, Uruguay, Internet	Analysis of existing legislation.
	Laws, decrees and regulations.	Report	Brazil	2003	Reports from national agencies	Available, Portuguese	FEPAM, FATMA, ANA, Internet	Analysis of existing legislation.
	Laws, decrees and regulations.	Report	Argentina	2003	Reports from national agencies	Available, Spanish	Secretaría de Ambiente y Desarrollo Sustentable, Internet	Analysis of existing legislation.
Poverty	Summary of river basin characteristics.	Report	Brazil	2003	Reports from national agencies	Available, Portuguese	FEPAM, Internet	Local populations cannot afford sewage treatment.
Regulations	Laws, decrees and regulations.	Report	Uruguay	2003	Reports from national agencies	Available, Spanish	Dirección Nacional de Medio Ambiente (DINAMA), Uruguay, Internet	Analysis of existing legislation.
	Laws, decrees and regulations.	Report	Brazil	2003	Reports from national agencies	Available, Portuguese	FEPAM, FATMA, ANA, Internet	Analysis of existing legislation.
	Laws, decrees and regulations.	Report	Argentina	2003	Reports from national agencies	Available, Spanish	Secretaría de Ambiente y Desarrollo Sustentable, Internet	Analysis of existing legislation.

Capacity to promote conformity and fulfill agreements and policies.	Legislation efficiency and effectiveness	Report	Argentina	1999	Reports from international agencies	Available, Spanish	World Bank	Report about water resources management.
	Assigned budgets, efficiency and legislation effectiveness	Report	Uruguay	1999	Reports from international agencies	Available, Spanish	BID Banco Interamericano de desarrollo, Progama de fortalecimento institucional	Report about Uruguayan government expenses in environmental law administration.
	Assigned budgets	Report	Argentina	1999	Reports from international agencies	Available, Spanish	World Bank Group	Assigned amounts to water resources in Misiones and Corrientes provinces.
Deficiency in direct interested participation.	No data	No data	No data	No data	No data	No data	No data	The lack of societal interest to fulfill environmental issues hinders environmental management institutions to demand suitable treatment system construction.
Poor coordination between different government levels and inadequate coordination of national, federal, state and local policies.	No data	No data	No data	No data	No data	No data	No data	Central government decisions and policies are distant and ignorant of local problems. Central governments advance in the development of management tools (in a theoretical context), regardless of local possibilities.
Inadequate integration of environmental concerns in public policies.	No data	No data	No data	No data	No data	No data	No data	Regional governments are dedicated to promote production, workmanship and social well-being.
Power structure.	No data	No data	No data	No data	No data	No data	No data	Big productive groups negotiation power (absence of regulating organisations to impose environmental issues) delays necessary investments in treatment systems.
Cost - Benefit and incentives.	Legal incentives	Report	Uruguay	1999	Reports from international agencies	Available, Spanish	Dirección Nacional de Medio Ambiente, Uruguay	Companies' control system expenses. No incentives in present legislation for those which fulfill environmental regulations.
	Legal incentives	Report	Uruguay	2003	Reports from international agencies	Available, Spanish	Palacio Legislativo, Uruguay	Economic incentives as instrument of companies' management.
Inadequate valuation of environmental goods and services.	Laws, decrees and regulations	Report	Uruguay	2003	Reports from national agencies	Available, Spanish	Dirección Nacional de Medio Ambiente, Uruguay Internet	Analysis of existing legislation.
	Laws, decrees and regulations	Report	Brazil	2003	Reports from national agencies	Available, Portuguese	FEPAM, FATMA, ANA, Internet	Analysis of existing legislation.
	Laws, decrees and regulations	Report	Argentina	2003	Reports from national agencies	Available, Spanish	Secretaría de Ambiente y Desarrollo Sustentable, Internet	Analysis of existing legislation.
Capacity to promote conformity to fulfill agreements and policies.	Legislation efficiency and effectiveness	Report	Argentina	1999	Reports from international agencies	Available, Spanish	World Bank	Report about water resources management.
	Assigned budgets Efficiency and legislation effectiveness	Report	Uruguay	1999	Reports from international agencies	Available, Spanish	BID Banco Interamericano de desarrollo, Progama de fortalecimento institucional	Report about Uruguayan government expenses in environmental law administration.
	Assigned budgets	Report	Argentina	1999	Reports from international agencies	Available, Spanish	World Bank Group	Assigned amounts to water resources in Misiones and Corrientes Provinces.
Deficiency in social participation.	No data	No data	No data	No data	No data	No data	No data	The absence of society interest to fulfill environmental issues hinders environmental management institutions to demand suitable treatment system construction.
Poor coordination between different government levels.	No data	No data	No data	No data	No data	No data	No data	Poor participation of local governments in the control of wastewater treatment systems.

Worksheet 3b: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: CHEMICAL / Immediate cause: DISCHARGE OF UNTREATED WASTEWATER / Sector: INDUSTRY								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Market forces	No data	No data	No data	No data	No data	No data	No data	Difficulty to access differential product markets which fulfill environmental regulations; delays necessary investment in processes and raw material substitution to environmentally suitable alternatives.
Inadequate valuation of environmental goods and services.	Laws, decrees and regulations	Report	Uruguay	2003	Reports from National Agencies	Available, Spanish	Dirección Nacional de Medio Ambiente, Uruguay, Internet	Analysis of existing legislation.
	Laws, decrees and regulations	Report	Brazil	2003	Reports from National Agencies	Available, Portuguese	Fundación Estadual de Protección Ambiental Enrique Luis Roessles de Río Grande del Sur (FEPAM), Fundación del Medio Ambiente de Santa Catarina (FATMA), Agencia Nacional de Aguas (ANA), Internet	Analysis of existing legislation.
	Laws, decrees and regulations	Report	Argentina	2003	Reports from National Agencies	Available, Spanish	Secretaría de Ambiente y Desarrollo Sustentable, Internet	Analysis of existing legislation.

Worksheet 3c: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: CHEMICAL / Immediate cause: APPLICATION OF BIOCIDES / Sector: AGRICULTURE								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Technology access	No data	No data	No data	No data	No data	No data	No data	More suitable environmental technologies are not available (requires important adjustments in production methods).
Prices	No data	No data	No data	No data	No data	No data	No data	Costs of substitution and elimination of biocides have to be absorbed by producers.
Inadequate valuation of environmental goods and services.	Laws, decrees and regulations	Report	Uruguay	2003	Reports from national agencies	Available, Spanish	Dirección Nacional de Medio Ambiente, Uruguay, Internet	Analysis of existing legislation.
	Laws, decrees and regulations	Report	Brazil	2003	Reports from national agencies	Available, Portuguese	Fundación Estadual de Protección Ambiental Enrique Luis Roessles de Río Grande del Sur (FEPAM), Fundación del Medio Ambiente de Santa Catarina (FATMA), Agencia Nacional de Aguas (ANA), Internet	Analysis of existing legislation.
	Laws, decrees and regulations	Report	Argentina	2003	Reports from national agencies	Available, Spanish	Secretaría de Ambiente y Desarrollo Sustentable, Internet	Analysis of existing legislation.
Inadequate scientific knowledge, information and qualification.	No data	No data	No data	No data	No data	No data	No data	Complexity of involved chemical substance performance.
Prices and inadequate valuation of environmental goods and services.	No data	No data	No data	No data	No data	No data	No data	Improvement in yields due to agro-chemical use and absence of additional costs.
Information and qualification.	No data	No data	No data	No data	No data	No data	No data	Ignorance by producers of environmental effects of products used.

Worksheet 3d: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38a La Plata River Basin: Uruguay River Basin / Concern: POLLUTION / Issue: SUSPENDED SOLIDS / Immediate cause: EROSION / Sector: AGRICULTURE								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Information and qualification	Studies of erosion rate reduction by the use of direct sowing methods	Report	Uruguay River Basin, Brazilian sector	1998	Publications from universities	Available if requested	IPH Instituto de Pesquisas Hidráulicas, Brazil	Technology available and evaluated for many years.

Worksheet 4: Description of indicators or quantitative information substantiating links between Issue and Immediate cause in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: SEE TABLE								
Immediate cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Overfishing of target species.	Decrease of biomass.	Reports with tables and graphs	Survey area	Marine species, annual data from 1986 to 2000 Coastal species 1994-1995-1996-1999	Publication from research institute	Free public access	INIDEP, Argentina DINARA, Uruguay	The biomass decrease of some resources due to overfishing has changed the ecosystem productivity.
	Decrease in density index Tn/mn^2 or CPUE (Catch per Unit Effort).	Reports with tables, maps and graphs	Survey area	Marine species, annual data from 1986 to 2000 Coastal species 1994-1995-1996-1999	Publication from research institutes	Free public access	INIDEP, Argentina DINARA, Uruguay	Decrease of density or CPUE is an indicator of the decrease in abundance and indicates a change of ecosystem productivity.
	Capture ages (%).	Reports with graphs	Survey area	Annual data 1986 to 2002	Publication from research institute	Free public access	INIDEP, Argentina DINARA, Uruguay	The high incidence of juveniles in the captures indicate changes in the population structure due to overfishing, deteriorating biotic components.
By-catch tortoise, fowls, mammals and others.	Percentage of discarded species (size, latitude, depth) per type of fleet.	Technical report with tables	North of 41°S	1998	Publication from research institute	Free public access	INIDEP, Argentina	The high values of by-catch and discards affect the ecosystem biodiversity.
	Fowls, mammals and tortoises: not quantitatively measured. Isolated reports about interaction of this fauna with fisheries (number of animals per voyage).	Report	Localised areas associated with some fisheries	Discontinuous data	Report from national and international agencies, and NGOs	Free public access	INIDEP, Argentina DINARA, Uruguay Secretaría de Ambiente y Desarrollo Sustentable, Argentina Fundación Vida Silvestre Argentina Asociación Ornitológica del Plata, Argentina UNMdP, Argentina	By-catch of these species during fishing cause conservation problems.
Modification of the seabed due to the use of destructive fishing gears.	A high impact on the seabed is presumed due to the use of bottom trawling nets and the high exploitation of the area.	No data[1]	No data[1]	No data[1]	No data[1]	No data[1]	No data[1]	Deterioration of the biotic and abiotic components of the ecosystem.
Land-based pollution (industries, agricultural chemicals, untreated sewage) and vessel source pollution (oil).	Heavy metals, hydrocarbon and pesticides in the water, sediments and organisms.	Reports with tables and graphs	Localised areas associated with cities and industries	Localised and discontinuous surveys	Publication from research institutes Reports from national and international Agencies, and NGOs	Free public access	SHN, Argentina SOHMA, Uruguay DINAMA, Uruguay UNMdP, Argentina Secretaría de Política Ambiental de Buenos Aires, Argentina FREPLATA,Argentina-Uruguay ECOPLATA, Uruguay Fundación Vida Silvestre, Argentina	Evidence of pollution impacts on biotic and abiotic components of the ecosystem.
Habitat modification.	Increase of coastal erosion (m/year).	Reports with maps	Coastal areas of both countries	Annual	Publication from research institute	Free public access	Centro de Geología de Costas y del Cuaternario (UNMdP) Departamento de Ecología (UNMdP) DINARA, Uruguay	The habitat loss or its modification produces changes in the diversity or abundance of the ecosystem species.
	Dredging of channels associated with an intense maritime activity. No quantitative measurments.	Reports	Coastal areas of both countries and La Plata River	No data	Publication from international agencies	Free public access	FREPLATA	Disturbs the habitat and benthic communities associated to it.
Introduction of alien species.	Abundance per unit area	Scientific paper (In preparation)	San Blas (Buenos Aires Province, Argentina)	No data	Publications from universities reports from national agencies	Free public access	Departamento de Ecología de UNMdP, Argentina Secretaría de Política Ambiental de la Provincia de Buenos Aires, Argentina Dirección de Acuicultura de la SAGyP, Argentina Dirección de Pesca Provincia de Buenos Aires, Argentina	Disturbance in the abundance of some species of local communities.

Note: [1]There are no studies about the impact on the ecosystems linked to the marine bed modification due to fishing gear. Nevertheless, it is included in the CCA because it is presumed as high due to overexploitation in the area. Likewise, there are no researches about the impact of continuous dredging of navigation channels, which are relevant due to the intense maritime traffic of the area.

Worksheet 5a: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: OVERFISHING OF TARGET SPECIES /Sector: FISHERY							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the links**
CPUE (Catch per Unit Effort)	Reports with graphs	Survey area	Annual	Publication from research institutes	Free public access	INIDEP (Argentina) DINARA (Uruguay)	The decrease of the CPUE of some species is an indicator of overfishing.
Total and reproductive biomass	Reports with graphs	Survey area	Annual	Publication from research institutes	Free public access	INIDEP (Argentina) DINARA (Uruguay)	A decreasing trend of total and reproductive biomass has been observed.

Worksheet 5b: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: BY-CATCH / Sector: FISHERY							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the links**
% of discarded species according to latitude, depth, season and type of fleet.	Reports with tables	The whole area	1998	Reports from national and international agencies, and NGOs	Free public access	INIDEP, Argentina DINARA, Uruguay Secretaría de Ambiente y Desarrollo Sustentable, Argentina Fundación Vida Silvestre Argentina Asociación Ornitológica del Plata, Argentina UNMdP, Argentina	The discard of non-target species or of species with small size is the result of the use of non-selective fishing gears.
Number of specimens of marine mammals, birds and tortoise per fishing occassion of a certain fishery.	Reports	Sporadic and localised surveys associated to each fishery and fishing gear	No data	Reports from national and international agencies, and NGOs	Free public access	INIDEP, Argentina DINARA, Uruguay Secretaría de Ambiente y Desarrollo Sustentable, Argentina Fundación Vida Silvestre Argentina Asociación Ornitológica del Plata, Argentina UNMdP, Argentina	Some reports point out the impact of different fishing gears on mammals, bird and tortoises. No quantitative measurements are available at the regional level.

Worksheet 5c: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: MARINE BED MODIFICATION BY BOTTOM TRAWLING / Sector: FISHERY							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the links**
The bottom trawling net disturbs the seabed and the benthic communities associated to it.	No data[1]	No data[1]	No data[1]	No data[1]	No data[1]	No data[1]	The use of trawling net and the high exploitation in the area presume a high impact on the seabed and benthic communities. No quantitative measurements are available.

[1]The bottom trawling net disturbs the seabed, damages or remove the sessiles marine species associated (epifauna, infauna). The high level of this activity produce a high impact on the ecosystem.

Worksheet 5d: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause:HABITAT MODIFICATION / Sector: SEE TABLE								
Sector	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the links**
Urban development and tourism.	Construction of ports and piers. Urban construction. Dune fixation, drainage, urban constructions. There are different indicators: number of constructions per area and % built area. Beach loss (m/year) Coastal erosion (m/year)	Reports with maps, tables and aerial photographs	Coastal areas of both countries	No data	Publication from universities, reports from national agencies	Free public access	Centro de Geología de Costas y del Cuaternario, UNMdP, Argentina DINAMA, Uruguay	The non-planned urban development activities and the coastal tourism produce habitat loss or modification and progressive coastal erosion.
Mining industry/ sand extraction	No quantitative measures	Reports	Coastal areas of both countries	No data	Reports from International agencies, publication from research institutes	Free public access	Centro de Geología de Costas y del Cuaternario, UNMdP, Argentina DINAMA, Uruguay	Non-planned coastal mining (sand extraction) produce habitat loss.
Shipping/ dredging of channels	No quantitative measures	Reports	Access areas to the ports	No data	Reports from international agencies	Free public access	FREPLATA	The continuous dredging of channels produces re-suspension of sediments and destruction of benthic habitats.

Note: Mining industry /Sand extraction takes place in beaches and coastal dunes. There are not quantitative measures. There are municipal reports that indicate an increase in erosion associated to extraction areas. Shipping/channels dredge , no quantitative measures. Shipping is intense, diverse and not regulated. The Fishery Common Zone is one of the most important path to the MERCOSUR (FREPLATA), so the activity may be considered of high impact on the local ecosystems.

Worksheet 5e: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause:POLLUTION / Sector: SEE TABLE								
Sector	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the links**
Urban development/ urban sewage	Bacterial and organic pollution in coastal areas close to the big cities. Presence of indicators of organic enrichment (nitrates and phosphates). No quantitative measurements of the impact on the regional-transboundary level.	Reports and papers with maps and tables	Point sources associated with the main cities	Dis-continuous	Reports from international and national agencies, publications of research institutes and universities	Free public access	Secretaría de Política, Ambiental de la Provincia de Buenos Aires, Argentina Obras Sanitarias de la Provincia de Buenos Aires y Aguas Argentinas, Argentina UNMdP, Argentina IADO, Argentina SHOMA, Uruguay ECOPLATA, Uruguay FREPLATA, Uruguay and Argentina	The reports show the presence of organic and bacterial pollution associated to urban development: untreated sewage and rain sewage.
Industries/ sewage	Presence of phenols, phosphates, detergents, heavy metals in sediments and in organisms. No quantitative measurements of the impact on the regional -transboundary level	Reports and papers with maps and tables	Point sources associated with the main cities and industries	Dis-continuous	Reports from international and national agencies, publications of research institutes and universities	Free public access	Secretaría de Política, Ambiental de la Provincia de Buenos Aires, Argentina UNMdP, Argentina IADO, Argentina SHOMA, Uruguay ECOPLATA, Uruguay FREPLATA, Uruguay and Argentina	The reports indicate impact of industrial activities on the marine ecosystem.
Agriculture/ run-off	Organic and microbiological pollution and presence of pesticides in sediment and organisms. No quantitative measures of the impact on the regional-transboundary level	Reports and papers with maps and tables	Point sources associated with main cities and industries	Dis-continuous	Reports from international and national agencies, publications of research institutes and universities	Free public access	Secretaría de Política, Ambiental de la Provincia de Buenos Aires, Argentina UNMdP, Argentina IADO, Argentina SHOMA, Uruguay ECOPLATA, Uruguay FREPLATA, Uruguay and Argentina	The reports indicate impact of agriculture on the marine ecosystems.
Oil:Transport, loading and unloading	Chronic pollution in coastal areas. Accidental spills that affect communities and habitat. No quantitative measures of the impact on the regional -transboundary level	Reports and papers with maps and tables	Point sources associated with main cities and industries	Dis-continuous	Reports from international and national agencies, publications of research institutes and universities	Free public access	Secretaría de Política, Ambiental de la Provincia de Buenos Aires, Argentina Obras Sanitarias de la Provincia de Buenos Aires y Aguas Argentinas, Argentina UNMdP, Argentina IADO, Argentina SHOMA, Uruguay ECOPLATA, Uruguay FREPLATA, Uruguay and Argentina	The reports indicate impact of transport and oil loading and unloading activities on the marine ecosystem.

Note: It is not possible to establish indicators that quantify the impact of these activities in the regional level (transboundary) due to lack of interdisciplinary surveys that allow a proper characterisation of the ecological process in the area (oceanographic, biodiversity) and of the source of pollution. The FREPLATA, in its first stage, is elaborating a Transboundary diagnose in order to fill the information gaps and to identify the main sources of degradation of the area.

Worksheet 5F: Description of indicators or quantitative information substantiating links between Immediate cause and Sector activities in the Causal chain analysis Region 38b South Atlantic Drainage Basin / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: INTRODUCTION OF ALIEN SPECIES / Sector: AQUACULTURE							
Indicator or supporting information	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the links**
Cooperative that exploits *Crassostrea gigas* in a low level addressed to the domestic market.	Reports	South of Buenos Aires province	No data	Reports from national agencies	Free public access	SAGPyA (Argentina)	Presence of an alien species in the benthic communities of the south of Buenos Aires Province, introduced for commercial purposes.

Worksheet 6a: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: OVERFISHING OF TARGETED SPECIES / Sector: FISHERY								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Economic: Markets	Exported tonnes	Reports with tables	All area	Data taken annually	Reports from national agencies	Free public access	DINARA (Uruguay) SAGPyA (Argentina)	The presence of important external markets for some species has increased fishing effort.
Economical entrepreneurial profit	Gross value, production, first sale and fisheries added value (primary and industrial)	Reports with tables	All area	Data taken annually	Reports of international agencies	Confidential information	Comisión Técnica Mixta del Frente Marítimo - COFREMAR (Technical Commission of Maritime Front, Argentina-Uruguay)	As long as there is positive profitability on resource extraction, their exploitation will be rational in entrepreneurial terms.
Legal: Unlimited fishing licenses	Presence of boats with unrestricted fishing licenses (no limits for fleet type, area and species)	No data	Argentina	No data	No data	Confidential information	SAGPyA (Argentina)	Easier access to the Buenos Aires Coastal Ecosystem for vessels which historically fished offshore species, with the subsequent increase in fishing effort at the Buenos Aires Coastal Ecosystem.

Governance: Failures of the control and surveillance system.	MACs (Maximum allowable catches) have surpassed, total length/limits are not respected in different areas, minimum landed sizes are not controlled, and selective devices are not used.	Report	Area of study	No data	Publications from NGOs and international agencies	Free public access	FARN, Argentina CEDEPESCA, Argentina Fundación Vida silvestre Argentina SAy DS, Argentina	There is no guarantee for the fulfilment of valid regulation for Buenos Aires Coastal Ecosystem arrangement.
Governance: Lack of budget for an adequate assessment of the Buenos Aires Coastal ecosystem and EPI.	Budgets for the assessment of species considered important from the commercial standpoint.	No data	Area of study	No data	No data	Confidential information	No data	Lack of studies allowing improved administration of other exploited species.
Political: Conflicts between Argentina and Uruguay by disagreement related to the administration of several shared stocks.	Record of COFREMAR Technical Meetings.	No data	Common Fishing Zone	No data	No data	Confidential information	COFREMAR, Argentina and Uruguay	Lack of agreement between Argentina and Uruguay prevents an effective management of shared resources.
Lack of Knowledge: On biological and biological fisheries knowledge of the same species.	There are species that have reached and even surpassed their maximum sustainable yields. Their biological and population parameters remain unknown, no fishing ban areas or nursery grounds have been defined.	Reports with tables	Area of study	Annual information	Publications from research institutes	Free public access	DINARA, Uruguay INIDEP, Argentina	Adequate levels of exploitation, fishing ban areas, nursery grounds, etc. cannot be established.
Knowledge: Failures in statistical compilation.	Exports higher than declared catches, mistakes in the compilation process, no specific discrimination of some groups (chondrichthyans), incompatible statistical systems in different jurisdictions.	Reports	Area of study	Annual information	Report from national agencies, publications of research institutes	Free public access	SAGyP, Argentina DINARA, Uruguay INIDEP, Argentina	Strikes negatively on the quality of scientific information and arrangement measures that the administrators have to take .
Technological: Lack of expert advice.	There is no experience in either country with respect to management of multi-species fisheries.	Document	Area of study	No data	Report from national agencies	Free public access	Consejo Federal Pesquero, Argentina	Does not allow advancement towards a better administration of the multispecies fishery.

Worksheet 6b: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis
Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES /
Immediate cause: BY-CATCH / Sector: FISHERY

Root cause	Indicator or supporting information	Format	Extent or area covered	Duration	Reliability	Availability	Source	Explanation or justification how the indicator support the link
Economic: Markets.	Under-exploited species with potential commercialisation possibilities.	Reports	Area of study	Annual	Publication of research institutes	Free public access	INIDEP, Argentina DINARA, Uruguay	There are under-exploited species presently discarded that are potentially interesting because of their characteristics.
Technology: Use of non-selective fishing gear.	By-catch discards. Not quantified.	Reports	Area of study	No data	Publication of research institutes	Free public access	INIDEP, Argentina COFREMAR, Argentina and Uruguay	Use of non-selective fishing gear generates high by-catch discards and incidental catches of higher fauna.
Governance: Inadequate integration of environmental aspects in public polices.	Lack of monitoring of discards. Lack of studies to improve present catch systems. Lack of monitoring of fishing impact on higher fauna.	Reports	Area of study	No data	Report from international and national agencies, and NGOs	Non-public work Free public access	COFREMAR, Argentina and Uruguay SAyDS, Argentina Fundación Vida Silvestre, Argentina-WWF Asociación Ornitológica del Plata, Argentina	There are no policies encouraging the study of measures to reduce or mitigate fishing impact on biodiversity.
Governance: Lack of or failure in control system.	Statutory selectivity devices are not used. Discards are not declared. Landings of species with smaller size than statutory values.	Reports	Area of study	No data	Reports from national agencies	No data	SAyDS, Argentina	Control failure/ lack does not guarantee the fulfilment of valid regulations.
Governance: Lack of budget.	Necessary budgets for an adequate control and studies of by-catch are not assigned.	Records of the Argentinean Federal Fishing Council	Area of study	No data	Documents of national agencies	Free public access	SAGPyA, Argentina DINARA, Uruguay	The complexity of administrative regulations increases the cost of the public administrative sector, which may not be afforded.
Socio-cultural: Traditions.	Statutory selective devices are not used.	Report	Area of study	No data	Reports from national agencies	No data	CFP-SAyDS, Argentina DINARA, Uruguay	Resistance from the private sector to change its traditional fishing methods, lack of incentives to fulfil regulations.

Worksheet 6c: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: MODIFICATION OF SEA BOTTOM BY FISHING GEARS / Sector: FISHERY								
Root cause	Indicator or supporting information	Format	Extent or area covered	Duration	Reliability	Availability	Source	Explanation or justification how the indicator support the link
Knowledge: Lack of studies on the impact of fishing gear on the sea bottom.	Not quantified with the exception of scallop seafloors within the CFZ.	No data	No data	No data	No data	No data	No data	High exploitation dynamics in the area and use of bottom trawlnets makes the quantification of impact on the seafloor and benthic communities necessary.
Governance: Inadequate integration of environmental aspects in public polices.	No policies encouraging the study of impact on seafloors and their associate communities, with the exception of more profitable fisheries (scallop).	No data	No data	No data	No data	No data	No data	Study of impact of the bottom trawlnets is necessary because of the high exploitation dynamics of the area and its potential effect on seafloors of the benthic communities (infauna and epifauna).

Worksheet 6d: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: HABITAT MODIFICATION / Sector: URBAN DEVELOPMENT AND TOURISM								
Root cause	Indicator or supporting information	Format	Extent or area covered	Duration	Reliability	Availability	Source	Explanation or justification how the indicator support the link
Governance: Inadequate integration of environmental aspects in public polices.	Urban developments do not respect the natural landscape. Tourist activities degrade the environmental quality.	Reports with tables, maps, satellite images	Coastal areas for both countries	No data	Publications of research institutes, reports from national agencies	Free public access	Centro de Geología de Costas y el Cuaternario, UNMdP, Argentina DINAMA, Uruguay	Urban development and tourism are not adequately planned.
Governance: Lack of co-ordination between executive and scientific organisations.	There are organisations carrying out these studies, but there are no established communication mechanisms.	Reports	Coastal areas for both countries	No data	Publications of research institutes, reports from national agencies	Free public access	Publications of research institutes, reports from national agencies	There are no formal communication channels between scientists and managers. This does not allow scientific knowledge to be incorporated into management tools.
Knowledge: Inadequate access to information.	Scientific information is not accessible to political decision-takers because of technical language used or restricted distribution channels.	Reports	Coastal areas for both countries	No data	Publications of research institutes, reports from national agencies	Free public access	Centro de Geología de Costas y el Cuaternario, UNMdP, Argentina FREPLATA	Public and private sectors do not have adequate information.
Lack of studies on transboundary impacts.	No studies on transboundary impact of coastal habitat degradation. Goal of FREPLATA Project for critical habitats.	Reports	Coastal areas for both countries	No data	Reports from national agencies	Free public access	FREPLATA	Important inasmuch as they affect availability of transboundary resources (e.g. reproduction areas).

Worksheet 6e: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: HABITAT MODIFICATION / Sector: MINING & SAND EXTRACTION								
Root cause	Indicator or supporting information	Format	Extent or area covered	Duration	Reliability	Availability	Source	Explanation or justification how the indicator support the link
Governance: Inadequate integration of environmental aspects in public polices.	Coastal mining activity not adequately planned.	Reports	Coastal areas of both countries	No data	Publications from reserch institutes and universities	Free public access	Centro de Geología de Costas y el Cuaternario, UNMdP, Argentina DINAMA, Uruguay	There is no integrated vision on the problem. This activity is planned at municipal level (Province of Buenos Aires, Argentina) or at department level (Uruguay).
Governance: Lack of coordination between executive and scientific organisation.	There are organisations carrying out these studies, but there are no established communication mechanisms	Reports	Coastal areas of both countries	No data	Publications from reserch institutes and universities	Free public access	Centro de Geología de Costas y el Cuaternario, UNMdP, Argentina DINAMA, Uruguay	There are no formal communication channels between scientists and managers. This does not allow scientific knowledge to be incorporated into management tools.
Knowledge: Inadequate access to information.	Scientific information not accessible to political decision-takers because of technical language used or restricted distribution channels	Reports	Coastal areas of both countries	No data	Publications from reserch institutes and universities	Free public access	Centro de Geología de Costas y el Cuaternario, UNMdP, Argentina DINAMA, Uruguay	Public and private sectors do not have timely and adequate information.

Worksheet 6f: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: HABITAT MODIFICATION / Sector: NAVIGATION & DREDGING OF CHANNELS								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Governance: Inadequate integration of environmental aspects in public polices.	Navigation/channel dredging is not planned.	Report	No data	Free public acces	Reports from international agencies	Free public access	FREPLATA	Navigation activities must be adequately planned to avoid interference in critical areas from the ecological viewpoint.
Knowledge: Inadequate access to information.	Lack of access to information on vessel, charges and operation records.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data-	Reports from international agencies	Free public access	FREPLATA	Lack of necessary information to plan navigation activities.

Worksheet 6g: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: POLLUTION / Sector: URBAN DEVELOPMENT								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Governance: Inadequate integration of environmental aspects in public polices.	Both countries have developed programmes to improve the quality of their water bodies. Nevertheless, transboundary impact is not considered yet.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	A Strategic Integrated Plan is necessary. Goal of the FREPLATA Project.
Governance: Lack of budget.	Both countries and the Bi-national Commissions have little resources.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Lack of funds at national and bi-national level. Goal of the FREPLATA Project
Politics: Lack of bi-national instrument and cooperation mechanisms.	There are only bi-national instruments and strategies for fisheries administration.	Report	La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Weak institutional capacity to confront transboundary effects of pollution. Goal of the FREPLATA Project.
Knowledge: Insufficient knowledge on the ecology of the region.	Lack of inventories of biodiversity, species distribution, and primary production levels.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Actual state of knowledge in descriptive stages, few studies dedicated to the study of ecological processes. Goal of the FREPLATA Project.
Knowledge: Limited and fragmented knowledge on pollutants and their effect on ecosystems.	Lack of ecological characterisation of areas and their standard levels.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Impacts of sector activities are unknown. Goal of the FREPLATA Project.
Knowledge: Inadequate access to information.	Fragmented information in many institutions with different jurisdictions.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Limited information, with inadequate spatial and temporal coverage.

Worksheet 6h: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: POLLUTION / Sector: AGRICULTURE & SEWAGE								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Governance: Inadequate integration of environmental aspects in public polices.	Both countries have developed programmes to improve the quality of their water bodies. Nevertheless, the transboundary impact is not considered yet.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	A Strategic Integrated Plan is necessary. Goal of the FREPLATA Project.
Governance: Lack of budget.	Both countries as well as bi-national Commissions have little resources.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Lacking of funds at national and bi-national level. Goal of the FREPLATA Project
Politics: Lack of bi-national instrument and cooperation mechanisms.	There are only binational instrument and strategies for fisheries administration.	Report	La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Weak institutional capacity to confront transboundary effects of pollution. Goal of the FREPLATA Project
Knowledge: Insufficient knowledge on the ecology of the region.	Lack of inventories of biodiversity, species distribution, and primary production levels.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data-	Reports from international agencies	Free public access	FREPLATA	Actual state of knowledge in descriptive stages, few studies dedicated to the study of ecological processes. Goal of the FREPLATA Project.
Knowledge: Limited and fragmented knowledge on pollutants and their effect on ecosystems.	Lack of ecological characterisation of areas and standard pollutant levels.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Impacts of sector activities are unknown. Goal of the FREPLATA Project.
Knowledge: Inadequate access to information.	Fragmented information in many institutions with different jurisdictions.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Limited information with inadequate spatial and temporal coverage.

Worksheet 6i: Description of indicators or quantitative information substantiating links between Sectors and Root causes in the Causal chain analysis Region 38b South Atlantic Drainage System / Concern: HABITAT AND COMMUNITY MODIFICATION / Issue: MODIFICATION OF ECOSYSTEMS OR ECOTONES / Immediate cause: POLLUTION / Sector: INDUSTRY & SEWAGE								
Root cause	**Indicator or supporting information**	**Format**	**Extent or area covered**	**Duration**	**Reliability**	**Availability**	**Source**	**Explanation or justification how the indicator support the link**
Governance: Inadequate integration of environmental aspects in public polices.	Both countries have developed programmes to improve the the quality of their water bodies. Nevertheless, transboundary impact is not considered yet.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	A Strategic Integrated Plan is necessary. Goal of the FREPLATA Project.
Governance: Lack of budget.	Both countries as well as bi-national Commissions have little resources.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Lack of funds at national and level. Goal of the FREPLATA Project.
Politics: Lack of bi-national instrument and cooperation mechanisms.	There are only bi-national instruments and strategies for fisheries administration.	Report	La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Weak institutional capacity to confront transboundary effects of pollution. Goal of the FREPLATA Projec
Knowledge: Insufficient knowledge on the ecology of the region.	Insufficient knowledge on the biodiversity of the region. Insufficient characterisation of sensitive areas.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Actual state of knowledge in descriptive stages, few studies dedicated to the study of ecological processes. Goal of the FREPLATA Project.
Knowledge: Limited and fragmented knowledge on pollutants and their effect on ecosystems.	Lack of ecological characterisation of areas and their base-line pollution levels.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Impact of industrial sewages on biotic and abiotic components of the ecosystem cannot be evaluated.
Knowledge: Inadequate access to information.	Fragmented information in many institutions with different jurisdictions.	Report	Coastal areas both countries, La Plata River and Common Fishing Zone	No data	Reports from international agencies	Free public access	FREPLATA	Limited information, with inadequate spatial and temporal coverage.

Annex IV
List of important water-related programmes and assessments in the region

Project name	ID	Country	External funds	Total project cost (million USD)	Implementing agency[1]	Project stage	Source[2]
Drainage Infrastructure Management Project: Water sanitation and flood protection (sewerage) (65%) Water sanitation and flood protection (solid waste management) (20%) Water sanitation and flood protection (flood protection) (15%)	P057453	Argentina	IBRD + IDA Commitment 100 million USD	100	Ministry of Economy of Argentina	ND	1
Reform of the Water Supply and Sanitation Sector	AR-0175 and 1134/OC-AR	Argentina	IDB 250 million USD	570.6	National Board of Water and Sanitation Works (ENOHSA)	Approved 1998	2
Emergency Flood Rehabilitation Program	1118/OC-AR	Argentina	ND	ND	ND	Approved 1998	2
Environmental Management of the Matanza-Riachuelo River Basin	AR-0136 and 1059/OC-AR	Argentina	IDB 250 million USD	500	Comité Ejecutor Matanza-Riachuelo (CEMR)	Approved 19 97	2
Aguas Argentinas Capital Investment - Water and Sanitation	AR0238 and 1182/OC-AR	Argentina	IDB 75 million USD	300	Aguas Argentinas	Approved 1999	2
Coastal Contamination Prevention and Sustainable Fisheries Management	459	Argentina	GEF grant 8.7 million USD	29.2	IBRD	CEO Endorsed Approved 1998	3
Management and Conservation of Wetland Biodiversity in the Esteros del Ibera	1312	Argentina	GEF grant 1.0 million USD	10.39	UNDP	CEO Approved 2002	3
Consolidation and Implementation of the Patagonia Coastal Zone Management Programme for Biodiversity Conservation	205	Argentina	GEF grant 5.2 million USD	18.11	UNDP	CEO Endorsed Approved 1997	3
Parana-Paraguay Waterway between Quijarro Port (Canal Tamengo), Corumba and Santa Fe	ARG/02/010	Argentina	CAF-UNDP	0.92		Implemented	4
PROSAP - Program for Provincial Agricultural Sector, Argentina	BID 899/OC-AR BIRF 4150-AR	Argentina	BID: 125 million USD BIRF: 125 million USD	337	Ministry of Economy and Production	Implemented	7
Small Municipalities Integrated Water Supply and Sanitation Project	P060555	Brazil	IBRD + IDA Commitment 60 million USD	85	Ministry of cities	ND	1
Sustainable Development Program for the Pantanal	1290/OC-BR	Brazil	IDB 200 million USD	400	Ministry of the Environment	Approved 2000	2
Integrated Watershed Management Program for the Pantanal and Upper Paraguay River Basin	583	Brazil	GEF grant 6.6 million USD	16.40	UNDP	CEO Endorsed Approved 1998	3
Development and Implementation of Mechanisms to disseminate Lessons Learned and Best Practices in Integrated Transboundary Water Resources Management in Latin America and the Caribbean	1426	Brazil	GEF grant 0.97 million USD	1.64	UNEP	CEO Approved 2002	3
Support to the Brazilian Electric Sector in Relation to the Global Climate Change	BRA/00/029	Brazil		583.78		Implemented	4
Strengthening Dialogue on Water Resources to Support the Development of Regional Strategies and Policies and Sustainable Development Projects in Critical Areas for the Integrated Management of Water Basins and Coastal Areas	AE-078/00	Brazil	CIDI(FEMCIDI)	0.08	OAS	Approved 2000	5
Coastal and Marine Management Project	P057753	Uruguay	IBRD + IDA Commitment 20 million USD	35	OPP	ND	1
Implementation of Strategic Action Program for the Bermejo River Binational Basin: Phase II	886	Argentina, Bolivia	GEF grant 11.04 million USD	19.77	UNEP	CEO Endorsed Approved 1998	3
Environmental Protection and Sustainable Integrated Management of the Guarani Aquifer	974	Argentina, Brazil, Paraguay, Uruguay	GEF grant 13.94 million USD	27.24	IBRD	Council Approved 2001	3
Environmental Protection of the Rio de la Plata and Its Maritime Front: Pollution Prevention and Control and Habitat Restoration	613	Argentina, Uruguay	GEF grant 6.01 million USD	10.81	UNDP	Council Approved 1999	3
Master Plan of Integrated Management of Pilcomayo River Basin	Europeaid/ 111998/C/sc	Argentina, Bolivia Paraguay	EU 3 445 300 EUR	ND		On implementation	6

Notes: ND = No Data
[1]List of agencies: CAF: Andean Development Corporation CIDI: Inter-American Agency for Cooperation and Development - AICD EU: European Union GEF: Global Environment Facility IBRD: International Bank for Reconstruction and Development IDA: International Development Association IDB=BID: International Development Bank BIRF: International Bank for Reconstruction and Development OAS: Organization of American States OPP: Office of Planning and Budget UNDP: United Nation Development Programme UNEP: United Nations Environment Programme
[2]Source of information (May 2003): 1: http://www.worldbank.org 2: http://www.iadb.org/ 3: http://www.gefweb.org 4. http://www.undp.org 5. http://www.oas.org 6. http://pilcomayo.org.py 7: http://www.sagpya.mecon.gov.ar

Annex V
List of conventions and specific laws

International agreements

- Treaty on the Rio de la Plata Basin, signed by Argentina, Brazil, Bolivia, Paraguay and Uruguay.
- Statute of the Uruguay River signed by Argentina and Uruguay, establishing needed mechanisms to rational exploitation.
- Treaty on the Rio de la Plata and the Maritime Front signed by Argentina and Uruguay.
- Cooperation Agreement between Argentina and Uruguay to prevent and fight against contamination incidents produced to the aquatic environment by hydrocarbons and other damaging substances.
- Agreement for the Development of the Bermejo River and Grande de Tarija River Upper Basin.
- Constitutive Agreement of the Comisión Trinacional de la Cuenca del Río Pilcomayo (Trinational Commission of the Pilcomayo Basin) signed by Argentina, Bolivia and Paraguay.
- Agreement on Climatic Changes signed with the United Nations.
- Agreement on Cooperation on Environmental Issues, signed by Argentina and Brazil.
- Agreement on Environmental Cooperation signed by Brazil and Uruguay.
- Treaty on Environmental Cooperation between Chile and Argentina.
- International Agreement on Cooperation, Preparation and Fight against hydrocarbon contamination.
- Fluvial Transport Agreement through Paraguay-Paraná Hidrovía signed by Argentina, Bolivia, Brazil, Paraguay and Uruguay.
- Agreement on Ichthyic Resource Conservation in Paraná and Paraguay Rivers signed by Argentina and Paraguay.
- United Nation's Convention on Law of the Sea signed by Argentina, Brazil, Bolivia, Paraguay and Uruguay.
- Basic Cooperation Agreement on the use of Natural Resources and the Development of the Cuareim River Basin, signed by Brazil and Uruguay.
- Complement to the Basic Agreement on Scientific, Technical and Water Resource Issues Cooperation, signed by Brazil and Uruguay.
- Basic guidelines for Environmental Policies. Resolution N° 10/94 of the Common Market Group (GMC-MERCOSUR) on Environmental Issues.
- MERCOSUR Framework Agreement on Environment. Decision N° 2/01 of the Common Market Group (GMC-MERCOSUR) on Environmental Issues (Argentina, Brazil, Paraguay and Uruguay).
- Biological Diversity Agreement. Ratified by Argentina (1994-11-22), Bolivia (1994-10-03), Brazil (1994-02-28), Paraguay (1994-02-24) and Uruguay (1993-11-05).
- International Watershed Agreement (Ramsar sites), effective in Argentina (1992-09-04), in Bolivia (1990-10-27), in Brazil (1993-09-24), in Paraguay (1995-10-07) and in Uruguay (1984-09-22).
- Convention on international trade of threatened wild fauna and flora. Ratified by Argentina (1981-04-08), Bolivia (1979-10-04), Brazil (1975-11-04) and Paraguay (1977-02-13).
- Vienna Convention for the Protection of the Ozone Layer, 1985. Ratified by Argentina (1990-01-18), the remaining countries adhere to this Agreement, Bolivia (1994-03-20), Brazil (1990-03-19), Paraguay (1992-12-03) and Uruguay (1989-02-27).
- Montreal Protocol relative to substances which deplete the Ozone Protection Covering, ratified by Argentina (1990-09-18), the remaining countries adhere Bolivia (1994-10-03), Brazil (1990-03-19), Paraguay (1992-12-03) and Uruguay (1991-01-08).
- Approval of Convention on wild animal migratory species conservation, signed in Bonn (Germany). Ratified by Argentina (1992-01-01), Bolivia (1903-03-01) y Paraguay (1999-01-01) and Uruguay (1990-05-01).

International organisations

- Comité Intergubernamental de Coordinación de los Países de la Cuenca del Río de la Plata (CIC) (Intergovernmental Coordinator Committee of the River Plate Basin Countries).
- Comisión Administradora del Río Uruguay (CARU) (Administration Commission of the River Uruguay), Argentina and Uruguay.
- Comisión Mixta Argentina-Paraguaya del Río Paraná (COMIP) (Mixed Commission of the Paraná River).
- Comisión Mixta Administradora del Río de La Plata (CARP) (Mixed Administration Commission of the La Plata River), Argentina and Uruguay.
- Comisión Binacional para el Desarrollo de la Alta Cuenca del Río Bermejo y Río Grande de Tarija (Binational Commission for the Development of the Bermejo River and Grande de Tarija River Upper Basin)Argentina and Bolivia.
- Comisión Trinacional para el Desarrollo de la Cuenca del Río Pilcomayo (Trinational Commission for the Development of the Pilcomayo River Basin), Argentina, Bolivia and Paraguay.

- Comisión Binacional Administradora de la Cuenca Inferior del Río Pilcomayo (Binational Administration Commission of the Pilcomayo River Lower Basin), Argentina and Paraguay.
- Comité Intergubernamental de la Hidrovía Paraguay - Parana (CIH) (Intergovernmental Committee of the Paraguay-Paraná Hidrovía).
- Comisión Técnica Mixta del Frente Maritimo (COFREMAR) (Technical Commission Maritime Front), Argentina and Uruguay.
- Comisión Técnica Mixta de Salto Grande (Technical Commission of Salto Grande), Argentina and Uruguay.
- Comisión Mixta para el Desarrollo del Río Cuareim (CRC) (Brazilian-Uruguayan Commission for the Development of the Cuareim River Basin).
- Entidad Binacional Yacyreta (EBY) (Binational Organization Yacyretá), Argentina and Paraguay.
- FONPLATA, Argentina, Brazil, Bolivia, Paraguay and Uruguay.

Argentina

National laws

- Constitution: Consecrates Federal Structure of the State: Attributes Provinces' domain on existing natural resources within the territory (including water resources) with special reference to the environment.
- Civil Code: Consecrates National and Provincial public property, territorial sea and superficial and underground waters.
- Law 17094 - Extension of sovereignty on territorial sea as far as 200 nautical miles.
- Law 18502 - Provincial jurisdiction on territorial sea as far as 3 nautical miles.
- Law 23879 - Evaluation of environmental consequences of dam constructions.
- Law 23968 - Determines part of the territorial sea as far as 12 nautical miles, adjacent area as far as 24 nautical miles and exclusive economic zone as far as 200 nautical miles. Continental platform includes seabed and underground waters as far as 200 nautical miles.
- Law 24922 - Federal Fishing Regime and processing of marine live resources.
- Law 25612 - Minimum Environmental Budget.
- Law 25675 - Environment General Law. Regulation on minimum budget for Environmental Policy.
- Law 25688 - Minimum budget for Management of the Water Environment.

National application authorities

- Water Resources: Subsecretaría de Recursos Hídricos de la Nación (SSRH) (Undersecretariat of National Water Resources depending on Federal Planning and Public Investment Ministry).
- Environmental: Secretaría del Ambiente y Desarrollo Sustentable (SAyDS) (Secretariat of Environment and Sustainable Development depending on Social Development Ministry).
- Provincial States have water title deeds and jurisdiction in the National Government Issues.

Provincial laws

Buenos Aires

- Constitution.
- Law 2078 - Creation of the Undersecretariat of Environmental Policies.
- Law 4732 - Competence of the Secretariat of Environmental Policy to exert police power.
- Law 10907 Natural Park Reserve regulated by decree 218/94 and modified by Law 12459.
- Law 11469 - Creation of the Provincial Environment Institute.
- Law 11723 - Protection, Preservation, Improvement and Restoration of Natural Resources and Environment.
- Law 11964 - Regulation on territorial demarcation, cartography and risk zones mapping, wild fauna and flora protected areas and flood control.
- Law 12257 - Water code and creation of Water Administration (ADA).
- Resolution 538/99 - Rules to evaluate Environmental Impact of Building Projects or other Activities.

Catamarca

- Constitution.
- Law 2577/72 - Approval of Water code.
- Decree 2142/74 - Regulation of Provincial Water Law 25773/73.
- Decree 829/96 - Creation of the State Secretariat of Environment.
- Decree 1064/99 - Regulation of natural areas.

Buenos Aires City

- Constitution.
- Law 119 - Environmental Management Plan of the Matanza-Riachuelo Basin.
- Law 123 - Technical-Administrative Evaluation of Environmental Impact.
- Law 303 - Environmental information.
- Law 336 - River and Watercourses periodic contamination monitoring.
- Decree 1252/99 - Impacts categorisation. Competence Authority. Environmental Aptness Certification.

Córdoba

- Constitution.
- Law 5589 - Approval of Water law.
- Law 6964 - Natural areas conservation regime.
- Law 8789 - Creation of Environment State Secretariat.
- Law 25657 - Approval of Environmental Policy.

Corrientes

- Constitution.
- Law 32028 and modifications - Creation of the Water and Environment Institute of Corrientes (ICAA).
- Law 3066 - Water code.
- Law 3979 - Environmental Protection.
- Law 4736 - Protected areas modified by decree-law 18/00.
- Decree 660/75 and modifications - Fishing Regulations.

Chaco

- Constitution.
- Law 3230 - Water code.
- Law 4302 - Environmental and Natural Resources Protection Rules.
- Law 4358 - Protected areas system.
- Decree 174/90 - Integration and Regulation's Approval of the Provincial Water Institute of Chaco (IPACH).

Chubut

- Constitution.
- Law 1503 and modifications - Water and atmosphere Protection.
- Law 3780 and modifications - Commercial fishing.
- Law 3847 - Environmental: Prohibition of toxic-waste discharges or water contamination.
- Law 4069 and modification Decrees - Creation of the Undersecretariat of Water Resources.
- Law 4148 - Water code.
- Law 4617 - Protected natural Areas.
- Law 4563 - Environmental General Law.

Entre Ríos

- Constitution.
- Law 4892 - Fishing Regulation.
- Law 6416 - Soil Use and Occupation Regulation in the area influenced by the Salto Grande Reservoir.
- Law 8613 and Modification Decrees - Creation of the Undersecretariat of Water Resources and Environment.
- Law 8967 - Protected areas Provincial system.
- Law 9008 - Riverside demarcation and water risk zone mapping in the Paraná, Uruguay and local navigable rivers of the Province.
- Law 9172 - Water code.
- Law 9172 - Creation of the Regulation Council of Water Source Use (CORUFA).

Formosa

- Constitution.
- Law 1060 - Environmental Policy - Related to protected areas.
- Law 1246 - Water code.
- Law 7343 - Environmental Impact Evaluation.

Jujuy

- Constitution.
- Law 1961 - Modified by Laws 2427 and 4396 - Water code.
- Law 3011 - Fishing and protection, preservation, restoration and dissemination of ichthyic fauna.
- Law 4090 - Creation of Water Resources Administration, water service, drainage and energy.
- Law 4203 - Preservation of natural resources, parks, reserves and provincial monuments.
- Law 4861 - Hydraulic Administration.
- Law 5063 - Environmental Law.

La Pampa

- Constitution.
- Law 607 - Approval of Water code.
- Law 773 - Creation of Water Provincial Administration (APA).
- Law 1321 - Protected areas - Regulatory decree 1283/95.
- Law 1666 - Creation of Environment Undersecretariat.
- Law 1914 - Provincial Environment.
- Decree 409/90 - Creation of Water Resources Secretariat.
- Decree 759/96 - Creation of Environment Provincial Council.

La Rioja

- Constitution.
- Law 3914 - Approval of Agreement: Abaucan - Colorado - Salado River Basin Committee.
- Law 4272 - Creation of Water Provincial Administration (APA).
- Law 4295 - Water code.
- Law 4678 - Fishing.

Mendoza

- Constitution - Creation of the Irrigation General Department as Application Authority.
- Waters General Law, Year 1884.
- Law 4035 and 4036 - Underground water.
- Law 5961 - Environment Preservation.
- Law 6045 - Provincial natural areas.

- Decree 2109/94 - Environment Preservation and Environmental Impact Evaluation.

Misiones

- Constitution.
- Law 1040 - Fishing and ichthyic fauna preservation.
- Law 1838 - Water resources preservation.
- Law 2557 - Competence of the Environment and Renewable Natural Resources Ministry.
- Law 2932 - Natural Parks and reserves modified by Law 3242.
- Law 3079 - Environmental Impact.
- Law 3337 - Sustainable protection and exploitation of the biological diversity and its components. Biodiversity Law.

Neuquén

- Constitution.
- Law 899 - Water code.
- Law 1875 - Environment Preservation, Protection and Improvement.
- Decree 1131/96 - Creation of the Environment Provincial Committee.

Río Negro

- Constitution.
- Law 2631 - Adhesion to Sustainable Development Regulation.
- Law 2669 - Protected Natural Areas.
- Law 2701 - Hydropower building and operation.
- Law 2951 - Coasts.
- Law 2952 - Water code. Creation of Water Provincial Department as Application Authority.
- Law 3266 - Environmental Impact.
- Law 6986 - Environment.

Salta

- Constitution.
- Decree/Law 433/57 and modifications - Creation of Salta Waters General Administration (AGAS).
- Law 4495 - Water code.
- Law 6986 - Environment Protection.
- Law 7107 - Protected Areas.

Santa Cruz

- Constitution.
- Law 786 - Regulation of parks, monuments and provincial reserves.
- Law 1005 - Multiple Development Program of Santa Cruz River.
- Law 1009 - Creation of Water Resources Provincial Administration.
- Law 1451 - Use and preservation of non-maritime provincial public waters.
- Law 1464 and modification laws 2144 and 2325 - Fishing.
- Law 2210 - Natural and cultural Patrimony.
- Law 2326 - Commercial fishing.
- Decree 1880/89 - Creation of the Maritime Fishing Provincial Commission.

Santiago del Estero

- Constitution.
- Law 4745 - Creation of the Water Resources Provincial Administration.
- Law 4869 - Provincial Water code.
- Law 5787 - Environment and natural resources protection.
- Law 6321 - Environment and natural resources protection, preservation and improvement.

Santa Fe

- Constitution.
- Law 775 - Waters Legislation. Water code.
- Law 4495 - Water code Modification.
- Law 4830 - Hunting and Fishing.
- Law 6253 - Environmental Protection, Preservation and Improvement.
- Law 6292 - Renewable Natural Resources and Protected Natural Areas.
- Law 6837 - Nation and Northwest Provinces Ratification Agreement to create Water Basin Committees.
- Law 9830 - Constitution of Basin Committees.
- Law 11001 - Creation of hydraulic buildings Provincial Administration.
- Law 11717 - Environment and sustainable development - Creation of the Secretariat of Sustainable Development. Creation, protection, defense and maintenance of protected areas.

San Juan

- Constitution.
- Law 0886 - Creation of the Hydraulic Department.
- Law 4363 - Fishing and pisciculture Regulation.
- Law 4392 - Water code.
- Law 4683 - Ichthyic Law.
- Law 5824 - Preservation of water, soil and air resources and contamination control.
- Law 6571 - Environmental Impact Evaluation.
- Law 6634 - Environment.

- Law 6911 - Protection and sustainable utilisation of flora and ichthyic fauna and protected natural areas.

San Luis

- Constitution.
- Law 5057 - Creation of Environmental Administration.
- Law 5122 - Water code.

Tucumán

- Constitution.
- Law 6253 - Environment protection, preservation and improvement.
- Law 6292 - Renewable natural resources protection and protected natural areas.
- Law 7139/7140 - Waters Legislation. The Irrigation Administration and the Water Provincial Department share the Application Authority.

Tierra del Fuego

- Constitution.
- Law 25 and modifications - Creation of Secretariat of Natural Resources, General Administration of Environment and Water Resources Department.
- Law 55 - Environment and Natural Resources.
- Law 244 - Fishing Regulation.
- Law 272 - Protected natural areas.

Interjurisdictional organisations

- Comisión Regional del Río Bermejo (COREBE) (Regional Commission of the Bermejo River).
- Comité Interjurisdiccional del Río Colorado (COIRCO) (General Interjurisdictional Committee of the Colorado River).
- Autoridad Interjurisdiccional de las Cuencas de los Ríos Limay, Neuquen y Negro (AIC) (Interjurisdictional Administration of the Limay, Neuquén and Negro River Basins).

Bolivia

- Constitution: Attributes Waters State domain.
- Supreme Decree Year 1879 (Legal value in 1906) - Waters Domain and Exploitation.
- Law 1333/92 - Environment.
- Law 1493/93 and modifications - Creation of the Ministry of Environmental Sustainable Development and Planning.
- Law 1551/94 - Population participation. Promotion and preservation of environment by local organisations.
- Law 1654/94 - Administrative Decentralization. Attributes environment faculties to Prefects.
- Law 2113/94 - Municipalities' Organisation Regulation on Natural Resources and Environment.
- Law 1715/96 - National Agriculture Reform and Land Distribution Regime.

National Application Authorities

- Water Resources: Administration of Water Resources (depending on National Secretariat of Natural Resources and Environment).
- Environmental: Secretariat of Environmental and Sustainable Development (depending on Sustainable Development and Planning Ministry).

Brazil

Federal laws

- Constitution: Consecrates all bodies of water to the Federal or State domain - October 1988.
- Law 9433 - Water Resources and Water Resources Management.
- Decree 2612 - Water Resources National Council.
- Law 9984 - National Water Agency (ANA) as application authority of Water Resources.
- Law 6938 - Environment National Policy.
- Decree 4548/02 - Environment Brazilian-Institute (IBAMA).
- Law 9059 - Fishing Protection and Incentive.

Federal application authorities

- As a federal country, States have the domain and jurisdiction of certain waters.
- General competence: Ministerio do Meio Ambiente, dos Recursos Hídricos e da Amazonia Legal (Environment Ministry and Water Resources of the Legal Amazon).
- Environmental: Instituto Brazileiro do Meio Ambiente e dos Recursos Naturais Renovaveis.
- Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovaveis (IBAMA) (Environment Brazilian Institute).
- Water Resources: Agencia Nacional da Aguas (ANA) (National Water Agency).

State laws

Goias

- Constitution.
- Ministry Law creates the Secretariat of Environment and Water Resources.
- Law 3550 - Environment Goiana Agency (AGMA).
- Law 13025 - Fishing and protection of aquatic fauna.
- Law 13123 - Water Resources State Policy.

Mato Grosso

- Constitution.
- Law 38 - Approval of Environment State Code.
- Law 6945 - Water Resources Code.
- Law 7155 - Fishing regime.
- Decree 10170 - Creation of the Secretariat of Environment and State Council of Sustainable Development Policies Management (COGEDES) and Environment Institute - Pantanal.

Minas Gerais

- Constitution.
- Law 772 - Environment protection, preservation and improvement.
- Law 12265 - Policy and protection of aquatic fauna, fishing and aquaculture.
- 12571 - Creation of the State Secretariat of Environmental and Sustainable Development (SEMAD).
- Law 12503 - Water Protection State Programme.
- Law 12584 - Creation of the Water Management Mine Institute (IMGA).
- Law 12583 - Creation of the Environment State Foundation (FEMA).
- Law 12585 - Creation of the Environment State Council (COPA).
- Law 13199 - Water Resources Policy.
- Decree 3872 - Creation of the Water Resources State Council (CERH-MG).

Parana

- Constitution.
- Law 7109 - Environment Protection System.
- Law 10066 - Creation of Environment State Secretariat.
- Law 11352 - Creation of the Environment Parana Institute (IAP) and Environment State Council (CEMA).
- Law 12726 - Water Resources Policies. Creation of the Information System and Water Resources State Fund and Water State Council. Conformation of Basin Committees, Water Agencies, Consortiums and Municipal Associations.
- Decree 4647 - Water Resources State Fund - Regulation.

Rio Grande do Sul

- Constitution.
- Law 10356 - Creation of the Secretariat of Environment and Environment State Council (CONSEMA).
- Law 9077 - Creation of the Environment Protection State Foundation.
- Decree 23082 - Environment Protection State Policy.
- Decree 29621 - Environment Protection System.
- Law 10350 - Creation of the Water Resources State System and Water Resources State Council (CERH).
- Law 8850 - Water Resources Investment Fund.

San Pablo

- Constitution.
- Decree 24932 - Creation of the State Secretariat of Environment (SMA).
- Law 9509 - Environment Policy and creation of Environment State Council (CONSEMA).
- Law 997 - Environmental Contamination Prevention and Control System.
- Law 7663 - Water Resources Policy and Management. Creation of Water Resources State Council and Water Resources Fund.
- Law 8275 - Creation of the State Secretariat of Water Resources, Drainage and Building.
- Law 9034 - Water Resources Plan (PERH).
- Law 7750 - Drainage Policy.
- Law 9866 - Protection and Recovery of Region Water Basins.
- Law 6134 - Underground waters preservation.

Santa Catarina

- Constitution.
- Decree 28458 and modifications: Creation of the State Secretariat of Urban and Environmental Social Development. Water Resources Administration and Environmental Management (DIMA) and Water Resources Management (GGRH).
- Law 9748 - Water Resources Policy.
- Law 10744 - Creation of the Water Resources Council (CERH).
- Decree 2648 - Creation of the Water Resources State Fund (FEIHIDRO).

Paraguay

- Constitution: Consecrates environmental sustainability obligation through priority objectives of environment protection and protection of life quality.
- Law 96 - Wildlife.
- Law 294 - Environmental Impact Evaluation.
- Law 352 - Protected Wild Areas.
- Law 716 - Transgressions against Environment.
- Law 758 - Agreement for the preservation of fauna, flora and natural landscapes of the American countries.
- Law 799 - Fishing.
- Law 816 - Protection of Natural Resources.
- Law 1561 - Creation of the Environment National Council and Environment National Fund integrated to the Environment National System.

Application authority

- As regards water: Water Resource Protection and Preservation General Administration within the Secretariat of Environment.
- Environmental: Secretariat of Environment depends on the President.

Uruguay

- Constitution.
- Law 9481 - Protection of national fauna.
- Law 13833 - Exploitation, preservation and study of water resources is declared of national interest. Establishes territorial sea limit as far as 200 nautical miles.
- Law 16466 - Environmental impact evaluation.
- Law 16688 - Possible waters contamination - prevention and survey.
- Law 16736 - Domain and jurisdiction on live resources.
- Law 17033 - Territorial sea, exclusive economic zone and continental platform.
- Law 17283 - Environmental General Regime.
- Decree/Law 14859 - Water code.

Application authority

- Water Resources: Hydrography National Administration (depending on Transport and Public Building Ministry).
- Environmental: Environment National Administration (depending on Housing, Territorial Regulation and Environment Ministry).

Annex VI
Tables

Table VI.1 Main cities of La Plata Basin.

City	Country	State / Province / Department	Last registered population[1]
São Paulo Metropolitan Area	Brazil	São Paulo	17 878 703
Buenos Aires Metropolitan Area	Argentina	Ciudad Autónoma de Buenos Aires	13 318 677
Great Rosario	Argentina	Santa Fe	2 997 376
Curitiba Metropolitan Area	Brazil	Paraná	2 726 556
Brazilia	Brazil	Federal District	2 051 146
Goiania Metropolitan Area	Brazil	Goias	1 639 516
Montevideo	Uruguay	Montevideo	1 303 182
Campinas	Brazil	São Paulo	969 396
Great La Plata	Argentina	Buenos Aires	681 832
Campo Grande	Brazil	Mato Grosso do Sul	663 621
Asunción	Paraguay	Asunción	513 399
Ribeirao Preto	Brazil	São Paulo	504 923
Uberlandia	Brazil	Mato Grosso	501 214
Cuiaba	Brazil	Mato Grosso	483 346
Salta	Argentina	Salta	462 668
Great Santa Fe	Argentina	Santa Fe	451 571
Londrina	Brazil	Paraná	447 065
São Jose do Rio Preto	Brazil	São Paulo	358 523
Bauru	Brazil	São Paulo	316 064
Corrientes	Argentina	Corrientes	314 247
San Salvador de Jujuy	Argentina	Jujuy	277 985
Paraná	Argentina	Entre Ríos	246 587
Resistencia	Argentina	Chaco	274 004
Ponta Grossa	Brazil	Paraná	273 616
Posadas	Argentina	Misiones	280 454
Santa María	Brazil	Rio Grande do Sul	243 611
Santiago del Estero	Argentina	Santiago del Estero	230 424
Ciudad del Este	Paraguay	Alto Paraná	223 350
Dourados	Brazil	Mato Grosso do Sul	164 949
Rondonópolis	Brazil	Mato Grosso	150 227
Coronel Oviedo	Paraguay	Caaguazú	141 975
Poços de Caldas	Brazil	Mato Grosso	135 627
Potosí	Bolivia	Potosí	112 078
Bagé	Brazil	Rio Grande do Sul	118 767
Corumbá	Brazil	Mato Grosso do Sul	95 701
Tarija	Bolivia	Tarija	90 113
Alegrete	Brazil	Rio Grande do Sul	84 338
Tres Lagõas	Brazil	Mato Grosso do Sul	79 059
Pedro Juan Caballero	Paraguay	Amambay	77 478
Santo Angelo	Brazil	Rio Grande do Sul	76 745
Paranavai	Brazil	Paraná	75 750
Paysandú	Uruguay	Paysandú	74 568
Encarnación	Paraguay	Itapuá	69 769
Tupã	Brazil	São Paulo	63 333
Rivera	Uruguay	Rivera	62 859
Maldonado	Uruguay	Maldonado	48 936
Melo	Uruguay	Cerro Largo	46 883
Tacuarembó	Uruguay	Tacuarembó	45 891
Mercedes	Uruguay	Soriano	39 320
Villarrica	Paraguay	Guaira	38 151
San José de Mayo	Uruguay	San José	34 552
Concepción	Paraguay	Concepción	31 376
Durazno	Uruguay	Durazno	30 607
Treinta y Tres	Uruguay	Treinta y Tres	26 390
Pilar	Paraguay	Neembucú	24 096
Salto	Uruguay	Salto	24 030
Quarai	Brazil	Rio Grande do Sul	24 002
Colonia del Sacramento	Uruguay	Colonia	22 200
Fray Bentos	Uruguay	Río Negro	21 959
Trinidad	Uruguay	Flores	20 031
Mariscal Estigarribia	Paraguay	Boquerón	19 908
Canelones	Uruguay	Canelones	19 388
Villa Hayes	Paraguay	Presidente Hayes	15 466
Artigas	Uruguay	Artigas	13 537
San Juan Bautista	Paraguay	Misiones	10 339
Aregua	Paraguay	Central	10 045

Note: [1]Years of last registered data: 2002 in Argentina and Paraguay; 2001 in Bolivia; 2000 in Brazil and 1996 in Uruguay.
(Source: DGEEC 2002, IBGE 1999, INDEC 1991, INE-Bolivia 2001, INE-Uruguay 1996)

Table VI.2 Hydropower and dams in La Plata River Basin.

Dam name (hydroplant in brackets if different)	River	Dam height (m)	Year dam completed	Hydropower capacity in operation (MW)	Hydropower capacity u/c or planned (MW)	Year of initial operation
ARGENTINA (La Plata River Basin)						
Yacyretá (binational - Paraguay)	Paraná	43	1994	1 800	1300	1997
Urugua-í	Urugua-í	90	1991	120	ND	1991
Salto Grande (bi-national - Uruguay)	Uruguay	47	1979	1 890	ND	1979
Arrazayal	Alto Bermejo	120	planned	ND	93	ND
Cambarí	Tarija	110	planned	ND	102	ND
Las Pavas	Alto Bermejo	110	planned	ND	88	ND
Garabi (bi-national-Brazil)	Uruguay	81	planned	ND	1 500	ND
Chapetón	Paraná	15	planned	ND	3 000	ND
Corpus Christi (bi-national - Paraguay)	Paraná	40	planned	ND	2 880	ND
Añacuá (bi-national - Paraguay)	Paraná branch	ND	planned	ND	250	ND
BRAZIL[1]						
Ituparacanga	Sorocaba	38	1914	56.2	ND	ND
Itutinga	Grande	23	1955	52	ND	ND
Alecrim	Jupiá	54	1955	72	ND	ND
Peixoto (Mascarenhas de Moraes)	Grande	72	1956	478	ND	ND
Río Bonito	Bonito	19	1958	57	ND	ND
Jurimirim (Armando A. Laydner)	Paranapanema	50	1962	97	ND	ND
Furnas	Grande	127	1963	1 216	ND	ND
Jacuí	Jacuí	15	1963	180	ND	ND
Barra Bonita	Tietê	32.5	1963	141	ND	ND
Bariri (Alvaro de S. Lima)	Tietê	32.5	1965	143	ND	ND
Cachoeira Dourada	Paranaíba	26	1966	658	ND	ND
Graminha (Caconde)	Pardo	60	1966	80	ND	ND
Jupiá	Paraná	43	1968	1 411	ND	ND
Ibitinga	Tietê	31.7	1969	131	ND	ND
Jaguara	Grande	55	1970	424	ND	ND
Xavantes	Paranapanema	98	1970	414	ND	ND
Passo Fundo	Passo Fundo	47	1972	226	ND	ND
Passo Real	Jacuí	58	1973	158	ND	ND
Ilha Solteira	Paraná	74	1973	3 444	ND	ND
Volta Grande	Grande	55	1974	437	ND	ND
Coaracy Numes - Paredão	Araguari	43	1975	70	ND	ND
Marimbondo	Grande	90	1975	1 440	ND	ND
Salto Osorio	Iguaçu	56	1975	1 096	ND	ND
Promissão	Tietê	50	1975	264	ND	ND
Boa Esperança	Paranaíba	53	1976	238	ND	ND
Capivara	Paranapanema	60	1976	640	ND	ND
Serraria	Jupiá	61	1977	24	ND	ND
Itaúba	Jacuí	97	1978	500	ND	ND
Saõ Simão	Paranaíba	127	1978	1 710	ND	ND
Agua Vermelha	Grande	63	1979	1 396	ND	ND
Foz de Areira	Iguaçu	160	1980	1 676	ND	ND
Salto Santiago	Iguaçu	80	1980	2 000	ND	ND
Itumbiara	Paraníba	110	1980	2 280	ND	ND
Jaguari	Jaguari	77	1981	28	ND	ND

Itaipú (bi-national Paraguay)	Paraná	196	1982	12 600	1 400	ND
Emborcação	Paranaíba	158	1982	1 192	ND	ND
Nova Avanhandava	Tietê	71	1982	348	ND	ND
Rosana	Paranapanema	30	1985	372	ND	ND
Segredo	Iguaçu	145	1992	1 260	ND	ND
Nova Ponte	Araguarí	142	1994	510	ND	ND
Derivaçao Río Jordão	Jordão	95	1996	6.5	ND	ND
Miranda	Araguari	85	1997	408	ND	ND
Salto Caxias	Iguaçu	67	1998	1 240	ND	ND
Taquaruçú	Paranapanema	61	1999	555	ND	ND
Tres Irmãos	Tietê	82	1999	808	ND	ND
Dona Francisca	Jacuí	ND	2000	125	ND	ND
Itá	Urugui	125	2000	1 450	ND	2001
Machadinho	Pelotas	126	2001	1 140	ND	2002
Jauru	Jauru	51	2003	ND	110	ND
Euclides da Cunha	Pardo	60	1960/1977	109	ND	ND
Corumbá I	Corumbá	90	ND	375	ND	ND
Estreito	Grande	92	ND	1 040	ND	ND
Igarapa	Grande	32	ND	210	ND	ND
Porto Colômbia	Grande	40	ND	320	ND	ND
Jaguari dike	Jaguari	60	ND	ND	ND	ND
Jordão	Jordão	67	ND	ND	ND	ND
Manso (MT)	Manso	60	ND	210	ND	ND
Porto Primavera	Paraná	38	ND	1 814	ND	ND
Canoas I	Paranapanema	29	ND	82.5	ND	ND
Canoas II	Paranapanema	25	ND	72	ND	ND
Salto Grande	Paranapanema	25	ND	70	ND	ND
Campos Novos	Canoas	196	ND	ND	880	ND
Quebra Queixo	Chapecó	75	ND	ND	120	2003
Ponte de Pedra	Correntes	35	ND	ND	176	n/c
Corumbá IV	Corumbá	ND	ND	ND	127	n/c
Funil (MG)	Grande	54	ND	ND	180	n/c
Pirajú	Paranapanema	37	ND	ND	70	n/c
Barra Grande	Pelotas	186	ND	ND	690	2005
Capim Branco I	Araguari	55	planned	ND	240	planned
Capim Branco II	Araguari	49	planned	ND	210	planned
São João	Chopim	51	planned	ND	60	planned
Barro dos Coqueiros	Claro	60	planned	ND	90	planned
Caçú	Claro	38	planned	ND	65	planned
Itumirim	Corrente	ND	planned	ND	50	planned
Corumbá III	Corumba	60	planned	ND	94	planned
Salto Santiago 2	Iguaçu	65	planned	ND	710	planned
Fundão	Jordão	52	planned	ND	119	planned
Santa Clara	Jordão	70	planned	ND	119	planned

Monjolinho	Passo Fundo	74	planned	ND	67	planned
Pai Querê	Pelotas	158	planned	ND	292	planned
Foz do Chapecó	Uruguai	48	planned	ND	855	planned
Garabi (bi-national - Argentina)	Uruguay	81	planned	ND	1 500	planned
Salto	Verde	ND	planned	ND	108	planned
Salto do Rio Verdinho	Verde	42	planned	ND	93	planned
PARAGUAY						
Itaipú (bi-national - Brazil)	Paraná	196	1982	12 600	1 400	ND
Yacyretá (bi-national - Argentina)	Paraná	43	1994	1 800	1 300	1997
Acaray	Acaray	41	1972	256	ND	ND
Yguazú	Yguazú	43	1972	ND	200	planned
Añacuá (bi-national - Paraguay)	Paraná branch	ND	planned	ND	250	ND
Corpus Christi (bi-national - Argentina)	Paraná	40	planned	ND	2 880	ND
URUGUAY						
Salto Grande (bi-national - Argentina)	Uruguay	47	1979	1 890	ND	1979
Constitución/Rincón del Bonete	Negro	66	1983	333	ND	ND
Gabriel Terra		ND	ND	152	ND	ND
Baygorria	Negro	ND	ND	108	ND	ND

Notes: [1]Many other planned hydro projects in Brazil are to be granted concessions by ANEEL. A further 2 734 MW is planned to initiate operation before the end of 2002, and 6 390 MW in 2003.
ND = No Data.
u/c = under construction.
(Source: Hydropower and Dams 2002)

Table VI.3 Hydropower and dams in the South Atlantic Drainage System.

Dam name (hydro plant in brackets if different)	River	Dam height (m)	Year dam completed	Hydropower capacity in operation (MW)	Hydropower capacity u/c or planned (MW)	Year of initial operation
Piedra del Aguila	Limay	170	1993	1 400	ND	1993
Los Reyunos PSP	Diamante	131	1980	224	ND	1980
Alicura	Limay	130	1983	1 000	ND	1984
Futaleufu	Futaleufu	130	1976	440	ND	1976
Agua del Toro	Diamante	120	1976	130	ND	1976
Valle Grande	Atuel	115	1965	22	ND	1965
Florentino Ameghino	Chubut	113	1963	47	ND	1963
La Viña	Los Sauces	106	1944	16	ND	1944
Cerro Pelado (Río Grande I PSP)	Grande	104	1984	750	ND	1984
Cuesta del Viento	Jachal	100	2002	11	ND	2002
Las Maderas	Perico	98	1974	20	ND	1974
El Chocón	Limay	86	1972	1 200	ND	1973
El Cadillal	Salí	85	1966	13	ND	1966
Las Pirquitas	Del Valle	83	1961	ND	ND	1961
Escaba	Marapa	83	1948	24	ND	1948
La Florida	Quinto	75	1953	ND	ND	1953
Piedras Blanca	Quinto	63	1953	ND	ND	1953
Los Molinos I	Los Molinos	63	1953	59	ND	1957
Itiyuro	Carapari	62	1974	ND	ND	1974
Esteban Agüero	Grande (Quinto)	60	1999	ND	ND	2000
Quebrada de Ullum	San Juan	60	1981	45	ND	1981
Planicie anderita	Neuquén	34	1977	450	ND	1978
Pichi Picun Leufu	Limay	48	1999	260	ND	1999
El Nihuil II (Aisol)	Atuel	38	1968	133	ND	1969
Arroyito	Limay	37	1982	120	ND	1983
El Nihuil I	Atuel	28	1947	74	ND	1956
Casa de Piedra	Colorado	47	1989	60	ND	1997
Arroyo Corto (Río Grande I PSP)	Grande	42	1989	60	ND	1989
Tierras Blancas (El Nihuil III)	Atuel	37	1973	52	ND	1973
Potrerillos	Mendoza	116	2004	170	ND	ND
Caracoles	San Juan	155	u/c	ND	123	ND
Punta Negra	San Juan	122	u/c	ND	60	ND
Saladillo	Quinto	70	u/c	ND	ND	ND
Chihuido II	Neuquén	78	planned	ND	230	ND
Cabra Corral (Gral M. Belgrano)	Juramento	112	1973	102	ND	1973

Note: ND = No Data. u/c = under construction.
(Source: Hydropower and Dams 2002)

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Patagonian Shelf region. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF"*.

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference"*.

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

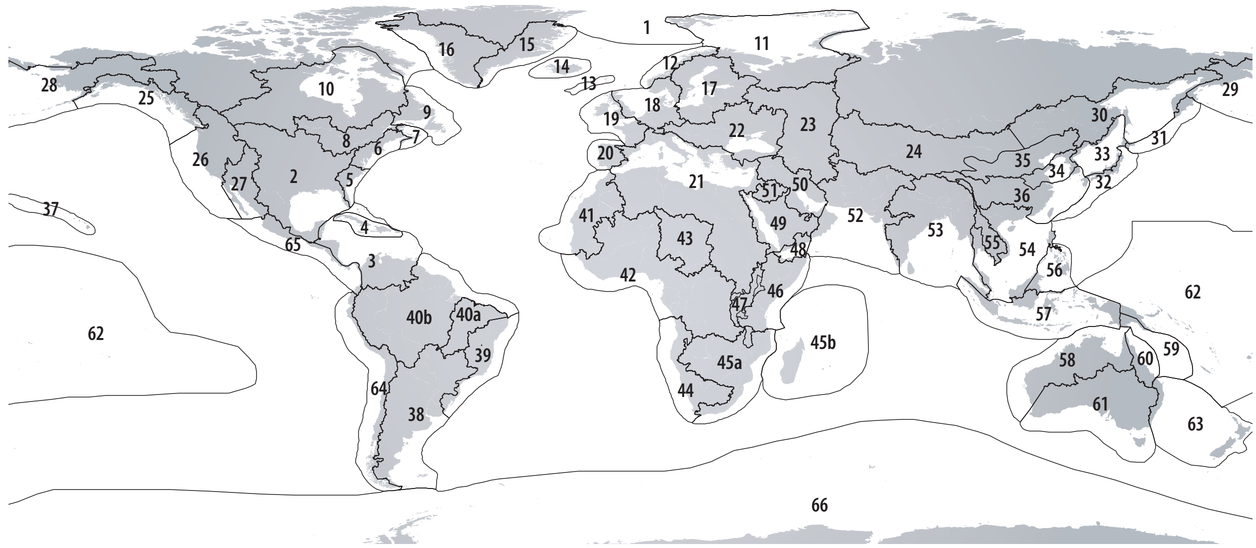
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1 Arctic
2 Gulf of Mexico (LME)
3 Caribbean Sea (LME)
4 Caribbean Islands
5 Southeast Shelf (LME)
6 Northeast Shelf (LME)
7 Scotian Shelf (LME)
8 Gulf of St Lawrence
9 Newfoundland Shelf (LME)
10 Baffin Bay, Labrador Sea, Canadian Archipelago
11 Barents Sea (LME)
12 Norwegian Sea (LME)
13 Faroe plateau
14 Iceland Shelf (LME)
15 East Greenland Shelf (LME)
16 West Greenland Shelf (LME)
17 Baltic Sea (LME)
18 North Sea (LME)
19 Celtic-Biscay Shelf (LME)
20 Iberian Coastal (LME)
21 Mediterranean Sea (LME)
22 Black Sea (LME)
23 Caspian Sea
24 Aral Sea
25 Gulf of Alaska (LME)
26 California Current (LME)
27 Gulf of California (LME)
28 East Bering Sea (LME)
29 West Bering Sea (LME)
30 Sea of Okhotsk (LME)
31 Oyashio Current (LME)
32 Kuroshio Current (LME)
33 Sea of Japan/East Sea (LME)
34 Yellow Sea (LME)
35 Bohai Sea
36 East-China Sea (LME)
37 Hawaiian Archipelago (LME)
38 Patagonian Shelf (LME)
39 Brazil Current (LME)
40a Brazilian Northeast (LME)
40b Amazon
41 Canary Current (LME)
42 Guinea Current (LME)
43 Lake Chad
44 Benguela Current (LME)
45a Agulhas Current (LME)
45b Indian Ocean Islands
46 Somali Coastal Current (LME)
47 East African Rift Valley Lakes
48 Gulf of Aden
49 Red Sea (LME)
50 The Gulf
51 Jordan
52 Arabian Sea (LME)
53 Bay of Bengal S.E.
54 South China Sea (LME)
55 Mekong River
56 Sulu-Celebes Sea (LME)
57 Indonesian Seas (LME)
58 North Australian Shelf (LME)
59 Coral Sea Basin
60 Great Barrier Reef (LME)
61 Great Australian Bight
62 Small Island States
63 Tasman Sea
64 Humboldt Current (LME)
65 Eastern Equatorial Pacific
66 Antarctic (LME)

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

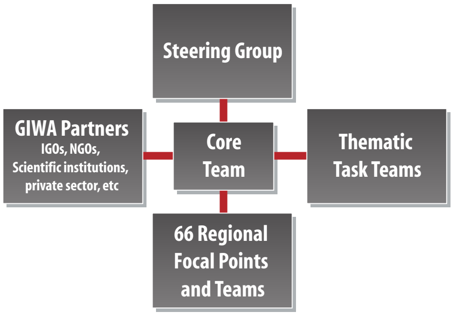


Figure 2 The organisation of the GIWA project.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

Global International Waters Assessment

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

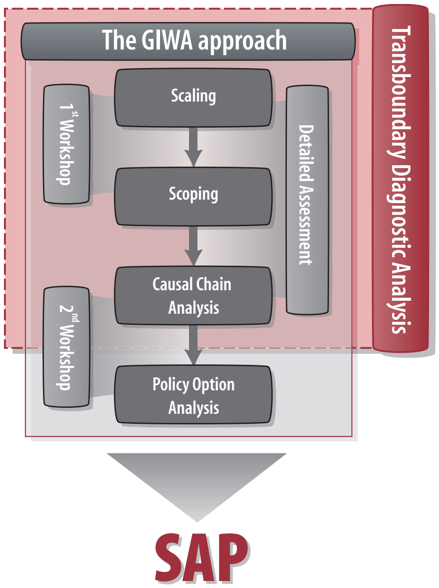

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades*." The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern. In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small – Very large 0 1 2 3	2	50
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

Global International Waters Assessment

Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.

Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

This Report

This report presents the assessment of Patagonian Shelf and associated river basins. The report focuses on the La Plata River Basin, the second largest watershed in South America, and the South Atlantic Drainage System, comprising basins that drain large arid areas of Argentina and one of the world's largest continental shelves. Pollution in the La Plata River Basin has caused considerable environmental degradation while fishing has changed marine habitats and communities. The root causes of environmental degradation in the Argentinean and Uruguayan Common Fishing Zone and the Uruguay River Basin, shared by Argentina, Brazil and Uruguay, are identified and potential remedial policy options are presented.