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Ecological Risk Assessment for the Paraguay River Basin

Argentina, Bolivia, Brazil and Paraguay

Executive Summary

January 2012

Foreword

This assessment is the first step to ascertain the vulnerability of the Paraguay River Basin to climate change. The purpose of this up-to-date picture is to encourage discussions on which risks could be magnified in the future if no action is taken now.

In order to get a sense of the importance of the Paraguay River Basin, just consider that it is home to the largest floodplain in the planet – the Pantanal – where the annual cycles of floods and droughts dictate the lives of thousands of species. Over 8 million people live in the region. The primary economic activity is agriculture, with 30 million head of cattle – approximately four times as many as the number of local inhabitants –, and crop lands cover nearly 7 million hectares, which is equivalent to almost one third of the entire state of São Paulo.

The natural treasures of the Pantanal Wetlands attract nearly one million tourists every year. Ecosystem services in the Pantanal are estimated at $112 billion annually, a study by Moraes (2008) reveals. Therefore, it makes much more sense to preserve a part of this region in its natural state than fully convert it into livestock and crops, whose estimated annual earnings would total a mere $414 million. Furthermore, the ecosystem services benefit society as a whole while the earnings from agriculture go to those involved in rural production. The remainder of the inhabitants only benefits from the consumption of produce.

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Interrelation – This study also helps enhance the understanding that the unique features of the Paraguay River Basin depend on the interrelation between the highlands and the pantanal plains. Therefore, actions that impact on the hydrological systems in the highlands will reflect as impacts on the plains. For example, negative impacts to the highlands – where the headwaters of rivers that flow into the plain are located – are harmful to the flood cycle, which is vital for the Pantanal.

The flooding and receding cycle accounts for the high ecological productivity in the region and for high value ecosystem services, such as fertilisation of fields. It also provides optimal conditions for the reproduction of fish and other species, and for aquatic plants which purify the waters and attract a myriad of birds in search for food.

Despite their ecological and economic importance, the aquatic environments in the Paraguay River Basin are under constant threat of degradation, especially in the highlands and plateaus that surround the Pantanal, where the most important rivers that sustain the life in the floodplain originate in the Cerrado. In order to try to reverse this situation, it is fundamentally important to understand how threats – whether individually or in conjunction with other threats – affect this area's ecological integrity, and to bear in mind that climate changes such as the intensity and frequency of floods or droughts will certainly further compound the problems, for instance.

Finally, this assessment is intended to provide subsidies to the governments of the four countries involved – Argentina, Bolivia, Brazil, and Paraguay –, as well as civil society organisations, to enable them to so that they can develop a climate change adaptation agenda for the Pantanal Wetlands. The assessment also aims to help these groups to design and implement actions that enhance the resilience, which is the ability of an ecosystem to recover and restore itself to its original conditions and functions after suffering an impact, such as drought, flood, fire or deforestation.

This study is the culmination of a partnership involving the WWF, The Nature Conservancy (TNC) and the Pantanal Research Centre (CPP) under the Synergy Project, with funding support from the National Council for Scientific and Technological Development (CNPq), the HSBC Group and the Caterpillar Foundation.

Methods

The guiding principle for this report was the Ecological Risk Index (ERI) devised by Mattson & Angermeier (2007), which provides a holistic view of the threats to which the basin is exposed, in addition to informing conservation decisions and actions. At least five functional aspects have been considered in order to determine the risk, which if altered, could severely compromise the Basin: **sources of energy, hydrologic regime, water quality, biotic interactions, and habitats physical structure.**

The ERI is based on the severity of impacts on ecosystems, their frequency and the sensitivity of the basin to them. The ERI is a tool for decision makers, an aggregated indicator that makes it easier for non experts to understand the problems involved and allows more targeted and effective actions to fight degradation of nature. For example, evidences show that the complete removal of natural vegetation along a river bank increases soil erosion and increase of sediments into the water since the protective function of the riparian forest is lost. As a result, the sediments carried by water cause the decline or disappearance of aquatic plants and algae that rely on light for photosynthesis. As trees are removed, less fruit will fall. This reduces the supply of energy and food for fish, which could affect the size of their populations or even drive them to extinction. How can one measure the extent to which this ecosystem is threatened? ERI is a method for assessing the level of risk to the integrity of aquatic ecosystems.

Thirteen stressors have been identified in the Paraguay River Basin. The three main stressors by order of importance are: **hydropower plants, urbanisation and agriculture.**

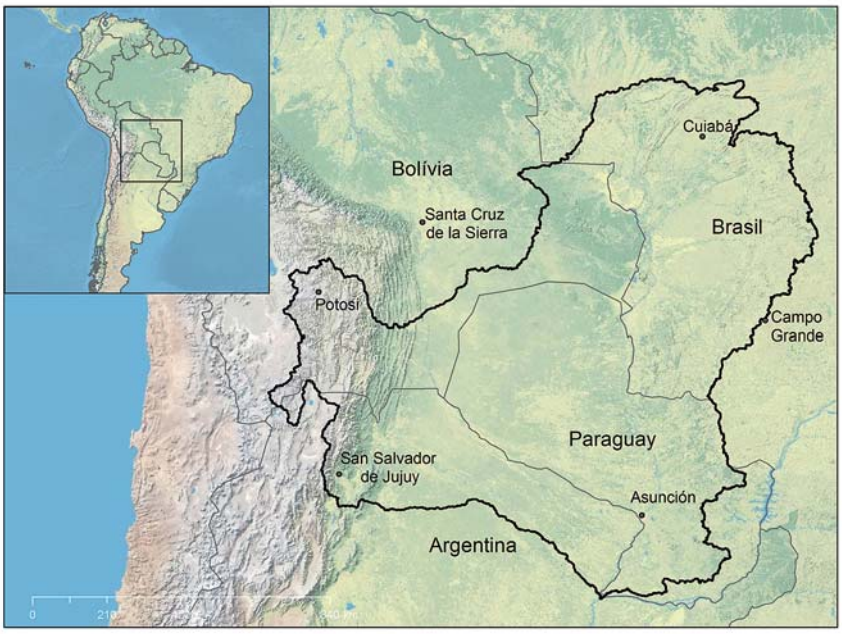
Stressors identified for the Paraguay River Basin

Stressor
Hydroelectric Plants
Urbanisation
Crops
Deforestation
Waterways
Roads
Mining
Fire
Livestock
Dams
Ports
Crossings/bridges
Gas pipelines

Scope

From its source, in the area of Diamantino, Mato Grosso, Brazil, to its confluence with the Paraná River in Corrientes, Argentina, the Paraguay River extends for over 2,600 kilometres. The drainage area covers more than 1,1 million square kilometres, which is equivalent to more than 800 Itaipu reservoirs combined, i.e., 35 times the territory of Portugal. The basin covers parts of Bolivia, Brazil, Paraguay, and Argentina.

Altitudes vary greatly in the basin area. The highest areas lie on the western side, in the Andes, over 4,500 meters above sea level. The lowest point is in the confluence with the Paraná River, 50 meters above sea level.



The climate in the basin varies significantly, it becomes increasingly dry and seasonal from east to west and from north to south. The climate is tropical in the north and northeast, with abundant summer rains and drought spells lasting three to four months. In the southeast, the climate is predominantly subtropical with cold fronts in the winter. The mid south and southeast areas have a dry climate with strong seasonality in rainfall patterns. As the topography rises along the eastern edge of the Andes, humidity falls and in the highest portion the climate is primarily semi desertic.

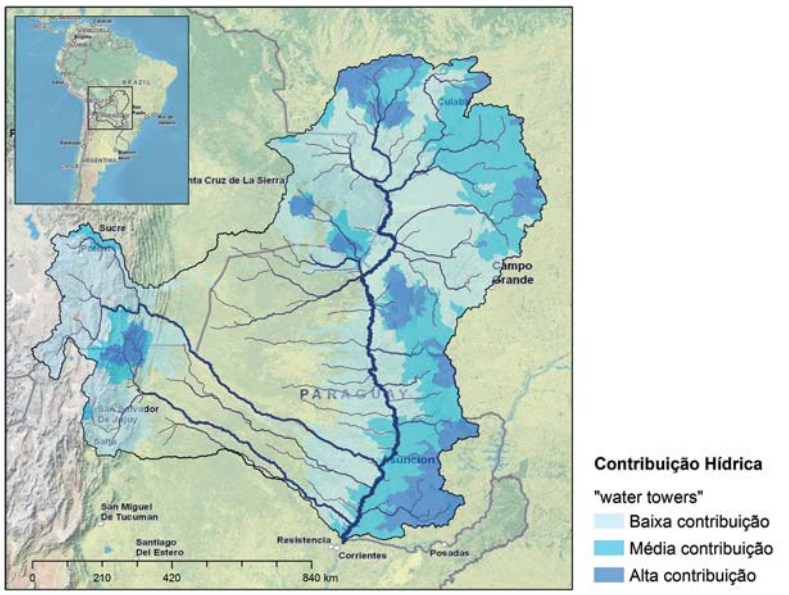
Although 75% of the basin is still covered by native vegetation, some biomes are heavily threatened by human activity. The best examples are the Cerrado and the Atlantic Forest, where 54% and 48% of the land has been deforested, respectively. About 11% (123,6 thousand square kilometres) of the Basin are protected in some way, and only 5% (56,8 square kilometres) are fully protected within national or state parks and ecological stations. Despite being the most endangered biome, the Cerrado is one of the least protected areas, with only 2% of its land under full protection.

In this region, seven out of ten people live in urban areas. The largest population concentration is in the metropolitan area of Asunción, Paraguay, with over 2 million inhabitants. Cuiabá (Mato Grosso), San Salvador de Jujuy (Argentina), Potosí and Tarija (Bolivia) are also major urban areas, but there are also large areas of very sparse population such as the central region of the Pantanal and north-western Gran Chaco.

Hydrological analyses

Water input levels clearly show which sub-basins generate most of the flow and contribute to the seasonal flood pulse that regulates life in the Pantanal floodplain. Of particular importance are the sub basins of the Cabaçal and Sepotuba Rivers, tributaries in the state of Mato Grosso located on the right bank of the Paraguay River. The lime-rich sub-basin of the Salobra River is located in the Bodoquena Mountains; and the Andean area in the Bolivian department of Tarija where the headwaters of of the Pilcomayo River emerge.

The map clearly illustrates the importance of the connection between the central floodplain and the remote headwater areas in the adjacent highlands. Any changes in these connections in terms of quantity, quality and timing of flows will have unforeseen impacts on the wetland systems of the Pantanal. **Therefore, areas of high and medium water input, as well as the headwater systems that connect them, should be a priority for conservation efforts in the basin.**



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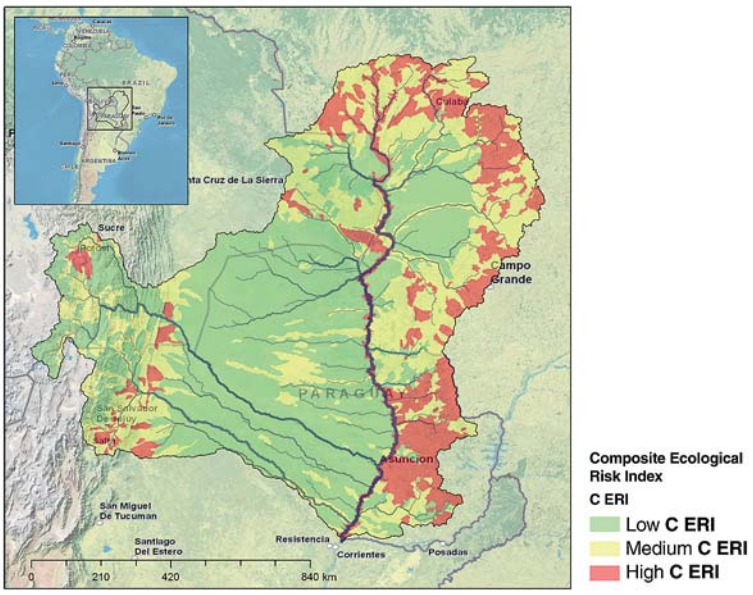
Risks

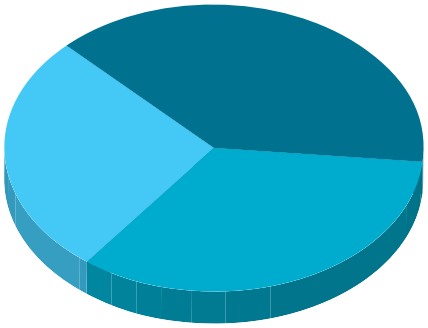
Analyses show that 14% of the water resources in the Paraguay River Basin are at high risk of being damaged, while 37% are at medium risk and 49% are at low risk, as shown in the map below.

An assessment of the spatial distribution of the most endangered areas in the Basin clearly shows that they appear to be concentrated in four different regions that have unique environmental characteristics. The 13 stressors are divided into the three following categories:

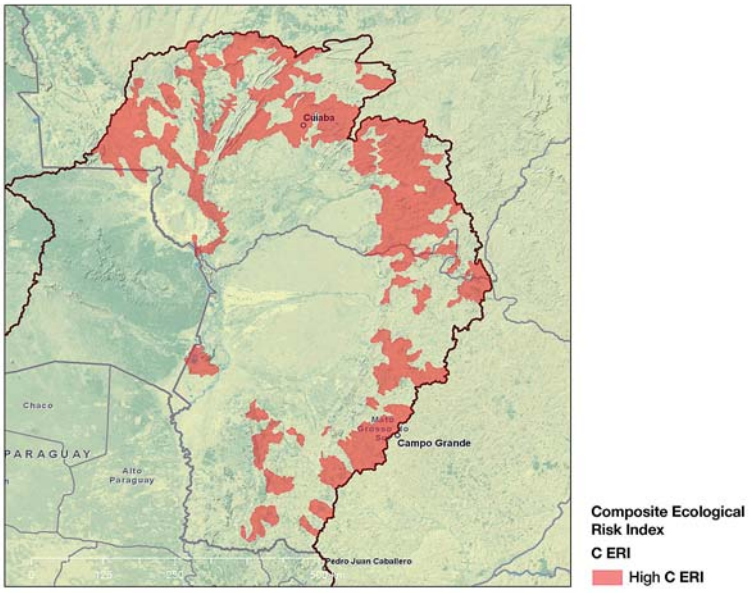


Infrastructure and population	Economic activities	Environmental degradation
People, roads, bridges, ports, waterways, dams, hydropower plants, and gas pipelines	Agriculture, mining, gas/oil prospection	Fires and deforestation

1. Headwaters and tributaries in the Brazilian Cerrado and Chiquitano Forest areas



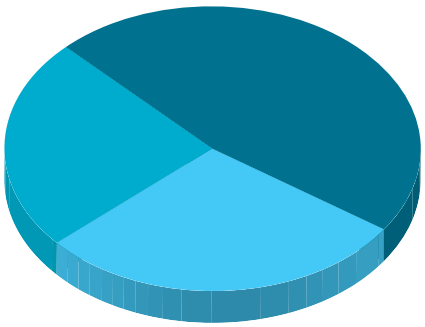
39% Infrastructure and Population
34% Economic Activities
27% Degradation



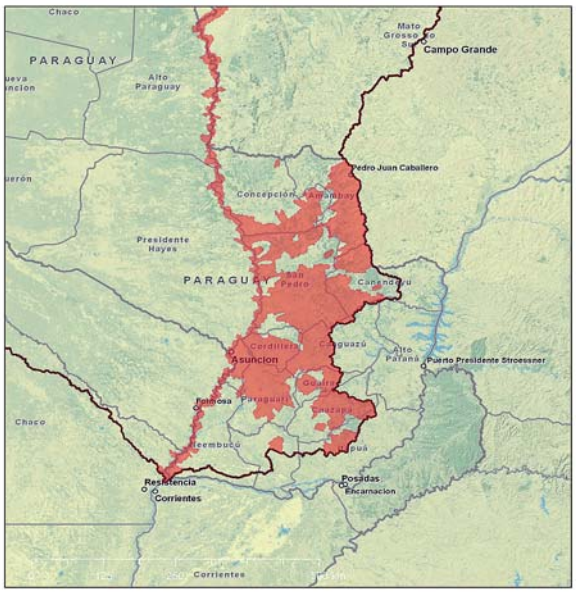
This area covers the headwaters of rivers in areas of Cerrado and Chiquitano Forest surrounding the Brazilian Pantanal. This area is under severe pressure from human occupation. The rivers that begin in this area and run toward the Pantanal floodplain are impacted by a number of threats. Nearly all of these headwaters are located in Brazil – in the states of Mato Grosso and Mato Grosso do Sul. It is important to remember that this region is the leading source of water to the Pantanal basin.

Just as in the entire Paraguay River Basin, the three sets of stressors operate in this region. Although the stressors are generally evenly distributed, the set of stressors with the most significant share of the ERI is related to the impacts of infrastructure and population (39%), in particular neighbouring roads, bridges and dams, including Small Hydroelectric Power Plants (SHPs). The second set of stressors is related to poorly planned economic activities, especially livestock (23%) and crops (13%).

2. Paraguay River Basin's Atlantic Forest area

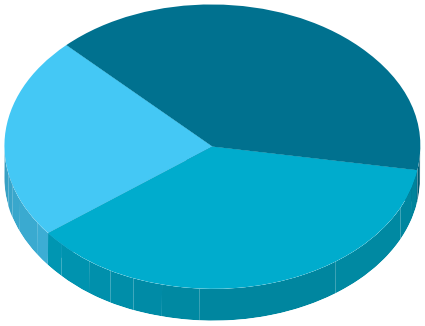


47% Infrastructure and Population
29% Degradation
24% Economic Activities

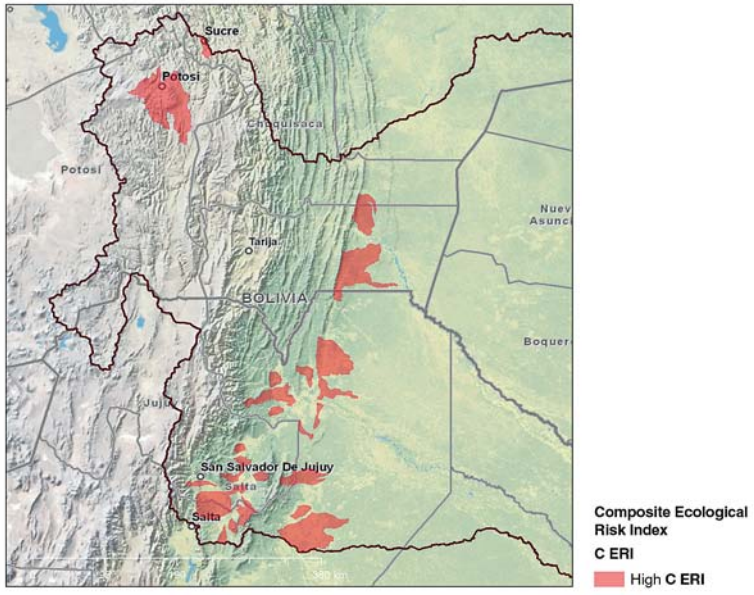


The Paraguay River Basin originally covered by Atlantic Forest, is also a region with aquatic systems that are under threat. The area has a long history of human settlement and the landscape is highly fragmented due to numerous urban centres and agricultural areas focused on dairy farming and monocultures, such as sugar cane. The metropolitan area of Asunción stands out with nearly one thousand square kilometres and over 2 million inhabitants – the largest population concentration in the basin. The number of inhabitants accounts for the fact that the stressors related to the population and infrastructure stand at 47%. Issues related to lack of water supply and sewage treatment capabilities are commonplace, as in most large urban areas in South America. It should be pointed out that about 30% of the water supply to the metropolitan area of Asunción comes from the Patiño Aquifer, and its uncontrolled use can lead to gradual salinisation of the water source.

3. Salta Jujuy development zone



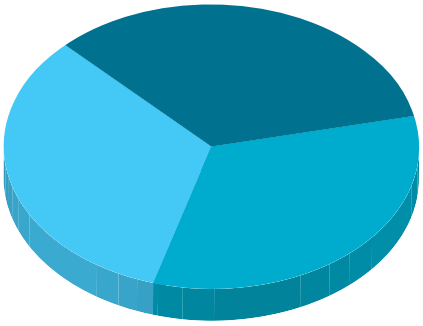
40% Infrastructure and Population
37% Economic Activities
23% Degradation



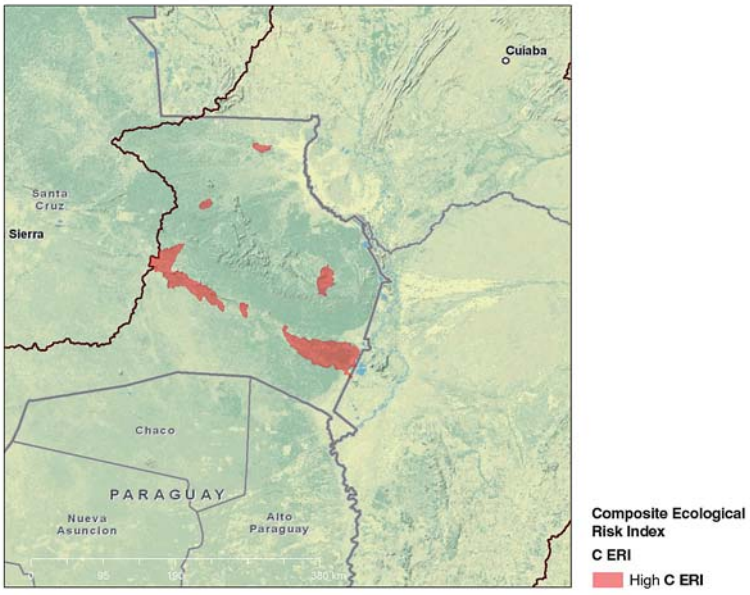
The western side of the basin, which stretches from Salta and Jujuy and goes northward into Bolivia, crossing the headwaters of two tributaries, Bermejo and Pilcomayo, is another critical area vulnerable to ecological impacts. The stressors associated to infrastructure are the most relevant- roads, railways and bridges stand out. The region is also a major producer of gas and oil.

Besides prompting the creation of trails that support logging activities, oil desalination contaminates huge amounts of water with hydrocarbons and chemicals, such as sulphur dioxide (SO2) and hydrogen sulphide (SH2), which is a toxic and extremely flammable gas. In concentrations of a mere 0.01 part per million (ppm), they make water unusable for human consumption. Degradation causing stressors include fire, which is a sizeable source of regional impact.

4. Puerto Suarez and Tucavaca Valley, in Bolivia



34% Infrastructure and Population
33% Economic Activities
33% Degradation



This region is located near the Brazilian border towards Santa Cruz de la Sierra, along the Tucavaca River - one of the major axes of the southern Bolivian Pantanal, providing a large volume of water to the Paraguay River. With one of the lowest Human Development Indexes (HDI) in Bolivia, this region has witnessed a gradual increase in environmentally degrading economic activities, mainly associated with Brazil's growing demand for timber and coal together with the establishment of mining ventures. The risk assessments show that cattle ranching in association with deforestation and burning are the primary sources of stress on water resources. Regional cattle ranching is traditionally extensive and uses fire to renew pastures.

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Discussion and Recommendations

The central portion of the basin, i.e., the Pantanal and the Dry Chaco, has low ecological risk. However, the flooding regime in the region and the interdependence between the highlands and the plains are an indication that the situation is very dynamic in hydrologic terms. In view of the high risk identified for the highlands, the cascading effect of transferring impacts downstream represents a proportionately high risk to the floodplain.

The entire Paraguay River Basin has a high potential ecological risk, and therefore requires immediate and priority action to protect its headwaters. However, the management and care of the Basin should be conducted in a concerted manner by implementing effective conservation actions on the highlands and plains.

Being the Pantanal a floodplain fed by headwater systems located in the adjacent highlands and plateaus, the high flow contribution areas – the so called water towers – need to be given priority in the basin conservation plans. The map below highlights the considerable overlap between medium and high flow contribution areas and areas of greatest ecological risk Protecting medium and high flow contribution areas in the highlands is key to support the seasonal flood pulse in the Pantanal.

As a result of this study a number of priority actions emerge:

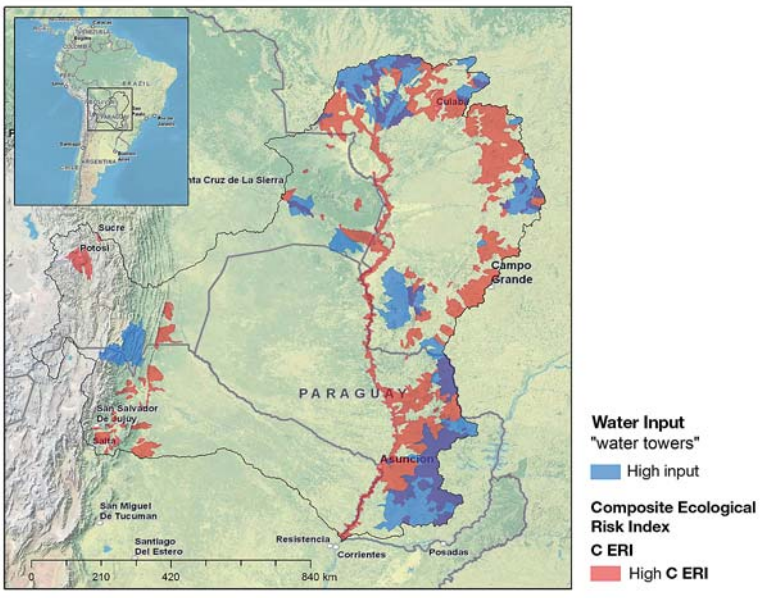
The establishment of public or private protected areas and implementation of conservation measures on private lands are essential to ensure connectivity between existing protected blocks and ensure resilience of ecosystems.

Cattle ranching proved to be one of the main stressors in the basin, especially in the highlands, where the Cerrado vegetation is found. Extensive cattle ranching in the Cerrado still lacks technical support, rural extension and economic incentives. The technology does exist; however local institutions lack capacity to provide necessary support.

Many financial institutions are already changing their policies for development and rural credit as they seek to incorporate environmentally sustainable requirements to extend credit to agriculture. This is a recent development, but an important step to mitigate the impacts of cattle ranching.

In view of the Paraguay River Basin's extremely fragile hydrologic system and economic importance in terms of farming production (Mato Grosso and Mato Grosso do Sul states have the largest bovine herds in Brazil), there is an urgent need for farmers to adopt better ranching practices, such as water and soil conservation, management and recovery of pastures and crop-livestock integration.

Tools that look at the cumulative and propagated impacts of large, medium and small hydropower plants along the water ways as a whole are recommended. Otherwise impacts will remain underestimated and focus only on local scale. It is recommended to include infomation on SHPs in any assessment. According to Calheiros et al. (2009), available tools include hydrologic modelling, basin-scale integrated environmental assessments, and prescription of environmental flows to quantify impacts to changes in the seasonal flood pulse in the Pantanal.



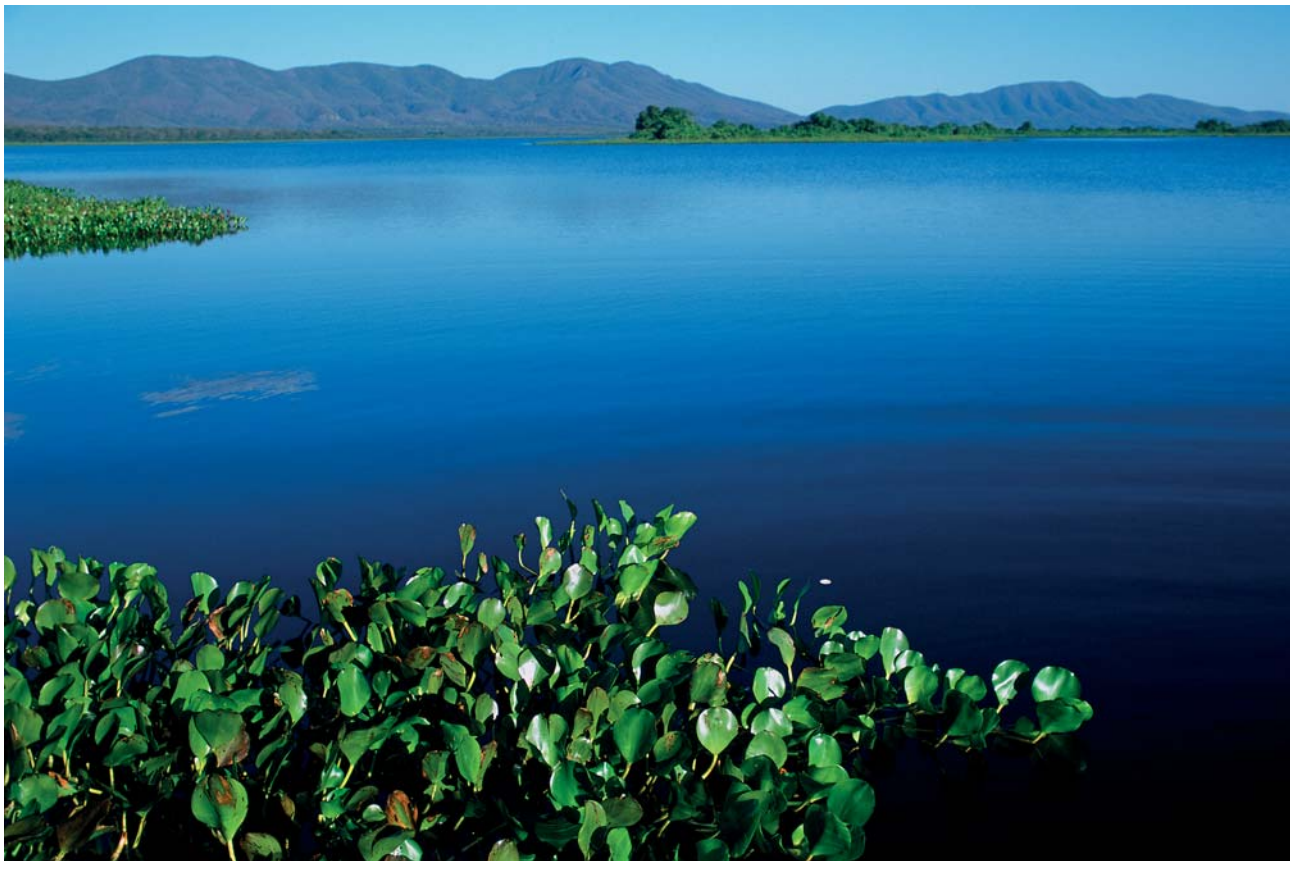
Conclusion

Looking at ecological risk is the first step in the assessment of the Paraguay River Basin's vulnerability to climate change. In order to outline climate change scenarios one must first identify and measure existing stressors (i.e., non-climate stressors).

The ecological risk assessment method is an important planning tool, which can be conducted in a participatory manner and easily replicated in other regions. Projections based on the information from global climate or climate variability models should be developed in order to identify which existing stressors will be intense to a greater or lesser extent in the future, and where and how they will occur. This makes it possible to design and implement effective adaptation actions. Furthermore, socioeconomic and political/ institutional risk assessments should also be taken into consideration in order to integrate a more systemic perspective into the basin's vulnerability assessment.

Good governance in the basin is key to ensuring its resilience in the long term. The existence of an active, inclusive and participatory group of water stewards in addition to strengthened government institutions, should help to minimise the impact of climate change in the basin.

We must work towards conserving biodiversity in the Paraguay River Basin and prepare it for the uncertain future imposed by climate change. This is the only way to ensure that the Pantanal will continue to be an important sanctuary for several species and a strategic reserve of freshwater, a resource that will become even scarcer in the future.



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With support from
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Supporting organisations
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