Report 54900 – LAC

SOUTHERN CONE

Argentina, Bolivia, Brazil, Paraguay, Uruguay

Southern Cone Inland Waterways Transportation Study

The Paraguay-Paraná *Hidrovía*: Its Role in the Regional Economy and Impact on Climate Change

March 2010

Sustainable Development Department
Latin America and the Caribbean Region

Document of The World Bank

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ACRONYMS AND ABBREVIATIONS

CIH	*Comité Intergubernamental de la Hidrovía* (Intergovernmental Waterway Committee)
CAF	*Corporación Andina de Fomento* (Andean Development Corporation)
CPTCP	*Comisión Permanente de Transporte de la Cuenca de la Plata*
CO_2	Carbon Dioxide
DPR	Development Policy Review
DOT	Department of Transportation
ECLAC	Economic Commission for Latin America and the Caribbean
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EU	European Union
GHG	Greenhouse Gas
GPS	Global Positioning System
GRT	Gross Registered Tonnage
HPP	*Hidrovía Paraguay-Paraná*
IBRD	International Bank for Reconstruction and Development
ICA	Investment Climate Assessment
IDB/IADB	Inter-American Development Bank
IFO	Intermediate Fuel Oil
IIRSA	*Iniciativa para la Integración de la Infraestructura Regional Suramericana* (Initiative for the Integration of Regional Infrastructure in South America)
IMF	International Monetary Fund
IRR	Internal Rate of Return
IWT	Inland Waterways Transportation
IT	Intelligent Technology
MERCOSUR	*Mercado Común del Sur* (Southern Common Market)
OAS	Organization of American States
OECD	Organisation for Economic Co-operation and Development
PPP	Public-Private Partnership
PPIAF	Public-Private Infrastructure Advisory Facility
RFP	Request for Proposal
RO-RO	Roll-on/Roll-off

TEU	Twenty-foot Equivalent Unit
UNDP	United Nations Development Programme
US	United States
USAID	United States Agency for International Development
VAT	Value-added tax
WB	World Bank
WTO	World Trade Organization

ACKNOWLEDGEMENTS

This study was prepared under the task management of Andrés Pizarro (World Bank) based on contributions from a team of Bank staff and consultants. The team was composed of Martin Sgut (consultant), José Barbero (consultant), Flávio Chaves (World Bank) and Paul Procee (World Bank).

The quality control for the report was provided by Aurelio Menéndez (World Bank) , Franz Drees-Gross (World Bank) and Jordan Schwartz (World Bank); Maria Emilia Sparks contributed to editing the report. The team wishes to thank peer reviewers Jean-François Arvis (World Bank), Robin Carruthers (World Bank) and Juan Gaviria (World Bank) for helpful and insightful comments.

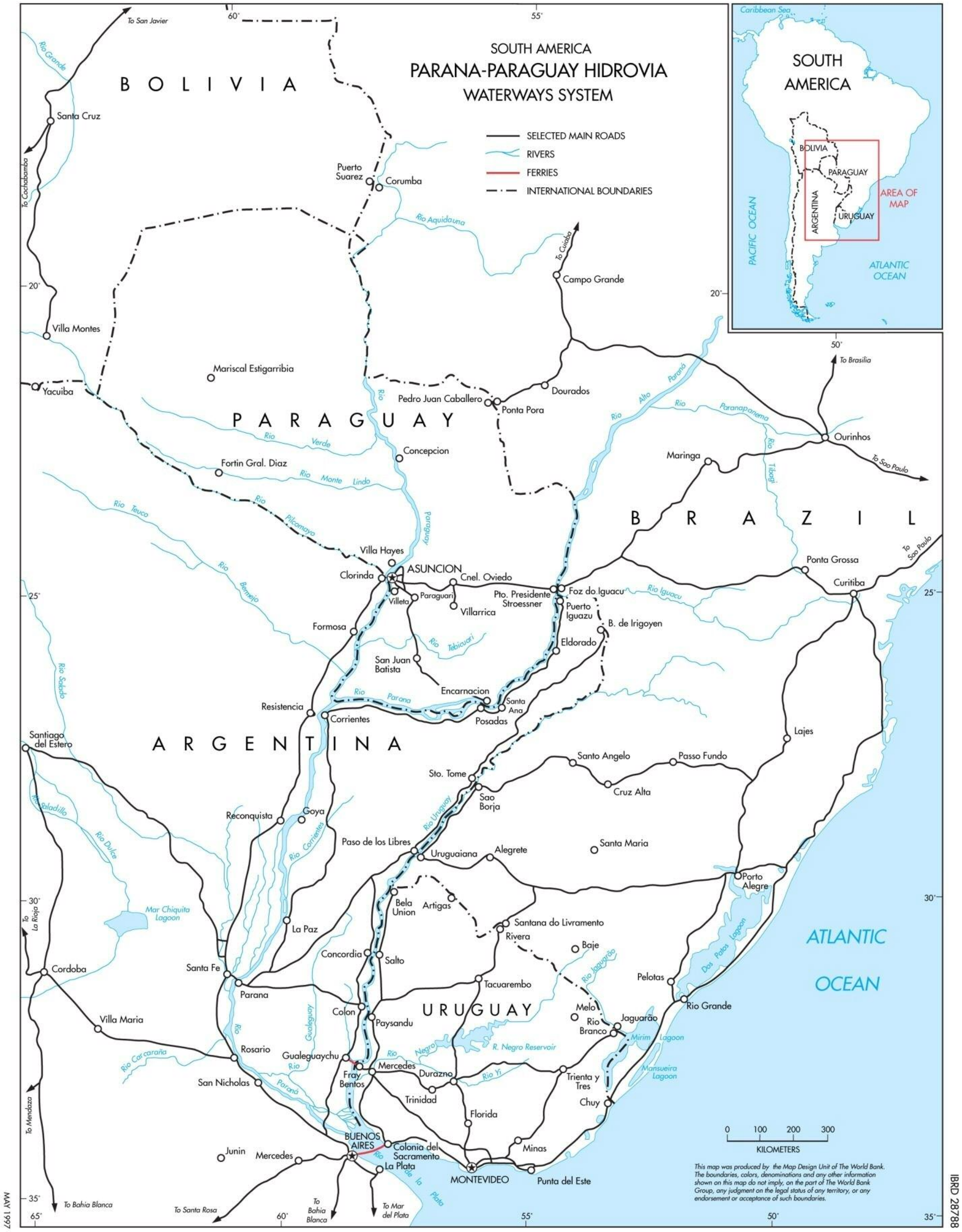
The team acknowledges the supervision and oversight of Jocelyn Albert (World Bank) for this study as the manager of the Sustainable Development Department Climate Change funds that permitted its execution.

Finally, the team wishes to dedicate the report to the memory of an esteemed friend and consultant, Martin Sgut, who participated fully in the conception and development of the study and was sadly taken by illness in January 2010.

PREFACE

This study was financed by the World Bank's Latin America Sustainable Development Department through its own funds dedicated to developing the knowledge base on the climate change agenda. Thus, the audience for the report is World Bank staff members, and more particularly those involved in infrastructure and climate change and those working in the Southern Cone.

The World Bank team decided to tackle this topic in order to develop its knowledge base on climate change and logistics issues, but also to design a possible regional strategy on what could be a very important regional, multi-country project. It is hoped that this report will contribute to developing the World Bank's logistics work and become an object of discussion internally in the various technical discussion groups dedicated to this subject. The author's also wish that the World Bank staff working on the Southern Cone countries see the report as a contribution to the development of a possible regional project.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KILOMETERS
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MAY 1997
IBRD 28788

EXECUTIVE SUMMARY

1. **The Paraguay-Paraná Rivers waterway system (referred to in the text as the *Hidrovía,* or *HPP*) is potentially the greatest axis for freight movement in the sub-region and a possible integration mechanism for the MERCOSUR countries.** However, 90 percent of freight in the sub-region is moved by road transport, a significantly inefficient mode of transport in terms of fuel consumption, space use and GHG emissions. For over 15 years the Southern Cone countries have attempted to coordinate their regulations and policies to improve the navigability of the HPP so that it can reach its full potential. These efforts have been marred by failures and disputes that have resulted in no concrete actions. Given the apparently limited investment needed to make the HPP the principal low-cost, low-impact freight transport system in the sub-region, it is worthwhile to investigate why the HPP has been unable to fulfill its promise.

2. **This report attempts to determine why the *Hidrovía*, one of most significant watercourses in South America, is underutilized.** This study analyzes the HPPs role in freight movement and trade in the subregion. It further looks at the technical, economic and environmental feasibility of the proposed improvements and defines what would be required to implement improvements. In the analysis of environmental impacts, the GHG emissions per mode of transport, particularly fluvial transport, are estimated in order to define the HPP's overall climate change impact. Next, it describes the institutional context and assesses the institutional arrangements in each country and the coordination efforts that have been attempted. Finally, it outlines several areas of intervention that the World Bank could explore to collaborate with this endeavor.

3. **The Paraguay-Paraná Rivers waterway system allows for more than 2,700 km of inland navigation within the South American continent and also supports maritime navigation (mid-sized bulk carriers) in the lower reaches of the system (the first 500 km).** The two systems—inland and maritime navigation—are connected in the lower reaches of the Paraná River and a short section of the Uruguay River; these sections act as a maritime estuary. Overall in South America, the largest inland waterway freight activity currently takes place in the Amazon Basin, where around 21 million tons of freight is moved per year. The Paraguay-Paraná Hidrovía follows with 14 million tons, the Araguaia-Tocantins with roughly 4 million, and the Magdalena and Paraná-Tietê with 2 million each.[1]

Figure A. Hidrovía Paraguay-Paraná (HPP)

[1] Values are approximated; countries record flows with different criteria. The figures exclude oceanbound navigation entering into the rivers, and river-port loading activity using boats (as in Urabá, Colombia).

4. Five countries, two of which are landlocked, take part of the Paraguay-Paraná Hidrovía. According to their respective positions within the network, each country utilizes and benefits from the HPP in different ways. In the upper extreme, landlocked Bolivia exports bulk commodities through the waterway. Brazil uses the HPP as a north-south alternative route for ore (iron, manganese) and oilseed exports generated in the regions close to the Paraguay River. This may be more efficient than shipping them to its Atlantic ports by means of west-east surface transportation. The waterway serves as the central export and import conduit for landlocked Paraguay. Argentina uses the river for several purposes: (i) to move domestic dry bulk from the northern regions to the transfer area; (ii) to receive freight from upstream countries for processing in its manufacturing plants (soy, iron ore); (iii) to transfer freight to oceangoing vessels; and (iv) to facilitate Paraguayan and Bolivian imports (fuel, wheat). Uruguay receives freight (dry bulk and containers) from upstream countries and transfers it to oceangoing vessels in its ports, and vice versa.

5. The HPP is composed of two main sections: the lower section located south of Santa Fe, which allows for annual depths of 34 feet at Rosario and 28 feet closer to Santa Fe, and the inland navigation section north of Santa Fe, which only allows for depths of up to 8 feet. The lower section has been deepened and is currently maintained by a private concessionaire. Upstream, not only is the water depth lower, but the channel is narrower and the curvature radii shorter, making navigation more difficult for larger vessels and convoys. Together with several bridges along the waterway, the current river conditions constrain navigation and require the disassembly of tug and barge convoys.

6. Many problems exist in the waterway's physical condition, in logistics, in transport facilitation, security performance, and in the coordination of investment plans. Users (shippers and carriers) are increasingly concerned, because in spite of the international institutions and agreements, no further progress is expected in the improvement of the waterway. A strong growth trend in transport demand, fleet increases and improvements in operational efficiency were experienced recently, however, significant constraints existing in the waterway have limited this trend, as summarized below:

- ***In the waterway's condition****:* shallow water, curvatures and bridges (mostly in the upper section), signaling flaws, and lack of maneuvering areas;
- ***In logistics and operations****:* lack of workforce with the skills for new technology, insufficient port capacity, pressure from growing market demands, navigation control difficulties, congestion from increased traffic;
- ***In transport facilitation and security conditions***: lack of adequate transfer facilities between rail and barges, excessive administrative requirements (even for cabotage), high theft rates (for cargo and fuel); and
- ***In investment plan coordination*****:** asymmetry in cost and benefits precludes actions (i.e., dredging or signaling) by individual countries; the generation of an international authority (able to charge users) is legally complex.

7. The cost-benefit analysis of the HPP improvement project results in a very high expected IRR (internal rate of return). The possible improvement alternative shows a 25.3 percent IRR over a 20-year horizon, and 19.2 percent in 10 years. The 2004–2005 study conducted by the CIH[2] includes a meticulous cost-benefit analysis of the HPP Project. The purpose of the analysis was not merely to examine the project's overall advantages, but also to comparatively examine the project's various options and alternatives. The analysis illustrates that, due to improvements in navigation conditions, the project's main benefits are the reductions in freight transport costs for transport using the waterway (freight transport rates are presumed to decrease proportionately). The proposed waterway improvements would reduce transportation costs between 15 percent and 20 percent per ton (priced at around US$2.20 per ton, according to the preferred option). Improvement costs, including sand/rock foundation demolition, signaling and environmental impact mitigation, vary depending on the alternative selected, between US$39 and US$94 million; annual maintenance costs are estimated at US$12.6 to US$20.5 million. It is interesting to note that the study brings to light the low elasticity of transport rates: freight whose characteristics make water transport an attractive option is already using the HPP. Freight being transported by other modes of transportation (mainly the transport of soy and its by-products) that would shift to the HPP due to its lower costs, is marginal. New traffic generation (basically from mining

[2] Prepared by the "Consorcio Integración Hidrovíario"–COINHI.

operations in the Corumbá area) was considered cautiously; it was found that the waterway's freight transport rates would have to be significantly low in order to encourage new mining projects.

8. An additional analysis carried out in this study, based on an extra-costs model, shows that the extra costs due to infrastructure constraints total around US$149 million per year. They are composed of extra costs due to depth constraints and are estimated at US$69 million per year. Extra costs are incurred due to delays along the waterway, estimated at US$20 million per year, with freight owners' inventory costs at around US$60 million. Overall, potential savings from infrastructure improvements would reduce IWT costs by around 30 percent, a proportion larger than that estimated in the CIH study (between 15 and 20 percent). The 30 percent savings was checked and confirmed with waterway operators. Furthermore, the delays also significantly impact costs and freight owners' inventory costs. These costs were not considered by the CIH. Therefore, for base year 2007, approximately US$89 million impacted the freight rates negatively, while the shippers directly absorbed roughly US$60 million. In terms of extra cost per ton, US$7.4 and US$5.0, respectively (US$12.4 in total), could have been avoided with better infrastructure. It is worth noting that in the case of improvements in infrastructure conditions, not all the cost savings will be passed on to shippers (carriers usually capture around 50 percent). Other costs may also be considered, such as the commercial opportunities lost due to the reduced competitiveness of regional products in the international market, resulting from high internal transportation costs.

Table A. Summary of cost reductions due to HPP improvements

Cost Type	Cost Amount (US$ millions)
Due to depth constraints	69
Due to delays along the waterway	20
Due to freight owners' inventory costs	60
TOTAL	149

9. There is asymmetry between the benefits accrued by the user country and their contribution relative to the improvement costs of the HPP, offering perhaps an insight into the reason for the lack of progress in its improvement. The countries directly using the HPP do so in different proportions, benefiting both from freight generation and reception (through import or transshipment). The greatest costs to be incurred in the improvement project are in Bolivia and Paraguay, but the country that would accrue the least benefits is Bolivia. It is interesting to note that the country that would accrue the most benefits from the project is Argentina, followed by Paraguay. This may explain why Argentina has been more active in improving its section of the HPP, and Paraguay is following with a similar initiative.

Table B. Relative distribution of freight rate savings and dredging costs for the HPP countries

Country	Savings in freight rates from freight originating in the	Savings in freight rates from freight in destination to	Dredging costs of the HPP in the country's

	country	the country	jurisdiction
Argentina	**26%**	**69%**	**14%**
Bolivia	**4%**	**0%**	**12%**
Brazil	**37%**	**0%**	**17%**
Paraguay	**33%**	**18%**	**57%**
Uruguay	**0%**	**13%**	**0%**
TOTAL	**100%**	**100%**	**100%**

10. **In terms of a country-by-country cost-benefit analysis (CBA), Argentina, Brazil and Uruguay show high rates of return, and Bolivia and Paraguay lower ones.** Argentina and Brazil show very high rates of return (in the range of 250 and 100 percent, respectively), because the costs they would bear are relatively small, and they make intensive use of the HPP (Argentina as origin and destination, Brazil only as origin). Uruguay bears no dredging costs in the river section under its jurisdiction; therefore, the country would receive benefits at no cost. Bolivia and Paraguay show much lower rates of return (-7 percent and 20 percent, respectively). In the case of Bolivia, benefits are moderate and initial dredging costs are high (not as much maintenance). In Paraguay savings are large (due to the intensive use of IWT), but initial and maintenance dredging costs are high as well.

11. **In addition**, **there will certainly be broader and indirect benefits due to the project, but these will prove to be relatively minor when compared to direct benefits.** At present, there is a dispute among those who analyze the HPP project's impact with respect to the "broader and indirect impacts," particularly the circumstances in which they are relevant, and whether they are duly captured using conventional cost-benefit analysis methods. Accessibility improvements interact with other determinants of economic growth, as do economies of scale and market sizes, particularly where the goods markets are fallible. The "broader and indirect impacts," which the cost-benefit analysis generally does not capture, result from market imperfections: economies of scale, imperfect competition and benefits stemming from increases in employment and productivity rates. The activity of soy and its by-products (soy pellets and meal resulting from vegetable oil production) would be able to increase due to waterway improvements. In the case of iron ore, new mining enterprises may develop in the area.

12. **The HPP also has a positive impact on the environment because it reduces GHG emissions. Even from a conservative standpoint, assuming no modal shift toward the HPP, it is clearly the most efficient mode of transport with respect to the other modes, and as a result has the least impact on climate change.** The HPP saves around 11.2 million tons of CO_2 emissions; with its improvement it would save around 11.9 million tons of CO_2. However, it is possible that some modal shift may occur to the HPP if it is improved; even if it small, this would mean that the HPP is potentially saving more than 11.9 million tons of CO_2.

5. **When GHG emission reductions are monetized at US$20 per ton of CO_2, the value saved by the existence of the HPP in the 10-year period analyzed is US$224 million.** The monetized value of the GHG emissions of the HPP, if it continues functioning as it does, is US$58.01 million for the 10-year period. If the HPP did not exist, the cost of GHG emissions would increase to US$282.23. If the HPP is improved as proposed, it would reduce GHG emissions to US$44.63 million.

6. **The HPP improvement may contribute between US$14 million and US$69 million in cost reductions due to GHG emissions over the 10-year period analyzed.** The monetary gains in improving the HPP are limited—US$14 million for the 10-year period analyzed—compared to an HPP that follows the present trend. It can also be stated that if the HPP is not improved, the deterioration of navigability conditions may make it stagnate, and in this case the additional the cost of CO_2 emissions during the period analyzed would be US$69 million.

Table C. Summary of GHG emissions

Scenario	Total emissions for 2010-2020 (tons of CO_2)	Cost of emissions for 2010-2020 ($US million)
No improvement present trend	**2,895,816.80**	**58.01**
No improvement and stagnation	**6,366,046.67**	**127.32**
HPP improved	**2,231,493.95**	**44.63**
No HPP	**14,111,559.32**	**282.23**

13. The project's environmental impact has been thoroughly studied; the conclusion is that the direct impacts of the proposed improvements to the HPP are well known and appropriate mitigation measures exist. However, indirect and cumulative impacts may pose a change in terms of impact identification and mitigation. All direct impacts are considered manageable and an Environmental Management Plan exists. The principal indirect impact is land use changes caused by the improved access; these may be the most difficult to handle. If land use changes follow the pattern of expanding frontier regions in Latin America, this may imply increases in deforestation, forest fires and habitat fragmentation. Thus, if not properly managed, these impacts may offset the potential gains of any GHG abatement by replacing road transport with IWT. To address the impacts of land use changes, it would be necessary to develop and strengthen an appropriate institutional framework. This would involve developing institutions in charge of planning and monitoring land use policy goals.

14. The proposed project to comprehensively improve the infrastructure of the HPP has an unusually favorable cost-benefit ratio for an infrastructure project. However, it is not currently being implemented. In recent years, the public sector in the five countries has made some major progress in regulatory matters, and the private sector has moved forward in fleet incorporation, improved operational efficiency, and development of modern port infrastructure, but the navigability of the waterway has yet to see significant progress**.** The public sector devised a common regulatory framework for the HPP, but it has only been partially ratified by all of the countries.

15. The causes of the inability to move forward with infrastructural improvements are not due to a lack of financial resources, but rather appear to lie in institutional deficiencies. The investment costs of the HPP improvements are relatively low; their scale in comparison to any other roadway or railway project is actually quite minor. The problems seem to lie clearly in the institutional framework. These difficulties appear in two areas: international coordination and the internal institutional weaknesses of each country.

16. Recent developments tend to show that integrated development of the HPP is increasingly inviable. This sets back the project's progress from an integrated framework and international negotiations, to partially supported solutions fostered by bilateral accords. In practice, Brazil did not adhere to the concept of a proposed supranational authority, and more than one country did not internalize the proposed universal regulatory framework. Since 2004–2005, due to the impossibility of collaborating on dredging and signaling, the countries have been attempting to resolve their differences bilaterally, with little progress. Traditional uses and customs persist throughout the waterway, perpetuating the notion that each waterway section's sovereignty is exclusively national or shared between only two countries. The CIH's virtual paralysis has made it evident that the international or regional nature of the waterway has remained minimal.

17. A fragmented approach is finally emerging for the dredging and signaling of the waterway. Each country is evaluating or implementing the necessary works in its sovereign sections of river, and in shared sections each is examining bilateral agreements to carry out the works. Although this strategy has produced minimal results over many years, it remains feasible. There are two important risks involved: (i) technical consistency may be lost (a minor risk since this particular case entails agreements with respect to design parameters including convoy type, canal depth and width requirements); and (ii) depending on how each country decides to charge tolls, if very high values are chosen they may negate the project's benefits.

18. Each country recognizes the project's importance. For some (Bolivia and Paraguay), it is vital for their economies, and each is advancing unilaterally in different ways, having completely abandoned the CIH and the multilateral approach. Argentina has included the dredging from Santa Fe to Confluencia as an extension to the pre-existing dredging and signaling contract (between Santa Fe and the Atlantic Ocean) in a process that, although still unfinished, shows some uncertainty. **Bolivia** has not resolved the limitations it has to access the Paraguay River through the Tamengo Channel, which is in Brazilian territory**.** The Tamengo Channel has been contentious due to its physical characteristics, in particular its width, which is decidedly less than that of the Paraná and Paraguay Rivers. Growth prospects of soy and iron ore output originating in Bolivian territory are very favorable; therefore, Bolivia is desperately seeking alternatives to improve its access to the HPP. **Uruguay,** under the HPP framework, maintains a dispute with Argentina, Paraguay and Brazil because its vessels are not allowed to navigate in the HPP without pilots from each country. Uruguay has developed the transshipment capacity of its ports and thus relies on the improvement of the HPP to attract more freight. Significant transfer infrastructure projects planned in the Nueva Palmira vicinity have been delayed, due in part to the global economic crisis as well as to administrative authorization delays. **Brazil** has implemented a sustained development policy for waterway navigation and cabotage at national level. With respect to the HPP, it has maintained a favorable position on its development in the past few years**.** While grain and oil exports from Brazil through the HPP are relatively limited, mineral exports have been extremely important but are currently experiencing uncertainties due to the global crisis. In addition to this uncertainty, there is substantial concern about the considerable decline of water levels in the northern section of the Paraguay River, the most significant decline in the past four decades. The potential environmental impacts of dredging in the Paraguay River and Tamengo Channel are sensitive issues in Brazilian public opinion. Nevertheless, some of the more radical standpoints have recently been rejected by the government, which now has taken up the defense of waterway navigation on environmental grounds, among others (e.g., GHG emission reductions). The Paraguay River section of the HPP, in Paraguayan territory, is considered to be the key to the regional waterway system and a crucial element to improving this landlocked country's accessibility to the waterway. Therefore, the declining water levels are a deep concern to **Paraguay**. The demand originating around Concepción is currently growing, and the Paraguayan section of the HPP tends to not only be for passing traffic, but is also beginning to be relevant for its own exports. Paraguay is studying the initiative of developing its own concession in its exclusive, sovereign segment. However, limited institutional and technical capacities may make this initiative difficult to implement.

19. An analysis of the evolution of institutional negotiations indicates that progress with a fragmented strategy is inevitable, country by country, since the regionally coordinated and integrated strategy has reached its apex of development and has not prospered. The regional coordination mechanisms are continually losing efficiency.

20. The private sector that takes part in the waterway navigation arena (freight owners, transport operators, terminals) has significant technical and financial capacity for contributing to the improvements, and strong incentives to execute them. But the private sector is unable to act without proper government authorization. These issues require the involvement of the public sector to authorize dredging and signaling works, or to permit waterway toll charges.

21. The project for improvement of the HPP infrastructure continues to present an enormous potential impact on the region. The waterway's principal benefits are to reduce logistical costs, promote competition and increase regional trade. Equally important, the project is definitely favorable to the environment. The short decline in water levels logged in 2009 consistently highlights the fact that the improvements are not only designed to foster navigation in the region, but to help maintain the waterway in cases of extraordinarily low water levels.

22. A Bank agenda to support this project can be structured around three sets of simultaneous yet interdependent activities: (i) institutional support to all five participating countries concerning waterway navigation; (ii) technical support to promote PPP projects for dredging and signaling works in Paraguay and Brazil to complete the improvements north of Confluencia; (iii) investments in supporting access infrastructure, particularly in Argentina, Paraguay and Bolivia. This agenda would be supported by the Bank together with other multilateral entities that are involved in the sector.

23. This report clearly shows the great impact the HPP can have on the reduction of GHG emissions and transport costs in the region, and a role for the Bank through a reasonable and viable strategy. The next steps would be to disseminate this proposal to stakeholders in the Bank. This study should be disseminated to interested parties in the Bank such as the Brazil, Bolivia, Argentina, Paraguay and Uruguay CMUs, the Transport Board, the Logistics Anchor, and the Logistics Beam in LAC. The purpose of the dissemination would be to refine the proposed strategy and prepare the next steps.

24. Likewise, additional work should be carried out to deepen the analysis of the HPP's impact. Because this study was a first step and only limited funds were available, an initial estimate of GHG reductions was made. However, many refinements could be added to the calculations that were made, in particular: (i) assumptions regarding modal shift; (ii) further analysis of vehicle and fuel efficiency; and (iii) further study of freight induction due to the existence of the HPP. This additional work should not limit the proposed dissemination, but simply be an addition that could enhance the study and could be carried out if it is agreed to pursue the proposed strategy.

25. The strategy presented should be discussed with the authorities in each country. Due to the findings of this report in which the importance of the HPP, its positive impact as well as its modest cost, have been established, it can be stated that this is definitely a worthy and important regional project in which the Bank could be involved. It has been shown that the main reason for the inability to get the project going has been its multilateral nature. The Bank should present these findings to all the countries and refine the proposed strategy with their participation. The proposed strategy should include the improvement of the analysis and result in an investment plan with the consensus of all countries and stakeholders involved.

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1.1. Background and context

1.1.1. The Paraguay-Paraná inland waterways network

1. In accordance with its current level of commercial activity, the Paraguay-Paraná Rivers waterway system (referred to in the text as the *Hidrovía, or HPP*) is one of the most significant watercourses in South America. Other relevant, commercially navigable waterways (shown in Figure 1) are the Magdalena and Orinoco Rivers in Northern South America, the Amazon and its linked Araguai-Tocantins Rivers in the widespread Amazon Basin, the São Francisco in Northeast Brazil, and the Paraná-Tietê in Southern Brazil. The latter is also part of the River Plate Basin. It is separated from the Paraná-Paraguay by the Itaipú Dam and has no connecting lock system. The largest inland waterway freight activity currently takes place in the Amazon Basin, where around 21 million tons of freight is moved per year. The Paraguay-Paraná Hidrovía follows with 14 million tons, the Araguaia-Tocantins with roughly 4 million, and the Magdalena and the Paraná-Tietê with 2 million each.[3]

2. The Hidrovía allows for more than 2,700 km of inland navigation within the South American continent and also supports maritime navigation (mid-sized bulk carriers) in the lower reaches of the system (the first 500 km). The two systems—inland and maritime navigation—are connected in the lower reaches of the Paraná River and a short section of the Uruguay River; these sections act as a maritime estuary. Commercial exchanges between both navigational systems are intensive and performed within numerous terminals. In addition to the main navigational axis (composed of the Paraguay River and the mid- and lower reaches of the Paraná River), there is another branch, the Upper Paraná. In this section a large dam has been constructed, with a lock system that allows for Inland Waterways Transportation (IWT). Inland navigation is also feasible in the upper reaches of the Paraguay River (upstream from Corumbá), although its water level is considerably lower and its use for transport has raised environmental concerns. Several small seafaring vessels are also able to reach Paraguayan ports. Figure 2 shows the main areas of activity in which most export-oriented traffic is generated. Most commercial exchanges take place in the lower sections, while the upper section experiences limited local traffic.

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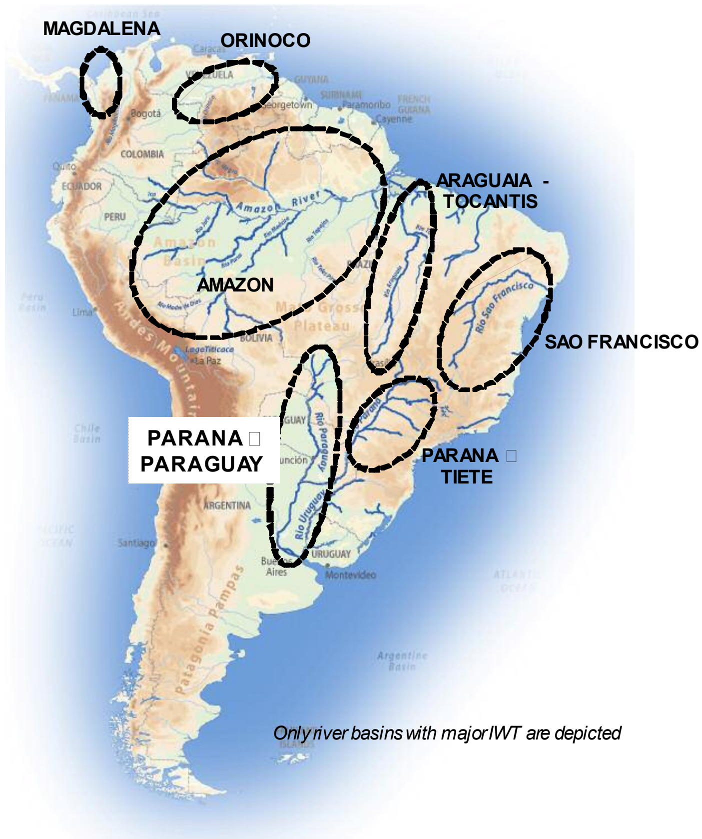
[3] Values are approximated; countries record flows with different criteria. The figures exclude oceanbound navigation entering into the rivers, and river-port loading activity using boats (as in Urabá, Colombia).

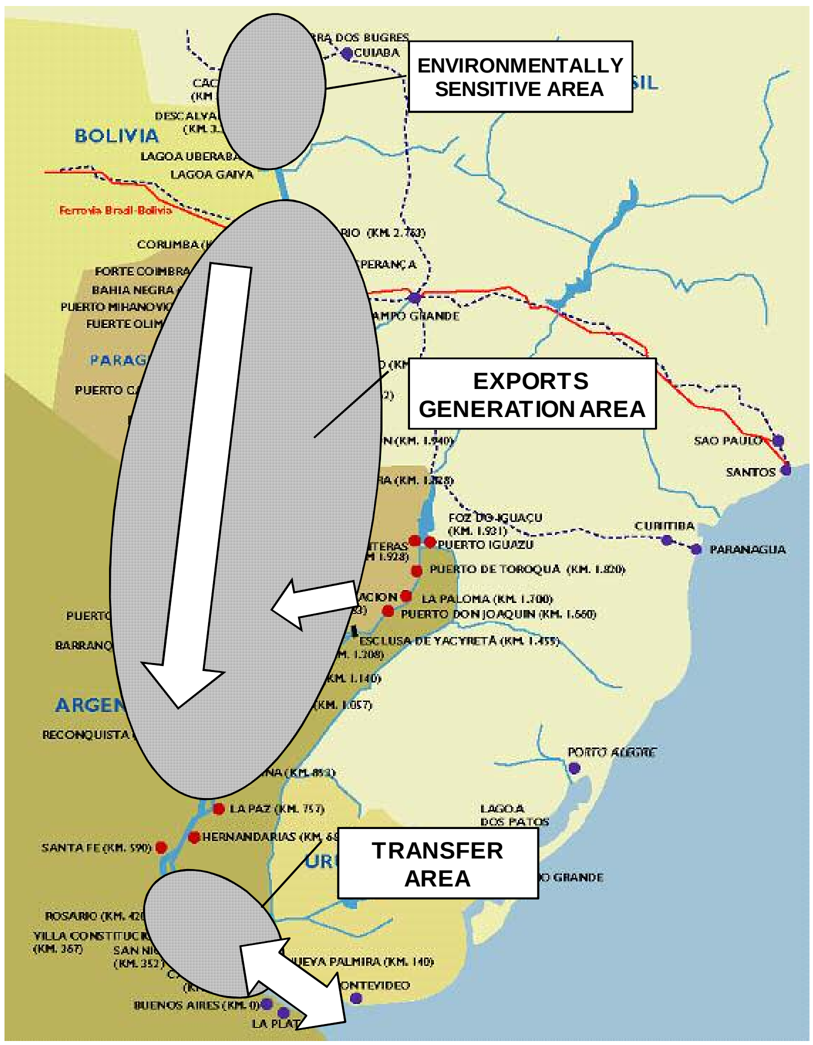
Figure 1. South America's main navigable basins



3. Five countries, two of which are landlocked, take part of the Paraguay-Paraná Hidrovía. According to their respective positions within the network, each country utilizes and benefits from the HPP in different ways. In the upper extreme, landlocked Bolivia exports bulk commodities through the waterway. Brazil uses the HPP as a north-south alternative route for ore (iron, manganese) and oilseed exports generated in the regions close to the Paraguay River. This may be more efficient than shipping them to Brazil's Atlantic ports by means of west-east surface transportation. The waterway serves as the central export and import conduit for landlocked Paraguay. Argentina uses the river for several purposes: (i) to move domestic dry bulk from the northern regions to the transfer area; (ii) to receive freight (soy, iron ore) from upstream countries for processing in its manufacturing plants; (iii) to transfer freight to oceangoing vessels; and (iv) to facilitate Paraguayan and Bolivian imports (fuel, wheat). Uruguay receives freight (dry bulk and containers) from upstream countries and transfers it to oceangoing vessels in its ports, and vice versa.

4. The fact that multiple countries share the waterway generates a great opportunity to increase regional and extra-regional trade, but also poses challenges that have proved difficult to solve thus far. The major benefits are the rise in commercial activity demands resulting from such an extensive waterway. The HPP allows for integrated operation, taking advantage of economies of scale. It also allows for the pooled cooperation of human resources, fleets and other production factors. But the existence of diverse national regulations generates significant asymmetries (i.e., labor rules, taxes, fleet habilitation rules, safety rules, etc.). In addition, the diverse degree of waterway use by each country is not proportional to the length of the sections that country will be required to maintain and eventually invest in improving. The disparity between the potential costs of IWT improvements (typically, dredging and signaling) in each country's river section and their respective potential benefits, hinders the overall effectiveness of the project's execution.

Figure 2. The Paraguay-Paraná Rivers Waterway



1.1.2. Historical background

7. The natural conditions of the Paraná and Paraguay Rivers have supported navigation for centuries, allowing countries within the basin to develop an efficient inland waterway transportation system. Motorized ships have been moving freight and passengers in the River Plate Basin's rivers since 1865, making use of its wide and extensive waterways. By the middle of the 20th century a tug and barge system was well developed, moving manganese from Corumbá (on the Brazilian banks of the Paraguay River) downstream and transferring it to oceanbound vessels at the Uruguay River port of Nueva Palmira. The strong emergence of road transportation in the region during the 1960s and a sequence of years with low water levels in the rivers pushed the countries to promote improvements in river basin management, in order to make navigation—in essence the transport of bulk commodities using barge convoys—more competitive than surface transportation.[4] The lower water levels did not allow for the efficient operation of large convoys, forcing their disassembly and restricting navigation to daylight hours.

8. Beginning in the 1960s and continuing predominantly in the late 1980s and early 1990s, the countries sharing the basin established an institutional framework for the common development of inland water transportation. The Plate Basin Treaty became an institutional pillar and was signed in 1969 by the five countries involved. The treaty was aimed at the joint execution of studies, programs and works to improve navigation, the rational use of water resources, the connection of other regional transport and energy networks, and the general promotion of regional development.[5] In 1987 the five countries collectively defined navigation and port development as a top priority, and in 1988, with the support of regional multilateral institutions (IDB, Fonplata), a series of studies were initiated. In 1989 a milestone was reached when the presidents of the five countries signed a more specific declaration, seeking the improvement of the waterway (making it navigable 24 hours per day), the development of ports, the enhancement of the fleet, and the harmonization of national navigation regulations.[6] Following this declaration, in 1989 the Ministers of Transport and Public Works created the Intergovernmental Waterway Committee (*Comité Intergubernamental de la Hidrovía*, CIH), which was aimed at the identification and prioritization of specific projects, and the development of a unified body of navigation regulations.

9. Several technical studies were conducted during this period in an attempt to outline the investment and regulatory projects needed to improve navigation. The initial studies, characterized by a comprehensive approach, began in the 1960s. After the Hidrovía Agreement was signed in 1989, the new lens of progress focused on defining and evaluating various waterway project alternatives: the works needed to improve navigation, demand forecasts, cost-benefit analysis, and environmental impact assessment. Later studies focused on the legal, institutional and financial mechanisms to implement the

[4] The minimum depth between Corumbá and Santa Fe was around 10 feet on average between 1940 and 1965; it was reduced to only 5½ feet between 1965 and 1975, and increased to 13½ feet between 1975 and 2000.
[5] *Tratado de la Cuenca del Plata*, signed in Brasília on April 23, 1969.
[6] *Declaración de La Paz*, August 6, 1989.

project as a Public-Private Partnership project (PPP), as well as to identify any related projects that would stimulate its regional economic impact. The abovementioned studies and their main findings are listed in Section 1.5, in which the Hidrovía Project is defined.

10. Despite the political will declared by institutional agreements and the profusion of technical studies, progress has yet to be made by governments with regard to the improvement of waterway infrastructure in the purely inland navigation section of the HPP (north of Santa Fe). The relatively high water level average since the 1980s has helped maintain navigable depths (of over 10 feet) in the middle and upper sections of the HPP. This leaves infrastructure constraints in approximately one dozen difficult passages (including bridges) that require convoy disassembly. Public investment in the purely inland navigation segment (north of Santa Fe) has been marginal, mostly centered on the maintenance of dredging passages, port accesses and the Tamengo Channel (which allows Bolivian ports to be connected to the HPP; see Box 1). A great improvement was made in 1998 in the Upper Paraná segment—technically outside of the HPP, but effectively part of the network—when Argentina and Paraguay constructed the Yacyretá Dam and its lock system for the movement of barge convoys. The private investment was mainly aimed ports (and plants contiguous to the ports), following the regional trend for increased participation of private capital in port development. In the lower section of the HPP (south of Santa Fe), the Government of Argentina implemented a public-private agreement in 1994, awarding the waterway under a concession. The private concessionaire[7] inherited the burden of increasing the waterway's depth and improving its signaling, in exchange for the right to charge a toll and to receive a subsidy for several years. Although the improvement south of Santa Fe was basically carried out to improve the conditions of maritime navigation, it helped foster inland navigation as well, due to its impact on the attractiveness of transfer ports.

11. Significant progress has been made toward adopting a common regulatory framework and the generation of unified technical specifications, safety and economic rules. However, not all countries have internalized these regulations. In 1992 the CIH generated a regional IWT agreement, which included various issues that govern navigation in an international waterway (customs, safety, insurance, equalization of taxes). Following this agreement, 11 sets of specific rules were approved by the CIH. These rules cover technical, safety and economic regulations, which were duly adopted by Bolivia, Brazil and Uruguay. Argentina and Paraguay adopted some of these rules and were reluctant about others, due to the pressure of waterway users. Three additional sets of rules regarding pilotage, ship security and staff training were later produced by the CIH.

12. Private operators improved operational efficiency, which helped drastically increase the Hidrovía's throughput volume in the last 15 years. This may be attributed to a combination of favorable water conditions, the development of large port hubs in the lower reaches of the basin and the impact of regional regulations. During this period, private inland navigation operators increased their fleet sizes, barge dimensions and tugboat power. Furthermore, new international firms

[7] The name of the private concessionaire is Hidrovía S.A., which often causes confusion between the entire HPP and the network comprising the lower 500 km of the Paraná River and some 300 km in the River Plate channels, awarded under a concession.

entered into the IWT business, bringing technological and operational innovations such as GPS to secure optimal river routes, IT (intelligent technology) -based control centers, and convoy collaborations. As a result, the tonnage carried by purely inland navigation in the HPP rose from 2.0 to 2.5 million tons per year between 1990 and 1995 to reach over 15 million tons per year in 2008 (this figure only reflects freight moved by barges and disregards the relatively marginal flows moved by self-propelled vessels).

1.1.3. The Hidrovía with regard to regional trade and transport

13. **Trade in the Southern Cone of South America is mostly aimed at nonregional partners; only 14.4 percent of Mercosur exports are aimed at countries within the trading block.** Four of the five countries that take part in the River Plate Basin are full members of Mercosur. Therefore, Mercosur trading patterns are a good indicator of general regional trade patterns. At present, Mercosur trade is largely directed toward markets outside the block; the larger the economy, the more pronounced the trend. Brazil, the leading Mercosur economy, directs only 11 percent of its exports to other Mercosur countries. Argentina, the second-largest Mercosur economy, directs 22 percent. Uruguay follows with 28 percent and Paraguay with 49 percent.[8] A similar pattern affects import origins.

14. **In this context, the Hidrovía plays a relevant role in the trade flows within the region, acting as factor for integration.** A large proportion of the freight flows on the HPP (described in detail in Section 1.2) are exports from one of the five countries to another: roughly 64 percent. Another relatively important proportion—around 27 percent—is transfers: cargo moved from a country of origin in the basin that, after being transferred in another country of the region, is headed to an overseas port. Finally, there is some cabotage in the HPP, with relatively smaller volumes (nearly 9 percent).

BOX 1. Bolivia's difficult access to the IWT

The boundary between Bolivia and Brazil is located west of the Paraguay River, meaning that both banks of the river belong to Brazil. (See Figure 3). In order to reach Bolivian territory, navigation should access Laguna Cáceres, a body of water west of the Paraguay River and connected by the Tamengo Channel. Therefore, the Tamengo Channel is key to connecting Puerto Suárez (located on Laguna Cáceres) with the waterway network. The dredging of this channel is critical to improve navigation, but may pose environmental problems because it may contribute to the drying-up of the Laguna. The water used in the Corumbá urban area is also pumped from the Tamengo Channel, adding another difficulty to navigation and further constraining the channel's dredging.

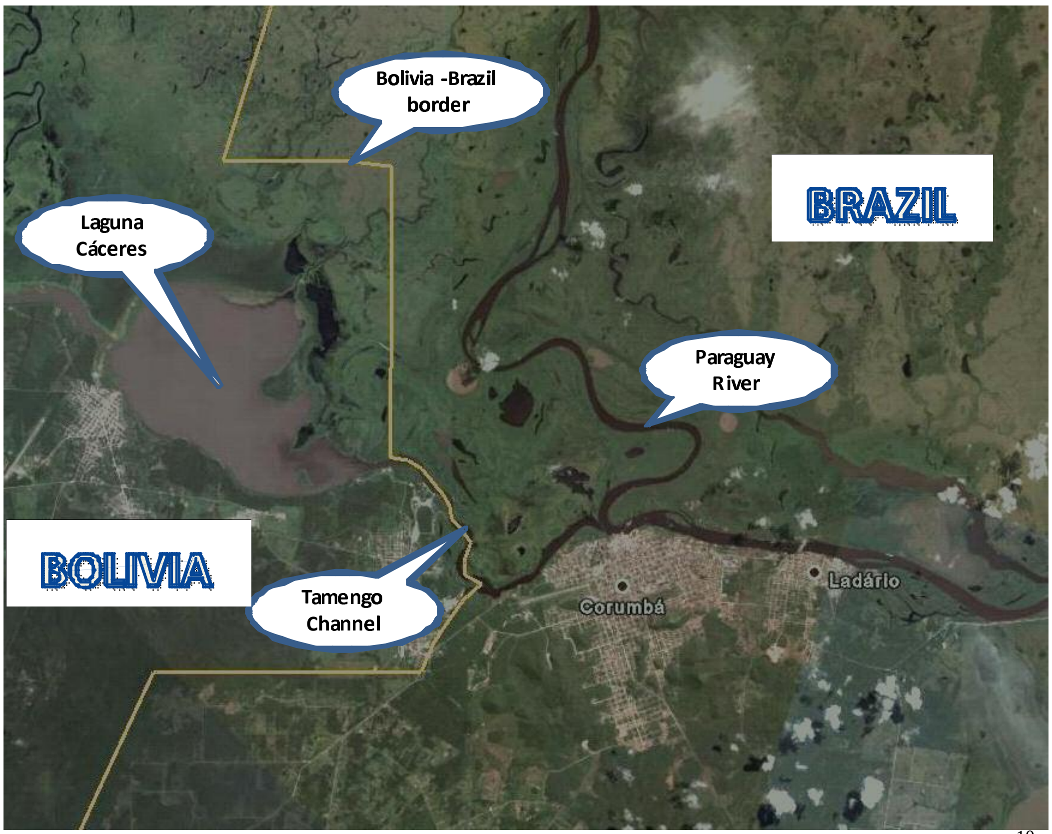
15. **For landlocked Bolivia, the Hidrovía is a major gateway to channel the exports of the eastern plains, mainly soybeans, vegetable oils and soy pellets/expellers, products for which the country can be very competitive, depending on trade logistics.** Agricultural products represent half of Bolivian exports in value and 88 percent in volume. Oilseeds produced in Bolivia's eastern provinces and close to the Paraguay River are exported in part as vegetable oil and by-products and in part as whole beans. These products are shipped on through the lower basin terminals or sent to Argentine processing plants. In terms of weight, they exceed 50 percent

[8] Source: WTO data for 2007.

of total agricultural exports originating in Bolivia. The HPP is important for Bolivia primarily as a route for this significant portion of its exports, which are highly transport-intensive. However, overall Bolivian access to the HPP has proved to be quite difficult (see Box 1).

Figure 3. Bolivia´s access to the Hidrovía

16. For Brazil, the region's largest economy, the Hidrovía is an alternative option for exports originating in the southwestern region that are normally shipped through the country's Atlantic ports. Ore (iron, manganese) and oilseed exports cultivated in the State of Mato Grosso do Sul may have more efficient means of reaching overseas markets through the use of the HPP instead of the country's Atlantic ports through west-east surface transportation. Although the freight generated in Brazil (mostly ore from the Corumbá fields) is relevant for the HPP, and may be more so in the future, the volume is still marginal within Brazil's aggregate trade. There is concern in Brazil over the existing modal freight shift, widely dominated by road haulage; as a result there are plans to increase the share of waterway,[9] railroad,



pipeline and maritime cabotage, but current plans do not include an improvement of the HPP.[10]

[9] Waterways currently carry 1 percent of total country tons-km.
[10] The World Bank has recently completed a report on freight logistics, and there is no project for the HPP in the list of priorities. World Bank, 2008: *How to Decrease Freight Logistics Costs in Brazil.*

17. The Hidrovía is the main physical trade link for Paraguay, the region's other landlocked country. Forty-seven percent of Paraguay's exports and 50 percent of its imports are transported by inland navigation. No other country in the region is so dependent on its waterways, which include the "official" Hidrovía and the Upper Paraná River as well. Paraguay is also a vital waterway service provider because a large portion of the fleet in the HPP is registered under the Paraguayan flag, providing jobs to the local labor force. The country faces many river navigation problems, which are partially related to the international nature of the waterway and partially to its own difficulties in surface transportation, port infrastructure and management, customs and other trade-related procedures, as detailed by recent World Bank and USAID studies.[11] The new government is seriously studying the deepening of the Paraguay River and improving signaling to allow for navigation 24 hours per day. This effort is being carried out with Bank support and in the form of analyzing the possibility of implementation through a Public-Private Participatory framework.[12]

18. Argentina's trade system uses the Hidrovía for several purposes: to move domestic dry bulk from the northern regions to the transfer area, to receive freight (soybean, iron ore) from the upstream countries for processing in its manufacturing plants, to transfer freight to oceangoing vessels, and to facilitate exports (fuel, containers) to Paraguay (fuel, containers). This freight includes an increasing flow of containers that connects national ports, Zárate, Rosario, San Nicolás and Buenos Aires. This activity also reaches Asunción and Montevideo. IWT flows are relevant to the Argentine economy, mostly due to upstream imports (soy from Paraguay and Bolivia, ore from Brazil), but also because of upstream exports (fuel, wheat). Cabotage movement feeding vegetable oil plants and maritime terminals (as an alternative to road and railway transportation) is still minor. Of grain cargo, only 1 percent received at the Rosario hub uses the waterway. The other 84 percent and 15 percent, most of which are imported from upstream, are transported by trucks and railways, respectively. The condition of the waterway in the lower section is crucial for the country, because 60 percent of its export volume is exchanged within the terminals around Rosario.[13]

19. Uruguay is becoming an increasingly vital shipping transfer center in the River Plate area with its two main port facilities: Montevideo and Nueva Palmira (the latter depending predominantly on the Hidrovía's influx of ore and grain). The Nueva Palmira terminals receive freight (dry bulk) from Bolivia, Paraguay and Brazil, and then transfer it to seafaring vessels. Nueva Palmira is the second-largest port complex after Montevideo, moving 40 percent of port system tonnage.[14] Montevideo's port increases the number of TEUs moved, from around 60,000 in 1990 to 750,000 in 2008, and the percentage of transshipment has grown to 50 percent, showing its significance for regional freight.

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[11] USAID, 2006 *Impacto del transporte y de la logística en el comercio internacional del Paraguay;* World Bank, 2008 *Paraguay, Transportes—Informe de Evaluación del Sector.*
[12] The World Bank 2010–Paraguay Fluvial Transport Study - PPIAF financing.
[13] The World Bank, 2006—*Argentina: The Challenge of Reducing Logistics Costs.*
[14] The World Bank, 2008 - *Uruguay: Infraestructura, Informe de Política de Desarrollo (DPR).*

1.2. A snapshot of the Paraguay-Paraná IWT

1.2.1. Waterways network, ports and intermodal links

20. The navigable rivers of the Plate Basin include (i) the Paraguay River, (ii) the Upper Paraná, (iii) the medium and lower sections of the Paraná, and (iv) the Lower Uruguay River. Figure 4 presents a schematic diagram. Not all of these internationally navigable waterways constitute what is legally defined as the *Hidrovía Paraguay-Paraná*, as detailed in Section 1.5.[15]

i. The Paraguay River's northern section, between Corumbá and Cáceres, allows navigation, but environmental reasons are restraining the circulation of large convoys (which are common south of Corumbá). At its southern extreme, the Paraguay River's waters flow into the Paraná at a junction named Confluencia.

ii. The Upper Paraná flows from its junction with the Paraguay in Confluencia up to the Itaipú Dam, which does not have a lock system. The Yacyretá Dam (which has a lock system) is located in the middle of the Upper Paraná; the dam lake has covered former rapids, which presented navigational difficulties prior to the dam's construction. The Paraná River also flows upstream to Itaipú, making the Paraná-Tietê waterway primarily Brazilian territory (as depicted in Figure 1).

iii. The Paraná River south of Confluencia has two different sections: the Middle Paraná, up to Santa Fe, committed mostly to inland navigation; and the Lower Paraná south of Santa Fe, used by inland navigation as well as seafaring vessels.

iv. The lower section of the Uruguay River is also navigable up to the Salto Grande Dam, where a complex of two locks and a channel linking them was originally designed but never completed. The lower reaches are deep enough to allow maritime vessels.

21. In simple terms, the waterway is composed of two main sections: the lower, located south of Santa Fe, which allows for annual depths of 34 feet at Rosario and 28 feet closer to Santa Fe, and the inland navigation section north of Santa Fe, which only allows for depths of up to 8 feet. The lower section has been deepened and is currently maintained by a private concessionaire that charges tolls to users according to the depth they require. Upstream, not only is the water depth lower, but the channel is narrower and the curvature radii shorter, making navigation more difficult for larger vessels and convoys. Together with several bridges along the waterway, the current river conditions constrain navigation and require the disassembly of tug and barge convoys.

Figure 4. Schematic representation of the waterway's depth (in feet)

[15] The Upper Paraná branch, although a key segment in the waterways network, is not "officially" included in the Hidrovía as defined by the five countries in 1989. The River Plate ports are also excluded because they act mostly as maritime terminals.

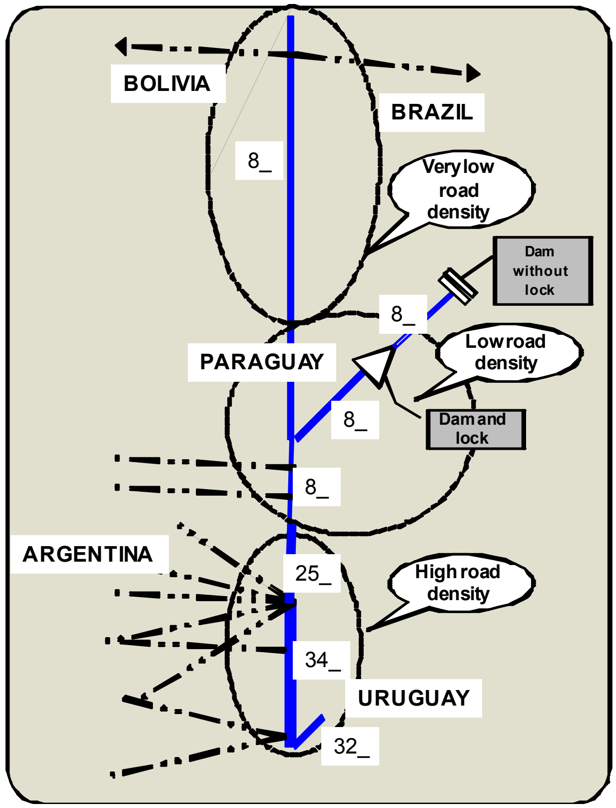

BOLIVIA
BRAZIL
8_
Very low road density
Dam without lock
8_
PARAGUAY
Low road density
8_
Dam and lock
8_
ARGENTINA
25_
High road density
34_
URUGUAY
32_

Figure 5. A typical soy transfer facility in the lower section of the Hidrovía

22. **Most ports along the waterways are private, belonging to specific shipping agencies.** There are some 200 port facilities at which barges and self-propelled vessels are loaded and unloaded. Many of them, particularly the loading terminals upstream, belong to a specific shipping company. Private ports also perform much of the unload-and-transfer activities within the lower section. The cluster of terminals around Rosario (22 facilities) is a major hub where grain and oilseeds are exported and often processed into vegetable oil and other by-products. IWT acts as a feeder for inbound flows to this hub, such as railway or road transportation. Large convoys and barges may also require special areas for assembly, disassembly and queuing. The increased activity and convoy sizes require a highly efficient organization in these areas, particularly in the lower reaches. The outbound leg is carried out by seafaring vessels and in certain cases transfers to these vessels are made by means of specialized platforms operating on the river.

23. **The waterway's inland connections are related to the density of regional economic activity, increasing from north to south.** The lower section of the waterway has a relatively dense endowment of roads and some major railway accesses linking the ports and vegetable oil-producing plants with a large hinterland (particularly around the city of Rosario, a major road and railway hub). The middle section of the Paraná River and the Upper Paraná, essentially northern Argentina plus southern Paraguay, has a sparse road network with few inland accesses and even fewer railway connections. The northern Paraguayan, Bolivian and Brazilian sections are very scarcely populated regions, with limited road connections and one transversal railroad.

1.2.2. The inland navigation fleet

24. Most inland navigation freight activity is carried out through barges and tows. Several self-propelled vessels are also used to move fuel, sand and containers. The size of the convoy determines the unit cost, because economies of scale are a fundamental element in the barge-tug system. The size and number of barges are restricted by the waterway's characteristics such as channel depths, widths and curvatures. Bridges create the need for convoy disassembly. Convoy size is also constrained by upstream river characteristics and by downstream maritime traffic.

25. The fleet—consisting mainly of push-tugs and barges, as well as various other watercrafts—is predominantly registered under the Paraguayan flag. Nearly 2,500 units are registered, of which 1,475 are barges[16] and 150 are tugs; of these, 41 are trunk tugboats (minor units used for convoy assembly and disassembly and other local activities). The remaining units are small, diverse types of riverboats, including some for passenger transportation. As Table 1 shows, 76 percent of the fleet's overall deadweight capacity is registered under the Paraguayan flag.[17] Ninety percent of the barges' deadweight consists of dry bulk, prepared for grain transportation. Trends show that barge sizes are increasing; most active barges currently weigh around 1,500 tons while older barges have a lower average, around 685 tons.

[16] It is worth noting that only 260 barges were registered in 1990.

[17] The fleet estimate is based on presentations made by the *Comisión Permanente de Transporte de la Cuenca del Plata* (CPTCP) and country data. Figures may differ according to varying sources, depending on the type of craft considered and the date, because many barges joined the fleet in 2008.

Figure 6. Typical size of convoys navigating the HPP

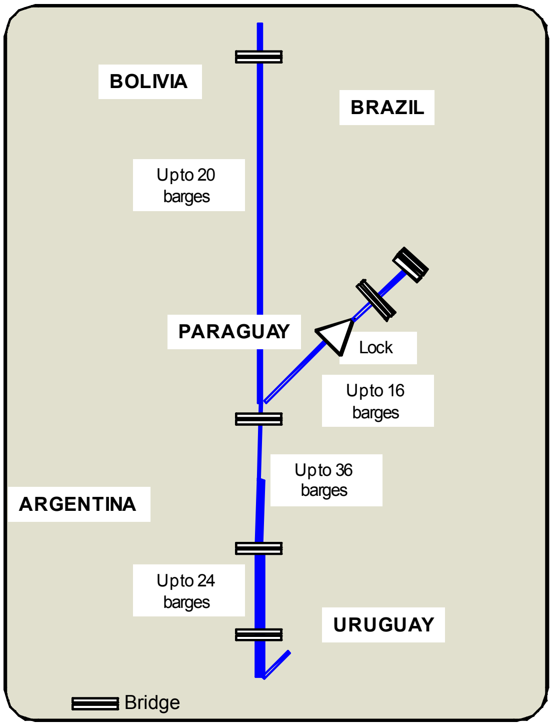


Figure 7. A large convoy navigating north of Santa Fe

Table 1. Hidrovía fleet, by national registry

Country	Number of vessels	Deadweight (thousand tons)
Argentina	344	138.1
Bolivia	106	69.1
Brazil	123	56.0
Panama	7	7.0
Uruguay	14	8.2
Paraguay	1869	894.8
TOTAL	**2463**	**1,173.2**

Table 2. Composition of barge fleet, by capacity (thousand tons)

Country	Dry bulk (grain)	Liquid bulk	Dry bulk (ore)	Total
Argentina	100.8	25.3	-	126.1
Bolivia	63.9	-	-	63.9
Brazil	33.5	-	4.7	38.2
Panama	6.9	-	-	6.9
Uruguay	8.2	-	-	8.2
Paraguay	687.8	78.4	-	766.2
TOTAL	**901.0**	**103.7**	**4.7**	**1,009.5**

1.2.3. Regulations, institutions and industry organization

26. Progress has been made in declaring a set of universal guidelines for international inland navigation, but not all countries have ratified them. Several regulations were agreed upon following the 1992 agreement (see Historical Background), focusing on the definition of regional rules that should override prior national ones. Examples of topics covered include: maximum convoy dimensions, signaling rules, technical safety inspections, hazardous cargo transportation protocol, criteria to determine vessel size, transportation contracts, pilotage, personnel training, and communications. Not all countries have signed all of the agreements: Brazil, Bolivia and Uruguay have adopted 12 rules generated by the CIH, Paraguay two, and Argentina none. Therefore, disagreement among diverse national rules still prevails in many cases. Each country has a unique institutional organization to deal with IWT. These institutions typically lack authority and undervalue IWT when compared with surface and maritime freight transportation.

27. With regard to the resolution of infrastructure constraints, the multilateral mechanisms established in 1992 were unable to acquiesce after 16 years. There has been some progress at the national level due to bilateral agreements but to not multilateral cooperation. Even after extensive meetings and studies, the infrastructure limitations hinder navigation efficiency and generate substantial extra costs (as detailed in Section 1.3).

28. A number of firms provide IWT services under the flags of two of the five countries. About a dozen firms are currently in operation; three of them hold a large portion of market share, as shown in

Table 3. Some firms have their own shipbuilding and repair facilities. Recently, large shipping clients such as mining companies have begun entering into the navigation business.

Table 3. Fleet concentration

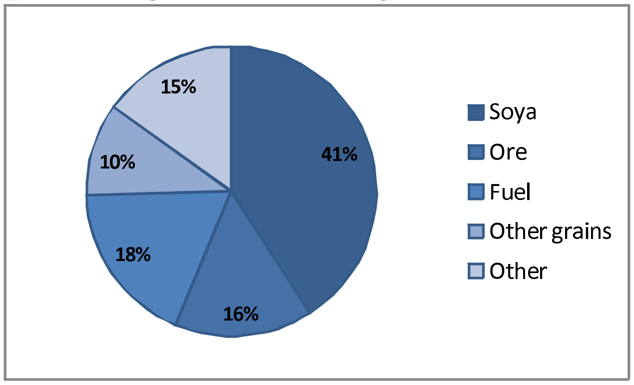
Firm	Dry bulk barges)	Liquid bulk barges	Tugs (#)	Tugs (power)
A	49%	30%	23%	21%
B	19%	28%	22%	14%
C	8%	22%	10%	9%
Others	24%	20%	45%	56%
TOTAL	**100%**	**100%**	**100%**	**100%**

1.2.4. Demand pattern and recent activity

29. There are basically two types of navigational activity in the HPP: that which is limited to river-inland navigation, and maritime freight that uses the HPP ports, mainly in the lower section. The former is comprised of origin and destination cargo within the HPP, much of which is then transferred to seafaring vessels. The information used to analyze IWT is usually limited to barge transactions in order to capture all purely river transportation. Self-propelled vessels, such as those moving fuel or extracting sand, should be also included. Inland shipping activity is mainly international: small domestic cargo traffic (origin and destination within the same country), which will be analyzed later in this section. Oceanbound freighters use the Lower Paraná and Uruguay River ports as terminals for maritime transportation. Over time, freight capacity has developed to a considerable extent, far surpassing the contribution of inland navigation. Roughly 80 million tons of oceangoing freight is moved through the Lower Paraná River terminals in Argentina alone, while the throughput of inland navigation (barges only) accounts for approximately 15 million tons.

30. Regarding purely river navigation activity, which is the main focus of this report, freight flow is concentrated on dry bulk cargo, creating a strong imbalance between dominant downstream flows and relatively scarce upstream flows. The barge-towing system is currently moving around 14.8 million tons per year (2007, estimated). It previously only reported moving one million tons in 1990. Dry bulk is the dominant cargo type, consisting of ore (iron, manganese), soybeans, other grains (maize, wheat) and fuel (crude oil and end-products). General cargo flows are still low in numbers, although the shipping of containers is growing, particularly in the lower section, linking ports such as Rosario, San Nicolás or Campana with Montevideo and Buenos Aires (strictly speaking, outside the waterway). The overall activity presents a significant imbalance; most dry bulk is dispatched downstream (with some exceptions) and fuel flows are upstream. In summary, roughly three-quarters of the tonnage is transported downstream. Container traffic shows a better balance: the principal container traffic is between Asunción and Buenos Aires; and there is a significant, albeit smaller, flow of containers between Asunción and Montevideo; between Zárate and Buenos Aires, Montevideo; and between Buenos Aires and Montevideo. There are minor movements between Rosario and Buenos Aires-Montevideo.

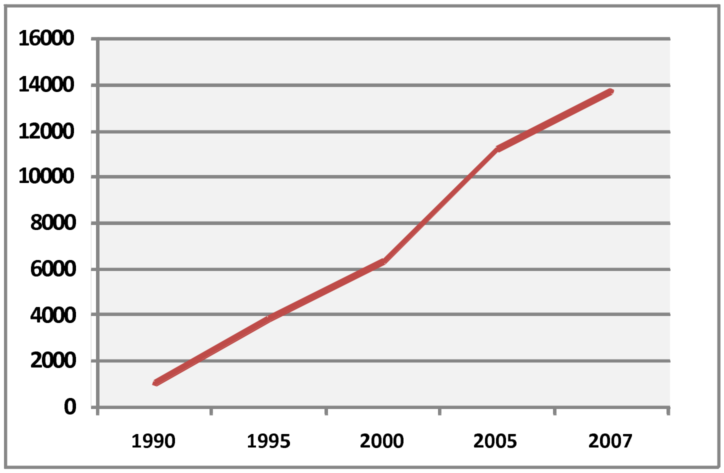
Figure 8. Types of freight with both origin and destination in Hidrovía ports



31. The level of activity has been growing consistently over the past 15 years. For inland barge navigation (for which information is recorded),[18] growth has been very intensive, particularly after 2000. It includes the "official" Paraguay-Paraná Hidrovía and the Upper Paraná section (up to Itaipú).

[18] Private operators and the *Comisión Permanente de Transporte de la Cuenca del Plata* produced statistics.

Figure 9. Evolution of IWT tonnage (thousand tons)



32. Total freight movements can be explained by a relatively small combination of origin, destination and cargo types: for 2007, 24 shipments accounted for 88 percent of total yearly flow. Table 4 depicts the most relevant shipments, sorted from larger to smaller. Table 5 consolidates this information, showing the IWT origin and destination by country. The 2007 data confirm the role of each country suggested in Section 1.1.3 and also allow the following conclusions to be drawn on the traffic pattern:

- Growth has been impressive over the last five years, averaging a cumulative yearly rate of 13.4 percent;
- Brazil only generates freight and Uruguay only receives freight; the other three countries send and receive cargo by IWT;
- Paraguay uses the HPP for its exports (35 percent of the activity is mostly oilseeds), its imports (23 percent: fuel, wheat, ore), and also some cabotage (3 percent: clinker);
- Argentina attracts foreign freight for processing or transshipment (59 percent of total activity), generating exports to Paraguay and Bolivia (18 percent: wheat, fuels), and some cabotage (6 percent: grain);
- Bolivia generates exports (6 percent: oilseeds and vegetable oils, transferred in Argentine and Uruguayan ports) and imports (1 percent: fuel, wheat from Argentina);
- Brazil solely originates freight, mostly ore shipped to Argentina's steel plants;
- Uruguay acts exclusively as a transshipment point, receiving grain and oilseeds (mostly from Paraguay).

Table 4. Main freight flows in the Hidrovía

Product	Port/Area of Origin	Country	Port/Area of Destination	Country	Flow 2007 (000 tons)	Rate Growth 2002–2007
Downstream Flows (from North to South)						
Ore (Fe, Mn)	P. G. Curvo	BRA	San Nicolás	ARG	3,923	25.8%
Grain, oilseeds, by-products	Ciudad del Este	PAR	Nueva Palmira	URU	1,366	20.6%
Fuel	Buenos Aires	ARG	Villa Elisa	PAR	1,360	9.4%
Grain, oilseeds, by-products	Ciudad del Este	PAR	Rosario/S.M.	ARG	1,136	21.8%
Grain, oilseeds, by-products	Reconquista	ARG	Rosario/S.M.	ARG	693	0.0%
Grain, oilseeds, by-products	Encarnación	PAR	Rosario/S.M.	ARG	459	21.8%
Clinker	Vallemi	PAR	Villa Hayes	PAR	400	0.0%
Grain, oilseeds, by-products	Encarnación	PAR	Nueva Palmira	URU	397	20.6%
Grain, oilseeds, by-products	Pto. Quijarro	BOL	Rosario/S.M.	ARG	300	-5.7%
Grain, oilseeds, by-products	Pto. Quijarro	BOL	Nueva Palmira	URU	249	49.1%
Grain, oilseeds, by-products	Asunción	PAR	Rosario/S.M.	ARG	220	21.8%
Ore (Fe, Mn)	Corumbá	BRA	Villa Hayes	PAR	212	4.2%
Vegetable oil	Pto. Quijarro	BOL	Rosario/S.M.	ARG	187	5.4%
Vegetable oil	Ciudad del Este	PAR	Rosario/S.M.	ARG	127	5.4%
Grain, oilseeds, by-products	Asunción	PAR	Nueva Palmira	URU	67	20.6%
Ore (Fe, Mn)	P. G. Curvo	BRA	Nueva Palmira	URU	65	-5.1%
Vegetable oil	Asunción	PAR	Rosario/S.M.	ARG	55	5.4%
Grain, oilseeds, by-products	Corumbá/Ladário	BRA	Nueva Palmira	URU	27	-38.8%
Upstream flows (from South to North)						
Wheat	Diamante	ARG	Asunción	PAR	44	0.0%
Fuel	Buenos Aires	ARG	Pto. Suárez	BOL	39	9.4%
Wheat	Rosario	ARG	Pto. Suárez	BOL	29	0.0%
Fuel	Buenos Aires	ARG	Encarnación	PAR	293	9.4%
Fuel	Rosario	ARG	Villa Elisa	PAR	219	9.4%
Crude oil	Formosa	ARG	Villa Elisa	PAR	206	9.4%
TOTAL					**12,071**	**13.4%**

Table 5. Paraguay-Paraná IWT origin-destination by country

From/To	Argentina	Bolivia	Brazil	Paraguay	Uruguay	TOTAL
Argentina	693	67	-	2122	-	**2882**
Bolivia	487	-	-	-	249	**736**
Brazil	3923	-	-	212	92	**4227**
Paraguay	1997	-	-	400	1829	**4226**
Uruguay	-	-	-	-	-	**-**
TOTAL	**7100**	**67**	**-**	**2734**	**2170**	**12071**

1.2.5. Trends and perspectives

33. **Recent developments (as of 2008) have been characterized by a strong growth trend in transport demand, fleet increases and improvements in operational efficiency.** Activity grew substantially and, before the onset of the 2008 financial crisis, the expectations for the future were very optimistic. This was also attributed to the prospect of large iron projects in the Corumbá area and a positive forecast for oilseed markets. Fleets were also growing in efforts to keep up with the increased demand; ship owners were ordering new barges and tugs. The typical dry-bulk barge size tended to increase from 1,500 tons to 2,500 tons, allowing for higher capacity in shallow waters. In some cases, ship owners have reported entering into the shipbuilding business. Operational efficiency was strongly improved by running larger convoys, using larger barges and more powerful tugs (some with up to 7,000 HP), navigating 24 hours per day with the support of carrier control centers, and improving the loading-unloading practices at port and transfer points. Existing tugboats have been enhanced by converting them to IFO (intermediate fuel oil), a mix of diesel oil and heavy fuel oil, in order to avoid fuel theft.

34. **However, many problems still persist in the waterway's physical condition, in logistics, in transport facilitation and security performance, and in the coordination of investment plans. Users (shippers and carriers) are increasingly concerned because in spite of the international institutions and agreements, no further progress is expected.** The main constraints users face are:

i. *The waterway's conditions:* shallow water, curvatures and bridges, mostly in the upper section; the main constraints to large convoys are signaling flaws and lack of maneuvering areas;

ii. *Logistics and operations:* lack of workforce with the skills for new technology, insufficient port capacity, pressure from growing market demands, navigational control difficulties, congestion from increased traffic;

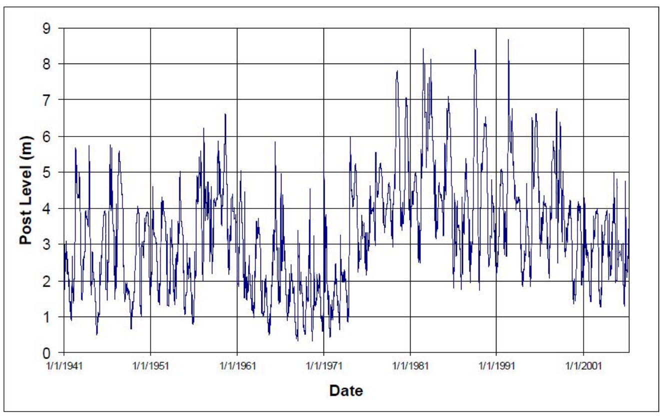
iii. *Transport facilitation and security conditions*: lack of adequate transfer facilities between rail and barges, excessive administrative requirements (even for cabotage), high theft rates (for cargo and fuel);

iv. *Investment plan coordination*: asymmetry in cost and benefits precludes actions (i.e., dredging or signaling) by individual countries; the generation of an international authority (able to charge users) is legally complex.

35. The 2008 financial crisis's impact on the HPP's activity has been severe, as other carriers linked to global trade have also experienced. The reduction in commodity prices such as those for ore and grain has decreased demand, adding to the negative impact of the severe drought that affected a large portion of the Hidrovía's hinterlands during 2008–2009. The Argentine Government's ban on soy imports (from Bolivia, Paraguay and Brazil) to feed vegetable oil plants in the Rosario area and problematic mining production in the Corumbá area have also negatively impacted the waterway's activity. The expected flow of activity in 2009 is around 12 million tons, down from nearly 15 million tons in 2008. As has occurred in ore and grain logistics, freight has been stored on barges, reducing their cycle and the efficiency of their fleet capacity.

36. The variation in water levels contributed adversely. Figure 10 illustrates the relatively high water levels from the mid-1970s to 2000. In 2009, due to the acute regional drought, water levels reached significant lows, reducing barge loads, requiring increased convoy fragmentation, and in some cases denying tugs navigation access. In the northern extreme of Ladário (in the Corumbá area), the water level is the lowest it has been in the last 10 years, allowing only 70 percent of normal barge capacity.

Figure 10. Water level at Concepción (Paraguay) between 1941 and 2006



Source: Rio Tinto "A visão empresarial da operação da Hidrovía Paraguai – Paraná". Second International Waterways Seminar, Brasília, 2007

1.3. The Hidrovía Project

1.3.1. Studies preceding the Hidrovía Agreement

37. Many studies on inland waterway transportation in the Paraguay and Paraná Rivers were conducted before the 1987 international agreement. Most were supported by regional multilateral organizations, such as the OAS, IADB, UNDP, IBRD and ECLAC. Table 8 summarizes the 23 studies performed between 1962 and 1985. The following paragraphs describe the key findings of the most relevant studies.

38. ***Mejoramiento de la Navegación del Río Paraná*, by FUTURA Consultores Asociados, financed by UNDP, 1971.** This study highlighted the increasing volume of agricultural products and the potential demand for IWT, whose competitiveness was eroded by high operational costs, port inefficiency and irregular services. Regional human resources were perceived as a modal strength. The implementation of transportation practices such as Ro-Ro or LASH barges (popular in discussions at that time) was discouraged. Flaws in trade facilitation were detected (duplication of information requirements). Local shipbuilding facilities were considered able to provide barge and tug needs.

39. ***Transporte Fluvial del Río Paraná*, by L. Rocholl and A. Koutoudjian, 1986, requested by the Argentine-Paraguayan Paraná River Committee, aimed at the stimulation of IWT in the Upper Paraná.** This study analyzed the waterway's constraints (prior to the construction of the Yacyretá Dam) and made various specific recommendations such as the dredging of several port accesses, the training of pilots, and the promotion of self-propelled vessels for some traffic. The study covered demand patterns, traffic seasonality and the strong downstream-upstream imbalance. It also stressed the need for the reform of the legal framework and union regulations regarding transshipments.

Table 6. Studies carried out between 1960 and 1987

Author/sponsor	Title	Location	Year
MOSP	Transportes Argentinos, Plan de Largo Alcance	Buenos Aires	1962
OAS	Estudio para la Planificación y Desarrollo de la Cuenca del Plata	Washington, DC	1969
OAS	Cuenca del Plata	Washington, DC	1971
UNDP	Mejoramiento de la Navegación en el Río Paraná	Buenos Aires	1971
IECO y ELC	Estudio del Río Paraná	n/d	1972
UNDP	Navegabilidad del Río Paraguay al Sur de Asunción	Asunción	1973
MRE, IDB, INTAL	El sistema institucional de la Cuenca del Plata	Buenos Aires	1973
A. Koutoudjián	Usos múltiples del agua: El transporte por agua	Buenos Aires5	1974
Lahmeyer, Harza y Asoc.	Aprovechamiento del Río Paraná	Buenos Aires	1975
IDB/INTAL	Inventario de proyectos de integración la Cuenca del Plata	Buenos Aires	1979
UNDP/IBRD	Estudio de las terminales portuarias del Río Paraná	Buenos Aires	1979
EBY	Estudio de las crecidas en los Ríos Paraná y Paraguay	Buenos Aires	1979
FANU	Desarrollo de la flota fluvial	Buenos Aires	1980
ECLAC	Transporte Fluvial en la Cuenca del Plata	Santiago	1981
IDB/INTAL	La Eficiencia del Transporte Fluvial en la Cuenca del Plata	Buenos Aires	1981
Ministério dos Transportes	Sistema de Transportes Brasileños y su Articulación con los países del Cono Sur	Asunción	1982
CONARSUD	Estudio del Flujo del Corredor São Paulo-Buenos Aires	Buenos Aires	1982
ECLAC	Aspectos Institucionales del Transporte en la Cuenca del Plata	Santiago	1982
José Barbero	Forecasting Barge Flows in the Plate Basin	Toronto	1982
A&E	Proyecto Paraná Medio, Transporte y Navegación Fluvial	Buenos Aires	1983
Luis Flory	Mejoramiento de la Vía Fluvial del Paraná	Buenos Aires	1983
CONSULTARA SA	Proyecto Puerto Escóbar	Buenos Aires	1983
OAS	El Transporte en la Cuenca del Plata	Washington DC	1985

1.3.2. Recent studies and the emergence of the current project

40. The political headway made in the late 1980s triggered a new set of studies aimed at the definition and evaluation of a regional waterway project. After several regional meetings between 1987 and 1989, the five countries of the River Plate Basin agreed to conduct specific studies in order to improve navigation between Puerto Cáceres and Nueva Palmira. In 1989, the Governments of Brazil and Argentina requested comprehensive studies on the recently defined Hidrovía, in order to identify the works needed to improve navigation and to perform a cost-benefit analysis of the waterway. These were the first studies focused on the Hidrovía as a regional project. Following these two studies (conducted by the firms Internave and CONARSUD, respectively), others were performed with the participation of all the countries, as detailed in Table 9. The two 1989 studies and the final two (supported by the CIH and by IIRSA) are examined in the following paragraphs.

Table 7. Studies carried out after 1987

Author/sponsor	Title	Location	Year
Internave Engenharia		Brasília	1989
CONARDSUD	Estudio de prefactibilidad técnico-económico para el mejoramiento de la vía fluvial de navegación Paraná–Paraguay	Buenos Aires	1989
Hidroservice – Louis Berger – EIH – IADB-financed	Estudio de factibilidad técnica y económica del mejoramiento de las condiciones de navegación de la Hidrovía		
Taylor – Golder – Consular – Connal IADB-financed	Evaluación del impacto ambiental del mejoramiento de la Hidrovía		
EU-financed	Necesidades de los puertos de la Hidrovía		
FONPLATA	Desarrollo de las zonas productivas en las áreas de influencia portuarias para 5 puertos de la Hidrovía		
ALADI – INTAL	Sistema de información de la Hidrovía		
Consorcio COINHI	Estudio Institucional-Legal, de Ingeniería, Ambiental y Económico Complementario para el Desarrollo de las Obras en la Hidrovía Paraguay-Paraná entre Puerto Quijarro (Canal Tamengo), Corumbá y Santa Fe		2004–2005
Koutoudjian – IIRSA, Fonplata, INTAL	Estudio Visión de Negocios de la HPP		2006

41. The first economic analysis of the Hidrovía project, conducted by Internave, showed a positive net return for the project of 17.9 percent for the spontaneous integration scenario, and 26.2 percent for the intentional integration scenario. The spontaneous integration scenario is the more conservative and assumes that growth in shipping will occur naturally, while the intentional integration scenario assumes that growth will be stimulated by the formation of a common market of countries of the River Plate Basin. It is limited to a simple benefit analysis resulting from savings in transportation costs and in costs involving construction, maintenance and equipment. The CONARSUD study looked at the investment needs in order to operate 240 m x 34 m convoys , requiring a 10-foot depth and 24-hour navigation, and identifying the diverse obstacles to efficient navigation (particularly ports).

42. The COINHI study is the most recent comprehensive analysis of the Hidrovía project. It was aimed at: (i) the updating and completion of technical, environmental, economic and financial analyses, re-estimating the scale of needed works and costs, and exploring the potential for total or partial financing by user contributions; and (ii) the proposal of legal and institutional approaches to contract out the works, including bidding documents. The study contained market forecasts and a complete cost-benefit analysis considering several project alternatives. The main conclusions were:

- From the institutional-legal perspective, an international RFP (request for proposal) for dredging and maintenance-operation was announced. Other alternatives were also considered: contracting out the dredging and maintenance as public works, and public construction combined with maintenance and operation concessions. Various governance alternatives were proposed for the international waterway; the most relevant difference among them was whether they should be approved by the congress or the executive branch of each country’s government.

- The technical section proposed several alternatives, settling on one that allowed 24-hour navigation with an 8-foot depth from Puerto Quijarro (Bolivia) to Santa Fe and with a 110-meter-wide channel (60 meters in the Tamengo Channel). The waterway should permit 310 m x 60 m convoys between Santa Fe and Asunción (20 barges plus the tugboat) and 290 m x 50 m convoys between Asunción and Corumbá (16 barges plus the tugboat); the Tamengo Channel should allow for navigation by four barge convoys.
- The construction (dredging and signaling) cost of the proposed alternative is US$27.7 million, plus US$10.6 million per year for maintenance. Financial and economic results vary according to the length of the concession. With a 20-year concession, the IRRs estimated were 15.5 percent and 19.2 percent, respectively; with a 10-year concession, they were 29.8 percent and 25.3 percent, respectively. In both cases a relatively small subsidy is considered (US$2.8 million). The toll was set at US$500 per barge (loaded or unloaded) in each of the three major river sections (Santa Fe to Asunción, Asunción to the Apa River, and the Apa River to Corumbá or the Tamengo Channel).[19]
- The environmental section provides recommendations to minimize environmental impacts and rejects major impacts.

43. The IIRSA study was aimed at providing a strategic view for the development of the Hidrovía as a regional integration corridor, identifying complementary projects that would disseminate its impact on regional growth. The study included the most up-to-date market analysis, which forecasts some 27.5 million tons of IWT for 2010 and 38.2 million tons for 2020. The regional analysis highlighted the economic potential of the Hidrovía's hinterland and the expected congestion in the surface transportation networks, as well as the positive impact of the deepening of the lower reaches of the Paraná River on IWT (proposing 32 feet south of Santa Fe and 36 feet south of Rosario). It also encouraged public investment in related transport projects, such as bridges, ports, logistics complexes and intermodal terminals, and promoted integrated international statistics and environmental monitoring systems.

[19] This toll level is equivalent to US$2.25 per GRT for international flags and $AR 2.25 per GRT for vessels under Argentine flag (mostly domestic).

1.3.3. The current official Hidrovía project

44. Studies conducted by the CIH have provided a concrete, consistent definition of the HPP while also defining the various implementation options. Topographic, bathymetric and hydrological studies were performed to adequately plan proposed improvements, considering myriad options and implementation alternatives. Each option was defined according to parameters of draft (in reference periods and levels with occurrence probabilities) and width, involving barge convoy configurations between the passages north and south of the Apa River. Considering the various options, the CIH adopted barges measuring 60 m in length and 12 m in width, with a maximum draft of 3 m. Push-tug dimensions should be 50 m in length and 12 m in width, and the draft required for navigation would be 8 to 10 feet, which would vary depending on the given option. The convoys should have a length of 290 m and a width of 50 m when navigating between Corumbá and the Apa River, with an increased length of 10 percent and width of 20 percent when navigating between the Apa River and Santa Fe.[20] The alternative ultimately adopted, named A-8, allowed for a draft of 8 feet from Corumbá to the Apa River and 10 feet from the Apa River to Santa Fe.

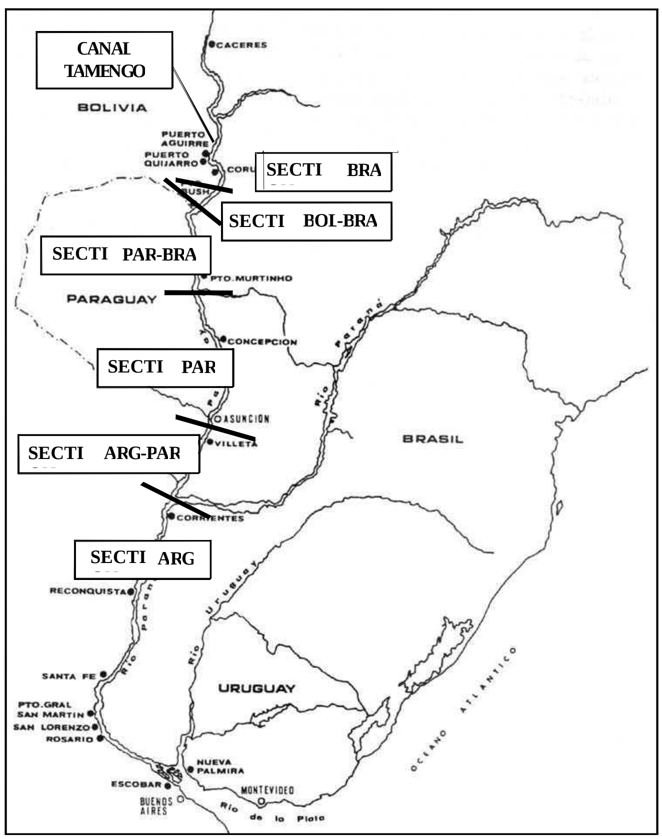
45. The Hidrovía project includes 90 different improvement operations between Santa Fe and the Tamengo Channel. Considering the costs of dredging and signaling maintenance, investment costs (without taxes), depending on which option is chosen, have a median cost of US$57 million, with the lowest possible cost option at US$35 million. The initial dredging is estimated to produce between 11.5 and 12.1 million cubic meters of waste, depending on final canal width. The maintenance dredging will produce between 6.4 and 6.9 million cubic meters annually. The cost of dredging soft ground makes up roughly 75 percent of the total initial dredging costs while the dismantling and extraction of hard mineral materials represent the remaining 25 percent of costs. Annual maintenance costs are equivalent to one-third of the total initial dredging costs. Table 8 shows the relative initial dredging and annual maintenance cost distribution, categorized by waterway sections north of Santa Fe. These figures are outlined according to their respective river-bordering countries, illustrated in Figure 11.

[20] A four-barge-convoy was assumed for the Tamengo Channel.

Table 8. Distribution of dredging costs by river section

	Initial dredging	Maintenance dredging
Argentine section *(km 580 to km 1200)*	5%	10%
Argentine-Paraguayan section *(km 1200 to km 1625)*	8%	16%
Paraguayan section *(km 1625 to km 2165)*	43%	41%
Brazilian-Paraguayan section *(km 2165 to km 2500)*	0%	1%
Brazilian-Bolivian section *(km 2500 to km 2600)*	17%	21%
Brazilian section *(km 2600 +)*	5%	9%
Tamengo Channel	21%	3%

Figure 11. Section division of the HPP north of Santa Fe



46. **Argentina recently added the dredging of the section between Santa Fe and Confluencia to an existing dredging contract originally devised for the area between Santa Fe and the Atlantic Ocean.** This indicates that a portion of the project (5 percent of the initial dredging and 10 percent maintenance) was embarked upon unilaterally. The potential toll for traversing this section of the waterway has yet to be established. This recently contracted agreement opens up the possibility of adding the section between Confluencia and Asunción in the same manner. This addition would have to be agreed on by both countries of jurisdiction, Argentina and Paraguay, because a possible toll could be instituted there as well.

1.3.4. The Hidrovía within IIRSA

47. The Paraguay-Paraná Hidrovía project is part of IIRSA (Iniciativa de Integración Regional de Sudamérica)[21] and is one of the 10 central tenets of regional integration, specifically at a continental level. In 2007, IIRSA outlined 285 integration projects: 158 of these projects were categorized as foundational projects, 84 percent of which come from the transport sector (31 percent roadways, 29 percent ports/harbors, 18 percent railroads and 6 percent waterways). The projects connected to the HPP are grouped by developmental themes including port, terrestrial and railroad projects (see Table 9).

48. The Paraguay-Paraná Hidrovía is part of the regional integration axis that will allow landlocked Bolivia and Paraguay to take part in commercial activities with neighboring countries and the rest of the world by accessing ports throughout the basin. The prospects for expansion in this context would allow Bolivia and Paraguay to harness the potential of grain production areas (particularly soy), the development of new mining activities, general freight trade and bulk-liquid transport.

Table 9. Project Portfolio of the HPP Development Axis[22]

Project	Country	Type	Value (US$ mill)
Motacucito – Mutún – Puerto Bush rail-port project	BO	Rail	138
Mutún – Puerto Bush artificial canal	BO	Fluvial	136
Puerto Suárez – Mutún road paving	BO	Road	19
Dredging of Tamengo wáter system	BO-BR	Fluvial	s/d
Infraestructure development of the Bolivian Free Zone of Zarate	BO-AR	Port	s/d
Water level forecasting system for navigation in the Paraguay River (upstream from the Apa River)	BR	Fluvial	s/d
Improvement of navigability between the Apa River and Corumbá	PY-BR	Fluvial	s/d
Paraguay river communication system (upstream from Asunción)	PY	Communication	s/d
Improvement of navigability between the Apa River and Asuncion	PY	Fluvial	s/d
Paving of the road section between San Estanislao and Puerto Rosario	PY	Road	s/d
Paving of the road section between Santa Rosa and	PY	Road	s/d

[21] Source: http://www.iirsa.org

[22] Source: Results from XIII Meeting of National Coordinators, held in Bogotá, Colombia.

Puerto Antequera (Ruta 11)			
Paving of the road section between Concepción and Vallemi	PY	Road	s/d

1.4. Comparative analysis with other waterways of the world

49. Inland waterway potential in South America appears to be largely untapped. When compared with the United States and Europe, IWT is fairly undeveloped in South America. Figures regarding IWT use in the United States and Europe are presented in Annex 2. This section describes some aspects of waterways' institutional settings in Europe and the US, to serve as a comparison for assessing the HPP's potential and challenges.

50. The development of waterway transport has been different in the US and Europe. A significant difference lies in the complexity of the European model given its transnational nature, possibly more relevant to the HPP. In both cases the development of institutions governing IWT has taken a significant length of time (i.e., centuries), and challenges to accommodate different interests (e.g., environmental conservation) still exist. In the case of the United States, IWT development began as part of a war effort and was led by the US Army Corps of Engineers, allowing for centralized planning and execution. In Europe, IWT development took place in each country at different paces. Europe has functioned over the years with different regulatory and institutional frameworks in each country, but is now moving with European Union (EU) common legislation to unify the regulatory framework under EU guidelines.

51. As mentioned elsewhere in this report, recent developments tend to show that integrated development for the HPP is increasingly inviable; this sets back the project's progress from an integrated framework and international negotiations to partially supported solutions fostered by bilateral accords. Since 2004–2005, due to the impossibility of collaborating on dredging and signaling, HPP countries have been attempting to resolve their differences bilaterally, with little progress. Traditional uses and customs persist throughout the waterway, perpetuating the notion that each waterway section's sovereignty is exclusively national or shared between only two countries. The CIH's virtual paralysis has made it evident that the international or regional nature of the waterway has remained minimal.

52. The transaction cost of developing a coherent institutional framework could explain the lack of progress in implementing the HPP as a multinational project. Both the European and United States experiences in designing and implementing IWT institutions could provide some insights into the challenges, institutional arrangements and possible roadmaps to reduce transaction costs and align incentives with a view to implement the HPP in a possibly more efficient manner.

1.4.1. The United States

53. In the US, the federal agencies most directly involved in the development and operation of the US navigation system are the US Army Corps of Engineers and the US Department of Transportation (DOT). The responsibilities of both agencies are part of their broader jurisdictions that include both maritime and inland waterways transportation. The DOT, through the US Coast Guard, has responsibility for vessel and navigation safety and provides navigational aids and search and rescue services. The DOT's Maritime Administration supports the development of US ports, intermodal systems and domestic shipping. The responsibility of the US Army Corps of Engineers is to facilitate the movement of vessels by constructing and maintaining navigation channels and harbors, and regulating water levels in inland waterways.[23] The legislative origins of the program are the Rivers and Harbors Act of 1890 that establishes permit requirements to prevent unauthorized obstruction or alteration of any navigable water, as well as for dams, dikes, refuse disposal and temporary employment. The Act's geographic jurisdiction includes all navigable waters of the United States, defined as "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce." This jurisdiction extends seaward to include all ocean waters within a zone of three nautical miles from the coastline (the "territorial seas"). Activities requiring permits include structures (e.g., piers, wharfs, breakwaters, bulkheads, jetties, weirs, transmission lines) and work such as dredging or disposal of dredged material, or excavation, filling or other modifications to the navigable waters.

54. Most of these permit authorities have been decentralized and delegated by the Secretary of the Army to the Chief of Engineers and his authorized representatives. In line with the decentralized system, the regulatory program management and administration is focused at the district office level, with policy oversight at higher levels. The backbone of the program is the Department of the Army's regulations that provide the district engineer with the broad policy guidance needed to administer the program's day-to-day operations, which are developed through formal rule-making procedures.[24] Some of the other legislation relevant to the Corps of Engineers includes: the Clean Water Act (permits for the discharge of dredged or fill material); the Marine Protection, Research, and Sanctuaries Act (permits for the transportation of dredged material to be dumped in the ocean in accordance with criteria developed by the EPA in consultation with the Secretary of the Army); other legislation (the National Environmental Policy Act, the Coastal Zone Management Act, the Endangered Species Act, International Agreements (Great Lakes, London Convention, IMO, etc.); and the Water Resources Development Act (WRDA).

55. Specifically related to environmental legislation, the Corps of Engineers works in association with the EPA, but the Corps is the institution that provides approval for new projects and operations. Recently, stream channelization has been greatly curtailed and in some instances even partially reversed. The United States Government now has in place a "no net loss of wetlands" policy, meaning that stream channelization in one place must be offset by the creation of new wetlands in

[23] http://www.vtn.iwr.usace.army.mil/pdfs/InlandNavigation.pdf
[24] http://www.usace.army.mil/cw/cecwo/reg/oceover.htm

another. In 1990 the US Congress gave the Corps a specific mandate to include environmental protection in its mission, and in 1996 it authorized the Corps to undertake restoration projects. The US Clean Water Act regulates certain aspects of channelization by requiring non-federal entities (i.e., state and local governments, private parties) to obtain permits for dredging and filling operations. Authority is delegated to the Corps to issue permits, with EPA participation.

1.4.2. Europe

56. In Europe, within each country a variety of institutions may be managing the waterways: e.g., Ministry of Transport or Water, or specialized waterways organizations. In addition, due to the nature of river basins in Europe, collaboration among countries is necessary in the management of rivers that cross various countries. Each country, in turn, is governed by its own set of legislation and policies; although the process has begun for unifying legislation and procedures, much still remains to be done.

57. The EU Water Framework Directive (laws) aims at protecting all EU waters, including surface waters and groundwater. Water management is organized on the basis of river basins. The directive on the assessment and management of floods aims to reduce and manage the risks that floods pose to human health, the environment, infrastructure and property. Other directives include issues for birds and habitat, waste, and environmental assessments. To support them, various guidelines have been created. Because of the fragmented nature in Europe, although legislation and procedures in the various countries are similar, the way they are applied may differ. In addition, each country in the EU is governed by its own set of legislation and policies, although the process has begun for unifying legislation and procedures. In addition, since 2000 the inland navigation market has been entirely deregulated.[25] The other type of legislation concerns the operations on waterways involving technical and nautical standards, river information services, and those regulations from the river commissions.

58. The following are some of the policies in place in the EU: The EU's policy is to promote inland waterway transport (NAIADES) with the objectives of creating favorable conditions for service, modernizing fleets, promoting jobs, improving cooperation and providing infrastructure. The program consists of support, policy and legislative measures. The time frame for the implementation of the plan is 2006–2013.

The following actions were launched in 2006–2007[i]:

Support measures

- National action programs in Austria, Belgium, France and the Netherlands
- 20% cofinancing for IWT priority projects and 30% for cross-border sections
- River information system implementation in the priority financing of transport projects
- Dedicated research for IWT innovation in 7th framework program—R&D
- Support for setting up promotion actions and offices

[25] http://ec.europa.eu/transport/iw/overview/objectives_en.htm

Policy measures

- Transport projects coordinator appointed
- Screening barriers studies (logistics, administrative)
- Funding handbook to outline incentives (state aid funds, public awards, state guarantees, state cofinancing, EU funding, innovation fund, tax breaks)
- Social dialogue ongoing

Legislation measures

- Unification of technical requirements for vessels
- Adoption of new regulation on IWT statistics
- Proposal on transport of hazardous goods
- Proposal on transport fuel quality
- Adoption of river information system standards under directive
- *De minimis* for inland waterway transport – government engine replacement program

59. The Convention regarding the Regime of Navigation on the Danube is the international legal instrument governing navigation on the Danube River. According to the Convention, the 11 Member States (Austria, Bulgaria, Croatia, Germany, Hungary, Moldova, Slovakia, Romania, Russia, Ukraine and Serbia) undertake to maintain their sections of the Danube in a navigable condition for river-going and, on the appropriate sections, for sea-going vessels and to carry out the works necessary for the maintenance and improvement of navigation conditions, and not to obstruct or hinder navigation on the navigable channels of the Danube. Funding is by national and international sources, where national funding is by the government or private sector of the specific country adjacent to the Danube, and international funding is by the EU, community assistance initiatives, intergovernmental organizations or the private sector. On the segment that runs through Germany, fees must be paid for travelling on the Rhine-Main-Danube Canal. The amount of the fees depends on the goods transported. No waterway fees are collected on the Danube and Rhine international waterways. On the Austrian segment, the via Donau is responsible for the upkeep of the Danube waterway on behalf of the federal government, the maintenance and protection of riverbanks and embankment structures, as well as flood protection. The regions for which via Donau is responsible include the Danube, March and Thaya Rivers. The Ministry of Transport is responsible for strategic planning, monitoring and control. Via Donau was founded by the Ministry of Transport and is a limited liability company, as the property of the Austrian Federal Ministry of Transport. Financing for the work on the Danube is from the Ministry of Transport and the EU's TEN-T program, which is a program that is cofinanced by the European Union from the budget of the Trans-European Transport Networks.

60. The Seine-Scheldt Committee is a common body of representatives of all member states active in implementing the Seine-Scheldt Project. With the aim of steering and coordinating the course of works to be undertaken, the Seine-Scheldt Project is a European-scale project. Funding for the development of this river segment is from public funding by member governments, and private funding is expected to be received through public-private partnerships (PPP). The project is also eligible for community funding as one of the priority projects of the EU Programme for Trans-European Transport Networks (TEN-T).

2. Economic Evaluation of the Hidrovía Project

2.1. CIH cost-benefit analysis

61. The 2004–2005 study conducted by the CIH[26] includes a meticulous cost-benefit analysis of the HPP project. The purpose of the analysis was not merely to examine the project's overall advantages, but also to comparatively examine the project's various options and alternatives. The study evaluated the economic and financial implications of the HPP, considering the total costs of dredging (initial and maintenance), signaling and environmental impact mitigation, and it assumed that the investments would come from the private sector (and would be included the corresponding management fees). The economic evaluation excludes taxes and considers 2002 to be the baseline "without project" year. One of the most delicate aspects of the evaluation is the future water level forecasts throughout the waterways: given the decision to assure a certain level of navigability conditions (channel depths and widths), the project's feasibility depends on the margin taken with respect to minimum water level forecasts (for example, the minimum observed in the last 10 or the last 50 years). The approach consists of generating "dry" and "wet" scenarios, which imply greater or lesser probability of reaching the desired parameters, but also involves varying construction and maintenance costs.

62. The analysis illustrates that given the improvements in navigation conditions, the project's main benefits are the reductions in freight transport costs for transport using the waterway (freight transport rates are presumed to decrease proportionately). The proposed waterway improvements would reduce transportation costs between 15 percent and 20 percent per ton (priced at around US$2.20 per ton according to the preferred option). The Hidrovía hinterland study brings to light the low elasticity of transport rates: freight whose characteristics make water transport an attractive option is already using the HPP. Freight being transported by other modes of transportation (mainly for the transport of soy and its by-products) that would shift to the HPP due to its lower costs, is marginal. New traffic generation (basically from mining operations in the Corumbá area) was considered cautiously; it was found that the waterway's freight transport rates would have to be significantly low in order to induce new mining projects.

63. Improvement costs, including sand/rock foundation demolition, signaling and environmental impact mitigation, vary depending on the chosen alternative, between US$39 and US$94 million, and maintenance costs are estimated at between US$12.6 and US$20.5 million annually. The cost-benefit analysis clearly illustrates that the lowest-cost alternative (labeled A-8, which assumes 8-foot depths in the upper sections of the HPP and favorable water levels) provides benefits that are only marginally lower than of those requiring much higher investment. This is because the majority of the benefits are obtained in the rectifications of sharp waterway bends (that force convoy disassembly), included in all the alternatives.

[26] Prepared by the "Consorcio Integración Hidrovíario" - COINHI

64. The expected IRR (Internal Rate of Return) of the HPP project is estimated to be very high according to the CIH studies. The selected alternative shows a 25.3 percent IRR over a 20-year horizon, and 19.2 percent in 10 years. The other alternatives merely show acceptable IRRs, between 7 percent and 17.8 percent, over 20-year horizons. It should be emphasized that market forecasts based on the CIH studies are moderately conservative; cost savings in waterway transport, representing the majority of the project's benefits, may even be underestimated; this provides a wide margin of security regarding the project's feasibility (this aspect is detailed further in a later section). The analysis shows low sensitivities to estimation errors in investment costs, maintenance costs or freight traffic forecasts, but higher sensitivities to errors in waterway transport unit cost reductions as a result of navigation improvements in the waterway.

2.2. Another look at the project's direct impacts

65. Several additional analyses were conducted to corroborate the CIH studies' conclusions. These included: (i) fleet operation efficiency analyses, (ii) updating of demand forecasts, and (iii) a new, detailed calculation of waterway-user cost savings as a result of infrastructure improvements. Despite the availability of a comprehensive and relatively recent study, such as the 2004–2005 CIH study, it was decided to review several critical aspects of the project's feasibility in order to confirm the study's conclusions. In addition, a brief analysis was conducted of the distribution of freight transport rate savings among the countries that use the HPP. The proportion of costs that would accrue to each country according to the location and type of improvements adopted was established (this includes 90 individual work projects and future maintenance in the corresponding country's jurisdiction).

2.2.1. Fleet operation efficiency

66. A fleet performance analysis was conducted, based on a simplified operational model, to ascertain whether operational inefficiency causes the incurrence of extra costs. Average convoy and barge sizes were adopted, as well as an average commercial speed (4 km/h, including overnight recesses and time spent during convoy assembly and disassembly at critical passages), and average time spent on loading and unloading (five days for both). Grain seasonality was also considered. Under these assumptions, the analysis yielded the estimate that each barge transports 19,000 tons per year.

67. The analysis shows that in a high-efficiency scenario model, the current 1,475-barge fleet could move a volume of 28 million tons, substantially larger than the current volume of 14 million tons. The existing utilization coefficient is therefore 43 percent, considering that the barges run empty in one of the trip legs (therefore, the effective utilization is half, or 21.5 percent). This utilization rate is a result of several factors: (i) many of the 1,475 barges are old units, underutilized or not utilized at all; (ii) some barges are notably smaller than the model's 1,500-ton size average; (iii) large convoys cannot be assembled in some cases (those with less demand, smaller tugs); and (iv) there are some constraints for fleet utilization in domestic traffic and domestically reserved freight. In conclusion, considering all factors, under present conditions the level of current fleet utilization may be considered acceptable.

2.2.2. Demand forecasts

68. **Demand forecasts for 2010 and 2020 were independently estimated for the 24 main traffic movements (combination of origin, destination and cargo type), quoted in the previous chapter, that make up 88 percent of the IWT tonnage**. Estimates are based on two sources: a recent CPTCP study[27] and an analysis conducted for a project aimed at the expansion of the Nueva Palmira port.[28] The total traffic forecast for barge IWT (shown in Table 10) has an implicit annual growth rate of 7.7 percent between 2008 and 2010, and 6.7 percent between 2010 and 2020. In the former case, growth is led by grain and oilseeds originating in Paraguay and transferred in Argentine and Uruguayan ports, linked to investment projects for production expansion and port development. In the latter case, most of the growth is attributed to a new ore project already under construction in the Corumbá area of Brazil, transshipping in Nueva Palmira (Uruguay).

69. **The results of the forecasts yield projections slightly higher than those of the CIH study.** The disaggregated demand forecasts show an annual growth rate of 6.9 percent over a 13-year period. This rate is higher than that of the CIH study, which yielded a rate of only 4 percent over 22 years. The CIH study's baseline year was 2002. However, from 2002 on, river navigation in the HPP increased at a much higher rate than expected. The new estimate reflects the higher rates.

2.2.3. A new user-savings calculation

70. **In order to calculate the project's potential benefits, a cost-structure analysis of a typical barge convoy was conducted. The analysis identified the project's most important elements. It helped to understand the relationship between navigation costs (including freight transport rates) and the infrastructure characteristics that determine freight shipment times and freight capacity.** The setting of freight transport rates is also related to the market behavior of transport goods. For the sake of the analysis, the tug and barge are considered to be inseparable, as if they were a single vessel. In real, practical terms the operation is much more complex because the tug arrives at the port of destination, leaves the barges full of freight, and proceeds to take empty barges back to the port of origin. The simplification adopted also permitted operational cost comparisons with and without the project—the primary aim of the analysis. The analysis considered a convoy of 16 barges with a maximum capacity of 1,500 tons and a 10-foot draft. Based on these parameters and according to the selected itinerary matrix, the operational cost per trip and per ton was determined, with and without the project.

Table 10. IWT demand forecast

Product	Port/Area of origin	Country	Port/Area of destination	Countr y	Flow 2007 *(000*	Flow 2010 *(000 tons)*	Flow 2020 *(000 tons)*

[27] "Dinamizando la Hidrovía". Presentation prepared by the Comisión Permanente de Transporte en la Cuenca del Plata, delivered to the Argentina Export Chamber in August 2008.
[28] Consorcio de Integración Hidrovíaria, sponsored by CAF.

					tons)		
Ore (Fe, Mn)	P. G. Curvo	BRA	San Nicolás	ARG	3,923	4,708	5,649
Grain, oilseeds, by-products	Ciudad del Este	PAR	Nueva Palmira	URU	1,366	1,776	2,664
Fuel	Buenos Aires	ARG	Villa Elisa	PAR	1,360	1,496	1,945
Grain, oilseeds, by-products	Ciudad del Este	PAR	Rosario/S.M.	ARG	1,136	1,477	2,215
Grain, oilseeds, by-products	Reconquista	ARG	Rosario/S.M.	ARG	693	832	1,247
Grain, oilseeds, by-products	Encarnación	PAR	Rosario/S.M.	ARG	459	597	895
Clinker	Vallemi	PAR	Villa Hayes	PAR	400	400	400
Grain, oilseeds, by-products	Encarnación	PAR	Nueva Palmira	URU	397	516	774
Grain, oilseeds, by-products	Pto. Quijarro	BOL	Rosario/S.M.	ARG	300	360	540
Fuel	Buenos Aires	ARG	Encarnación	PAR	293	322	419
Grain, oilseeds, by-products	Pto. Quijarro	BOL	Nueva Palmira	URU	249	299	449
Grain, oilseeds, by-products	Asunción	PAR	Rosario/S.M.	ARG	220	286	429
Fuel	Rosario	ARG	Villa Elisa	PAR	219	241	313
Ore (Fe, Mn)	Corumbá	BRA	Villa Hayes	PAR	212	254	305
Crude oil	Formosa	ARG	Villa Elisa	PAR	206	248	372
Vegetable oil	Pto. Quijarro	BOL	Rosario/S.M.	ARG	187	224	336
Vegetable oil	Ciudad del Este	PAR	Rosario/S.M.	ARG	127	153	229
Grain, oilseeds, by-products	Asunción	PAR	Nueva Palmira	URU	67	87	130
Ore (Fe, Mn)	P. G. Curvo	BRA	Nueva Palmira	URU	65	65	8,000
Vegetable oil	Asunción	PAR	Rosario/S.M.	ARG	55	66	98
Wheat	Diamante	ARG	Asunción	PAR	44	0	0
Fuel	Buenos Aires	ARG	Pto. Suárez	BOL	39	43	55
Wheat	Rosario	ARG	Pto. Suárez	BOL	29	0	0
Grain, oilseeds, by-products	Corumbá/ Ladário	BRA	Nueva Palmira	URU	27	630	1260
TOTAL					**12,071**	**15,077**	**28,724**

71. The analysis also led to the creation of a model that estimates both fixed and variable costs, depending on given convoy parameters (see Annex I). The fixed costs are those that the ship owner must cover regardless of his activity level. The variable costs are those that the ship owner incurs only when he transports freight and handles the vessel (including fueling, wages, etc.). In hydrocarbon or mineral transportation, the analysis assumes that the vessels operate year-round. In seasonal cases, such as with bulk agro-products, it was assumed that in the inactive periods wage expenses or operational expenses are not accrued, and the operational time frame was 200 days per year. For nonseasonal freight, the operational time frame was set at 350 days per year, allowing for precautionary inactivity time for repairs. The applicable cost variables are detailed in Table 11.

Table 11. Cost model including fixed and variable costs

Fixed Costs	Variable Costs
Depreciation of tugs and barges	Wages
Tugboat hull and machinery insurance	Personnel administrative costs

Tugboat PANDI insurance	Fuel costs
Barge hull insurance	Lubricant costs
Barge PANDI insurance	Repairs and maintenance
Provison for tugboat dry-dock inspection	Food for crews
Provision for the barge dry-dock inspection	Agency and port fees
Fleet administration costs	Navigation fees
"Flag" fees	

72. At present, waterway depth variability is significantly impeding the existing inland navigation fleet's efficiency. Unmet depth minimums cause a typical 1,500 DW barge (Mississippi class) to sacrifice 200 tons of effective load per foot of depth. Under the waterway's current conditions, the depth deficiency causes a typical 16-barge convoy to sacrifice 13.3 percent of its potential capacity, equivalent to 3,200 tons of freight. This estimate is based on current conditions as reported in various studies and consultations. Key parameters adopted for this estimate are as follows: (i) the Paraguay River from Asunción to Confluencia and the Paraná River from Confluencia to Santa Fe allows for a 9-foot depth, a barge load of 1,300 tons and a convoy to achieve 87 percent of its capacity; (ii) in the Upper Paraná (north of Confluencia) and in the Paraguay River north of Asunción (up to Corumbá and other neighboring ports), operational depth is 8 feet, limiting barge loads to 1,100 tons, and a convoy efficiency of 73 percent; and (iii) there are some seasonal variations in river water levels.

73. Based on current waterway conditions, the extra costs due to depth shortages were estimated for each of the 24 relevant inland waterway movements. Table 12 shows an example of extra costs per ton incurred in navigation between Porto Gregório Curvo, located in Corumbá (or the nearby Puerto Suárez, or Puerto Quijarro) and San Nicolás, a 2,500-km route. The current practice is that carriers charge for the convoy, regardless of the extent to which it is loaded, because most of the costs to be incurred are invariable. Therefore, the extra cost has a proportionately inverse relationship to the degree of barge-capacity efficiency. In the case illustrated in Table 7, the degree of barge capacity utilization due to depth constraints is 73.3 percent, and the extra cost for the shipper is 36.2 percent (the inverse of the former).

Table 12. Extra costs due to depth shortage in the Corumbá–San Nicolás itinerary

Total Convoy Price	*US$*	563,200
Full load	*Tons*	24,000
Resulting rate per ton	*US$*	23.5
Incomplete load (depth constraint)	*Tons*	17,600
Resulting rate per ton	*US$*	32.0
Extra cost per ton	*US$*	8.5

74. By adding all relevant transport movements, extra costs due to depth constraints are estimated at US$69 million for 2007.[29] The contribution of each movement depends on the freight volume, the distance between origin and destination, and the waterway constraints along the route. The longest transport distance (ore between Corumbá and San Nicolás, grain between the Upper Paraná Paraguayan terminals and the Nueva Palmira and Rosario terminals, and fuel between the Buenos Aires area and Asunción, Villa Elisa), are those that contribute the most, representing almost 80 percent of total extra costs due to depth constraints. Overall, potential savings from infrastructure improvements would reduce IWT costs by around 30 percent, a proportion larger than that estimated in the CIH study (between 15 percent and 20 percent). The 30 percent savings have been checked and confirmed with waterways operators.

75. The lack of adequate signaling (combined with depth shortages) generates additional extra costs; convoys must stop at night, reduce speed in some passages, and spend time disassembling and reassembling. Recent studies have found that the commercial speed differential due to infrastructure constraint is 0.8 km/h (4.0 km/h under current conditions, 4.8 km/h if infrastructure is improved).[30] The number of trips lost per year was estimated for each of the 24 most relevant movements. Because the average convoy rental value is known (US$9,800 per day), a monetary value can be associated with the delays in each movement. The aggregated value for all itineraries is around US$20 million. The itineraries contributing the most are those that include long distances, large volumes and constraining river sections. This impact was not considered in the CIH study.

76. The delays also significantly impact shipper inventory costs. According to Hummels,[31] the incremental inventory cost associated with delays ranges from 0.5 percent to 0.8 percent of the freight value per day. A value of 0.4 percent was adopted for oil, grain and fuel, 0.5 percent for clinker, and 0.6 percent for fuel, and inventory cost estimated for all 24 relevant movements. The resulting aggregated cost is US$60 million for the base year (2007). The CIH study did not consider logistics costs (which include inventory costs), but only transportation costs.

77. The previous paragraphs estimate that the extra costs due to infrastructure constraints total around US$149 million per year. Therefore, for base year 2007, approximately US$89 million impacted freight rates negatively, while shippers directly absorbed roughly US$60 million. In terms of

[29] The last year for which demand information is available.
[30] COINHI, IIRSA Business Plan.
[31] Hummels, D. *Time as a Trade Barrier*.

extra cost per ton, US$7.4 and US$5.0, respectively (US$12.4 in total), could have been avoided with better infrastructure. It is worth noting that in the case of improvements in infrastructure conditions, not all the cost savings will be passed on to shippers (carriers usually capture around 50 percent). Other costs may also be considered, such as the commercial opportunities lost due to the reduced competitiveness of regional products in the international market resulting from high internal transportation costs.

78. With lower levels of freight demand and lower savings due to navigation improvements, the CIH study found positive results in the economic evaluation of the project. These additional analyses largely confirm these results. Push-tug convoy operations are efficient and river transport operators reasonably utilize their fleets as far as infrastructure conditions permit. The demand for waterway transport could yield much greater results than those projected, and the direct benefits from HPP improvements, basically the savings enjoyed by users, are substantial. These results clearly convey a positive economic viability for the full implementation of the HPP.

2.2.4. Asymmetry in costs and benefits

79. The countries directly using the HPP do so in different proportions and benefit both from freight generation and reception (through import or transshipment). Section 1.1.3 summarizes the manner in which each country capitalizes on the HPP through commercial shipping transactions: as a market exporter, importer, or transshipment site. The benefits are generally distributed according to market origin, assuming that the favored country is the exporter. But strictly speaking, with improved navigability and freight transport rate reductions, the importing country would also benefit. Cargo transshipment can also be a lucrative operation to a given country. Carriers also benefit from the project; however, it is difficult to assign the benefits to a specific country because the origin of shipments does not always reflect the origin of the capital invested in the venture.

80. To illustrate the asymmetry between the benefits accrued by the user-country and their contribution relative to the improvement costs of the HPP, a summary chart with various assumptions was prepared. Table 13 shows each country's savings percentages from the reduction of freight transport rates, considering both the generation and attraction of freight. The table bases these estimates on the 2010 forecasts of the 24 main HPP movements and on the cost model from the previous section. It shows the proportion of investment costs for HPP improvement per country, considering dredging and signaling projects. This includes initial costs and three years of maintenance. Although the calculations may be somewhat rudimentary, the results are compelling:

- Argentina benefits from freight transport rate savings and imports (which come from the northern extreme of the HPP), and its participation in dredging is relatively low since the river is ample in size with a soft substratum.
- The volume of shipments to and from Bolivia is relatively limited, and the two stretches in the short section of the Paraguay River that falls under Bolivian jurisdiction require significant improvement works.

- Brazil faces costs similar to those of Bolivia, but generates a proportionately large quantity of exports.
- Paraguay benefits both as an exporter and importer; with approximately half of freight transport rates savings resulting from the HPP project, proportionately its dredging costs would also equate to roughly half (although in other sections of the waterway).
- Uruguay mainly operates as a freight transfer platform and should not incur improvement costs with respect to interior navigation; similar to Argentina, it is responsible for dredging that would give access to seafaring vessels and would facilitate the outward shipments of exports from throughout the HPP.

Table 13. Relative distribution of freight rate savings and dredging costs for the HPP countries

Country	Savings in freight rates from freight originating in the country	Savings in freight rates from freight in destination to the country	Dredging costs of the HPP in the country's jurisdiction
Argentina	**26%**	**69%**	**14%**
Bolivia	**4%**	**0%**	**12%**
Brazil	**37%**	**0%**	**17%**
Paraguay	**33%**	**18%**	**57%**
Uruguay	**0%**	**13%**	**0%**
TOTAL	**100%**	**100%**	**100%**

The country-level estimates of the expected freight savings and dredging costs (initial and maintenance) would allow a project cost-benefit analysis (CBA) from each country's perspective, i.e., considering the dredging (initial and maintenance) cost each country should bear in order to enhance the HPP infrastructure in the segments of river under its jurisdiction, and its trade savings in freight rates. The performance of a CBA depends on several factors, for which assumptions have been made:

- Initial dredging costs are estimated at US$70 million (the average between maximum and minimum CIH report calculations) and annual maintenance at US$22.5 million (above the average CIH estimate of US$15 million per year, reflecting worse conditions in the river due to draft).
- Benefits are distributed according to both the origin and destination of the freight, in equal shares.
- Works are expected to be completed in two years, and benefits are constant over time.
- Reductions in freight rates are considered between the large savings estimated in Section 2.2.3. and the more moderate ones estimated in the CIH report.

The objective of the exercise is not to generate an accurate CBA for each country (because only a few relevant costs and benefits are considered, with arguable assumptions), but rather to take a closer look at the different position each of them would have when addressing the enhancement of the HPP's infrastructure. The results allow the identification of three different situations.

i. Argentina and Brazil show very high rates of return (in the range of 250 percent and 100 percent, respectively), because the costs they would bear are relatively small, and they make intensive use of the HPP (Argentina as origin and destination, Brazil only as origin).
ii. Bolivia and Paraguay show much smaller rates of return (-7 percent and 20 percent, respectively). In the case of Bolivia, benefits are moderate and initial dredging costs are high (not as much maintenance). In Paraguay savings are large (due to the intensive use of IWT), but initial and maintenance dredging costs are high as well. Additionally, in these two countries the size of the economy—and the capacity to invest in infrastructure—is much smaller than in Argentina and Brazil. Therefore, although it is a useful investment (very useful for Paraguay), a relatively larger resources requirement is combined with a smaller financial capacity.
iii. The case of Uruguay is different: no dredging is required in the river under its jurisdiction; therefore, the country would receive benefits but would not bear dredging costs.

2.3. Indirect Impacts

2.3.1. Freight induction and impact on developmant

81. At present, there is a dispute among those who analyze the HPP project's impact with respect to the "broader and indirect impacts," in particular the circumstances in which they are relevant, and whether they are duly captured using conventional cost-benefit analysis methods. Accessibility improvements interact with other determinants of economic growth, as do economies of scale and market sizes, particularly where the goods markets are fallible. The "broader and indirect impacts" that the cost-benefit analysis generally does not capture result from market imperfections: economies of scale, imperfect competition and benefits derived from increases in employment and productivity rates. Because conventional methodologies do not capture all benefits, negative biases may be introduced in project investment evaluations. A growing list of reference materials addresses this matter.[32]

82. It would be worthwhile to consider the relevance of the Paraguay-Paraná Hidrovía's broader and indirect impacts; the recent studies carried out by the CIH are skeptical that the proposed improvements will produce these impacts. The HPP's area of influence, particularly north of Santa Fe, for the most part is a territory with low population and activity numbers. It is not considered an urban area, where positive externalities of transport are created through economies of scale. The CIH demand studies foresee little modal shift (the freight activity likely to use the waterway for transport is already doing so) and display a relatively pessimistic scenario for the stimulation of new activities due to the improvement of the waterway. The fact that the report was produced in 2003–2004, before the

[32] For example, ECMT (2001), New Zealand Transport Agency (2009), Graham (2006).

increase in the prices of commodities transported by means of the river (primarily soy and iron ore), has likely caused much of the skepticism.

83. Soybeans and its by-products (soy pellets and meals resulting from vegetable oil production) would be able to increase activity due to waterway improvements. In the case of iron ore, new mining enterprises may develop in the area. In the case of soy and its by-products, it is likely that the project will cause some modal shift (as envisioned by the CIH model). In addition, it is also likely that an expansion of crop areas may result due to improved transport conditions, with the consequent increase in regional GDP, thus facilitating new oil processing plants (for example, in Bolivia and Paraguay). The iron ore case is a typical example of how new economic development may be encouraged by improvements in transport infrastructure; important iron mining projects have been pending the implementation of improvements, mainly to ensure navigation during the less-favorable water-level scenarios. Finally, along the same lines, one could argue that HPP project's improvements consolidate economies of scale in agro-exportation in the Rosario area (even when freight contributions are relatively minor). This also applies in other areas such as those adjacent to Corumbá and the Tamengo Channel.

84. In conclusion, there will certainly be indirect benefits, but these will prove to be relatively minor when compared to direct costs. Their manifestation merely confirms the high rate of social return on the proposed investment.

2.3.2. Transport alternatives to the HPP: another way of measuring its relevance

85. As an alternate method of measuring the HPP's relevance, the 24 basic movements were analyzed considering the nonexistence of the HPP and using other possible routes. In each case an alternative route was chosen, linking origin to destination by using other modes of transportation. In some cases the alternative was a freight truck, in others (particularly those connected to Corumbá) a combination of railroad, port transfer and sea navigation was applied. The exercise was based on 2007 transport flows. The calculation considered: (i) the total ton-kilometers transported through the waterway at present, the ton-kilometers transported per mode (railroad, road and maritime) in cases where the HPP was not used, and (ii) the present freight transport rates and those that would result from alternative routes to the waterway.

86. Due to the increased distances of the alternative routes, the activity levels measured in ton-kilometers stand to increase by 26 percent. As of 2007, the HPP activity level was calculated at 20.7 billion ton-kilometers, examining the 24 main movement volumes. When considering the alternative routes, this figure would actually be 26.2-billion ton-kilometers, using the modal composition seen in Table 14.

Table 14. Incremental activity levels per mode for cases using alternatives to the HPP

Mode	Tn-km	Tn-km

	(million)	**(%)**
Road	9112.4	*34.8%*
Railroad	7388.5	*28.2%*
Maritime	9692.6	*37.0%*
TOTAL	26193.4	*100.0%*

87. The aggregate value of transport rates would double, surpassing the current figures (2007) from US$380 million to US$763 million. The calculation considers the average freight transport rates for the alternative mode for grain transport, excluding possible economies of scale from increased activity. The values adopted were 2.5¢ per ton-kilometer for railroad transport, 5.5¢ per ton-kilometer for road transport, and 0.6¢ per ton-kilometer for maritime transport. For port transfers a value of US$4 per ton was used; it includes loading, unloading and storage.

3. Environmental and climate change aspects of the Paraguay-Paraná Hidrovía

3.1. Background

3.1.1. General context

88. **Currently, more than 90 percent of the region's freight is moved by road freight transport, which is the least energy-efficient form of transport and the one that contributes the most to GHG emissions**. The HPP region's main products are soy (50 percent), corn (10 percent), wheat (5 percent), oil and gas (20 percent), iron (5 percent) and limestone (10 percent). MERCOSUR has important trade among its member countries; thus the HPP is an excellent means for expanding this trade. In the short run, fluvial transport demand for the HPP will likely be composed almost entirely of soy and its by-products (45 percent), oil and its by-products (20 percent) and iron and manganese (18 percent).

89. **When compared to other transportation modes, waterways are often deemed more environmentally friendly.** Undoubtedly, waterways are more energy efficient, cause fewer accidents and produce less (air) pollution. If the development of the HPP relieves roads of the volume now transported by truck, waterway development would be a significant contribution to GHG abatement efforts.

90. **During construction and operation, inland waterways have direct, indirect and cumulative impacts.** As with all other economic activities, transport has environmental impacts that may affect ecosystem services and structure. These impacts are associated with the construction of transport infrastructure and with the operation of transport services. These impacts must be identified and mitigated in order to increase the social benefits of waterway development**.**

3.1.2. Environmental studies carried out on the HPP

91. **In order to assess the possible impacts of the HPP, several studies were carried out by independent researchers or commissioned by the CIH.** Although justifiable concerns regarding the integrity of the Pantanal floodplain permeate some of the studies, by and large most detailed studies concluded that the proposed works would cause minor impacts that could be mitigated with an adequate environmental management plan. Moreover, river hydrology would not be negatively affected by the proposed works. The impact of dredging works on river levels would be minor and there would be no irreversible impacts on the waters of the Paraguay River and Pantanal floodplain.

92. **The first study considered here was commissioned by Argentina, Bolivia, Brazil, Paraguay and Uruguay in 1996.** That study comprised technical and economic feasibility studies and an environmental impact assessment**.** It was divided in three parts: 1) navigation canal design, environmental

impacts, and an economic feasibility study for the Santa Fe-Corumbá section and the Tamengo Channel ; 2) preliminary design and economic feasibility studies for the Corumbá-Cáceres section and long-term improvement of the Nueva Palmira-Cáceres section; and 3) an environmental impact assessment and navigation improvement plan for the entire waterway.

93. The second study reviewed here is the 2004 COINHI study, to our knowledge the most recent comprehensive analysis of the Hidrovía project. The study was aimed at: (i) updating and completing the technical, environmental, economic and financial analysis of the previous studies; and (ii) assessing and proposing legal and institutional approaches to contract out the works, including bidding documents. The report's main conclusions in its environmental chapter rule out major environmental impacts if appropriate environmental management measures are planned and implemented.

94. The following section presents the project's definition and summarizes the findings of the studies commissioned by the CIH. These studies conducted extensive field research in addition to the compilation of prior studies.

3.2. Environmental analysis of the HPP

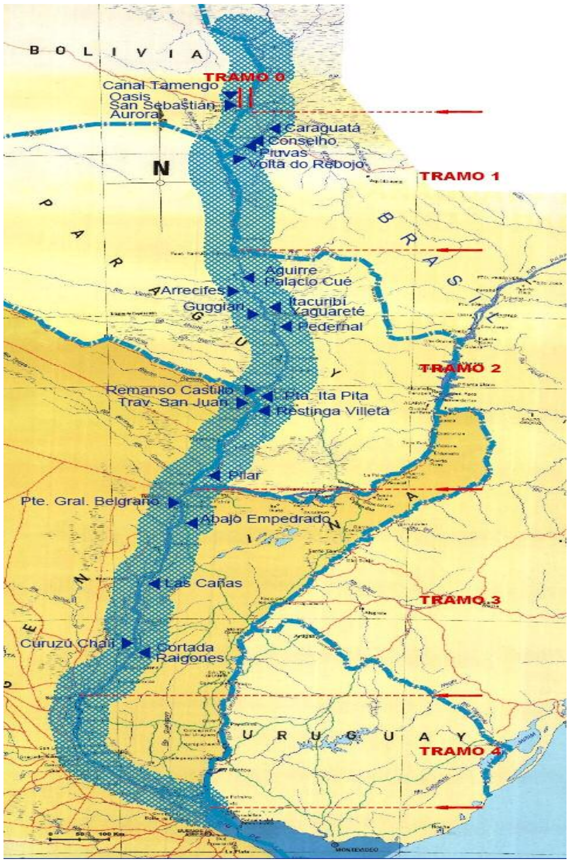
3.2.1. The definition of the project

95. As defined in the COINHI study and in this paper, the Hidrovía project includes 90 different improvement operations, including 22 critical passages (see list below) between the Tamengo Channel and Santa Fe (Figure 12). The operations to overcome these passages include dredging, dismantling, hard mineral extraction and signaling maintenance. The dredging of the river is of particular concern because it may impact water quantity and quality. The initial dredging is estimated to yield 11.5 to 12.1 million cubic meters, depending on final canal width. Maintenance dredging will yield 6.4 to 6.9 million cubic meters annually.

Table 15. Critical points in the HPP

Sections (South-to-North)	#	Critical points	Location (km)	Country(ies)
Paraná (km 601)/ Corrientes (km 1208)	01	Cortada Raigones/San Juan	776–783	Argentina
	02	Curuzú Chalí	784–787.5	Argentina
	03	Paso Las Cañas	940–942	Argentina
	04	Abajo Puerto Empedrado	1130–1131.5	Argentina
	05	Puente General Belgrano	1204	Argentina
Corrientes (km 1208)/ Asunción (km 1630)	06	Pilar	1329–1331.5	Argentina/Paraguay
	07	Restinga Villeta	1593–1594	Argentina/Paraguay
	08	San Antonio - Travesía San Juan	1602.5–1605.5	Argentina/Paraguay
	09	Ita Pita Punta	1626	Argentina/Paraguay
Asunción (km 1630)/ Vallemí (km 2161)	10	Remanso Castillo	1645	Paraguay
	11	Pedernal	1881–1886	Paraguay
	12	Guggiari	1935–1942	Paraguay
	13	Itacurubí-Yaguareté	1952–1954	Paraguay
	14	Arrecifes	2047–2050	Paraguay
	15	Aguirre - Palacio Cué	2095–2100	Paraguay
Vallemí (km 2161)/ Corumbá (km 2770)	16	Volta do Rebojo	2541.5–2544	Bolivia/Brazil
	17	Piuvas Inferior y Superior	2570.5–2577	Brazil
	18	Conselho	2606.5–2610	Brazil
	19	Caraguatá	2658–2660	Brazil
Tamengo Channel	20	Aurora (Marina Gattass)	3.6	Bolivia/Brazil
	21	San Sebastián	4.4	Bolivia/Brazil
	22	Oasis	5.5	Bolivia/Brazil

Figure 12. Critical passages in the HPP



3.2.2. The first environmental impact studies

96. Argentina, Bolivia, Brazil, Paraguay and Uruguay commissioned technical and economic feasibility and environmental impact studies in 1996 as one the first measures to implement the Paraguay-Paraná waterway. The study was divided in three parts:

- Navigation channel design, environmental impacts and economic feasibility study for the Santa Fe-Corumbá section and the Tamengo Channel (assigned to the Consorcio Hidroservice–Louis Berger-EIH).
- Preliminary design and economic feasibility studies for the Corumbá-Cáceres section and long-term improvement of the Nueva Palmira-Cáceres section (Consorcio Hidroservice-Louis Berger-EIH);
- Environmental impact assessment and navigation improvement plan for the entire waterway (Consorcio Taylor-Golder-Consular-Connal).

97. **The findings of the above studies stated that most of the HPP's environmental impacts would be negligible and could be adequately managed through the implementation of a proper Environmental Management Plan**. According to the studies, the proposed plan would need to anticipate and avoid any undesirable impact caused by the increase in waterway traffic.

Impacts on water levels and river runoff speed

98. **The various studies concluded that the HPP's impacts on water levels and river flow speed would be minor, and would occur in the dry season.** The Hidroservice–Louis Berger-EIH study prepared a mathematical model of the 600 km Paraguay River section which included most of the sections/passages, both of soft and hard materials to be dredged. The model simulated the river's response to changes caused by dredging and other works. The section simulated goes from Porto da Manga (km 2685) to close above (km 2080) and including the Aguirre-Palacio Cué passage which has the largest volumes of rocks to be removed from the riverbed.

99. **The model simulated river water levels before and after the dredging from different levels of runoff ranging from 800–1,500 to 2,500 m^3/s**. Runoff of 800 m^3/s only occurs 1 percent of the time, i.e., for approximately four days per year, while 80 percent of the time outputs exceed 1,500 $m^{3/}$s. The most critical situation, from the hydrodynamic point of view of the present analyses, occurs during the dry season when the river flow sections are at their lowest level and when the modifications are proportionately larger (i.e., the dredged area/section area ratio is the largest).

100. **The model's results suggest that the reduction in water levels would be 20 cm in a drought.** This would occur in the area of largest dredging and its effects would extend upstream on a decreasing basis, reaching values below 8 cm beyond 100 km (upstream). This effect would decrease as river runoff increases. It should be noted that the model considered that the dredged material was fully removed from the riverbed, which decreases the impact even more. Moreover, the simulation results suggest that in other places where dredging takes place, the impact in terms of magnitude and distance would be even less significant because the basis of the analysis considered the least-favorable condition in which there was an impact on the Pantanal even then.

101. **Since the analysis was based on a "worst-case scenario," these results suggest that the impact would be even smaller in magnitude and scope in the other locations where the dredging would have to be carried out**. Moreover, the model indicates that the dredging would not impact the runoff levels of the Pantanal. During periods of river flooding/flow the water levels are even greater, causing the effects of dredging on runoff conditions to be barely discernible. This implies that flow would not be affected by dredging. Thus, there would be no changes in time of occurrence or in the magnitude of peak flows. The results of this analysis and of the mathematical model also suggest that the dredging of the Santa Fe-Corumbá river section would not impact the river's hydrological regime in terms of flooding and ebbing.

Impact of dredging on runoff speed

102. The increase in a section's dimensions as a result of dredging at critical points would not cause increases in flows, even when assuming that the dredged material would be removed from the riverbed. According to the results of the mathematical model, flows would not increase. Instead, flows would decrease because the section of increased runoff would entail a decrease in velocity and a lower slope at the free surface in this section. The model indicated that in the most critical situation the reduction in runoff velocity was less than 3 cm/s of the average speed where the section speed was of 50 to 90 cm/s.

Impact on fluvial geomorphology

103. The geomorphological changes to a river may be due to natural and man-made causes. The Paraguay and Paraná Rivers undergo significant changes in their morphology as a result of their water system. Thus, the formation and disappearance of islands, changes in areas of greater depth from one location to another, sealing and cutting loops, etc. are typical of such rivers.

104. The river's hydraulic regime would not be affected by the dredging, as it will not cause significant changes in flow speeds, and as a result river talweg or slopes, would not be affected. Therefore, no morphological changes caused by dredging works in the passages are expected. This is corroborated by the experience in the lower area of the Paraguay and Paraná Rivers, where dredging of the waterway to ensure navigation to Asunción has been carried out for many years. The experience in dredging indicates that there were no impacts on the rivers' morphology or environment when dredged material was deposited in the riverbed. It should be noted that due to changing water levels detected in the Paraná River, a result of its settlement in its upper part, dredging over a 25-year period was done conducted than it is now in order to navigate with the same draft.

3.2.3. The COINHI study

105. The COINHI study is the most recent comprehensive analysis of the Hidrovía Project. It was aimed at: (i) updating and completing technical, environmental, economic and financial analyses, re-estimating the scale of needed works and costs, and exploring the potential for its total or partial financing by users' contributions; and (ii) proposing legal and institutional approaches to contract out the works, including bidding documents. The study contained market forecasts and a complete cost-benefit analysis that took into account several project alternatives. The report's main conclusions ruled out major environmental impacts if appropriate environmental management measures are planned and implemented. However, the study did not address possible capacity issues for implementing the measures proposed in its environmental management plan.

106. Under the environmental chapter, an environmental assessment was carried out for each of the 22 critical passages. The assessment used both primary and secondary information. Field surveys were conducted to collect primary data on water quality, sediments, coastal vegetation, social aspects, risk assessments (as a basis for contingency planning), fish fauna (eggs and larvae), and identification of soils and rocks. The field work was complemented by laboratory research related to sediment quality, soil granulometry, determination of chlorophyll and physical resistance to breakage of riverbed rocks.

107. The IEA established two areas of impact analysis, the first dealing with general aspects and the second with a detailed assessment of the 22 critical passages studied. The diagnostic was based on primary and secondary data. As mentioned above, the primary data consisted of field surveys and subsequent laboratory analysis and evaluation. For specifications and focus on the 22 critical passages, the IEA was spatially and thematically limited. The study may be considered a preliminary environmental assessment (screening) for the following purposes:

1. to identify the main possible scenarios of environmental conflict,
2. to indicate the major mitigation measures,
3. to propose an environmental management plan, and
4. to propose major monitoring programs for further development.

108. The potential environmental impacts were identified using ratings for each of the factors considered. The impacts associated with dredging and signaling works were considered for two areas: the physical environment and biota. The study of ichthyofauna was noteworthy. The analysis pointed to the presence of species of economic value and ecological aspects of reproduction, the development of fisheries and legal issues.

109. The study indicates that the impact of dredging works, generally considered as the main hypothesis of an environmental conflict, would be low or negligible. These impacts would become apparent only during periods of low water availability. Regarding the level of the waters in the Pantanal, analyses and studies have shown that future works will not cause any change.

110. In terms of flows, the study indicates that the dredging will not cause any change in the 22 critical passages. Since no flow changes would occur in the 22 passages, because of the increase in section areas there would be significant reductions in overall low rates of runoff. River morphology would not be impacted by the works on the waterway. Future channels would not influence the natural processes of the Paraná and Paraguay Rivers. These rivers are constantly undergoing modifications because of their highly complex hydraulic and sediment systems. Changes include the formation and disappearance of islands in relatively short periods, changes in depth and margins, changes in cut loops, transfer of submerged dunes and intense sediment and sand transport.

111. With regard to water quality, the study suggests that the dredging will result in a temporary turbidity of the water column during the execution of works. The biggest problem with dredging is generally the release of contaminants in the removed soil. This situation is not expected in the waterway, because no contaminants in concentrations involving risks were found in the samples taken from the sections to be dredged in the 22 critical passages.

112. The study also indicates that almost 99 percent of aquatic life in these areas will be immune to the effects of dredging. The dredging would adversely affect aquatic life in only one area of the rivers, less than 1.4 percent of the total. The need for channel maintenance in the sections of the passages in short periods (one to two years) would cause some damage to benthic communities, which are likely to fail to recover their original state.

113. For dredging using explosives, the study recommended the adoption of specific prevention and mitigation measures. This situation would occur in very few passages and negative effects could be partially offset by the discharge of the rocky material in the riverbed where it would create a substrate for future colonization.

3.2.4. The hydrodynamic model (COINHI study)

114. A one-dimensional mathematical model was prepared to analyze the physical and hydrological conditions for certain with- and without-project situations in a stretch of the Paraguay River. The model incorporated data from the section geometry and hydraulic characteristics of river water for events representing dry and intermediate periods as well as floods. The model is operated for the selected scenario (Alternative A-8) and its main objective was to determine possible changes in river levels and runoff speed as a result of the planned work that could affect the biotic and human aspects related the river's behavior. The results showed that the influence of the works on hydrometric levels would tend to be zero. The expected variations in some sections would reach maximum values around 3 cm. The influence on the velocity of water, whose values are reduced in critical passages, would also be negligible.

115. In summary, according to the COINHI study the environmental impacts of the proposed improvements are manageable. The works under Alternative A-8 would not result in significant changes in the hydraulic system and would not have irreversible impacts on the behavior of the waters of the Paraguay River.

116. As part of the study, an Environmental Management Plan (EMP) was prepared with a set of plans and programs. The EMP sets minimum requirements to be met in order to build and operate the waterway in an environmentally sound manner. The EMP was prepared for the 22 critical passages, but the minimum requirements contained in the plans and programs would have to be observed in the passages along the entire length of the waterway (Corumbá-Santa Fe, including the Tamengo Channel) during the waterway's construction and operation. The analysis undertaken included the potential impacts on the "receiving environment" made up of rivers and coastal environments. The EMP comprises the following plans and programs:

- dredged crossings management plan;
- sediment quality assessment program;
- water quality assessment program;
- erosion and sedimentation monitoring program;
- program for the identification of alternative uses of dredged material;
- coastal vegetation monitoring plan;

- monitoring plan for fish eggs, larvae and reproductive activities;
- communications plan;
- contingency plan;
- waste management plan for dredging;
- environmental education plan for HPP staff;
- occupational health plan.

117. **The completion of the dredging and signaling works would be subject to the controls of the environmental authority in each country's respective jurisdiction**. The same would occur with regard to the implementation of the EMP and related plans and programs.

3.3. Environmental assessment conclusion

118. **As pointed out by the abovementioned studies, most of the direct impacts of the proposed improvements to the HPP are well known and appropriate mitigation measures exist.** The responsibilities for mitigating these impacts are easier to attribute because they are linked to construction and operation of infrastructure and equipment; all of these activities have clearly identifiable agents. However, the studies did not assess the capacity of the environmental authorities to monitor the implementation of the proposed EMP. This can be a major issue and should be addressed if the project is to move forward in an environmentally responsible manner.

119. **However, indirect and cumulative impacts may pose a change in terms of impact identification and mitigation.** This is the case for land use changes: these changes, caused by improved access, are perhaps the most significant impact of the HPP also the most difficult to handle. If land use changes follow the pattern of expanding frontier regions in Latin America, they may imply increases in deforestation, forest fires and habitat fragmentation. Thus, if not properly managed, these impacts may offset the potential gains of any GHG abatement gained by replacing road transport with IWT.

120. **To address the impacts of land use changes, it would be necessary to develop and strengthen an appropriate institutional framework**. This would involve developing institutions in charge of planning and monitoring land use policy goals. Together with the abovementioned tasks, these institutions would have to bring often conflicting interests to the table and possibly arrive at a shared vision in which stakeholders commit to the outcomes of the negotiation process. More than a technical issue, this would involve building trust among stakeholders as well as developing shared rules of the game and ensuring buy-in and commitment to whatever agreements are achieved. So far, none of the countries involved in the HPP initiative appears to have this type of approach to land use planning.

121. **In several cases the land use change caused by transport infrastructure enhancement has been addressed through the creation and expansion of protected areas**. These protected areas have been considered as both compensatory and mitigation measures for the inevitable intensification of land use brought by improved access. This was the case of many transportation projects in Brazil. However, in

many cases the creation of protected areas cannot help with the issues caused by habitat fragmentation within the production landscape (i.e., farms, ranches, etc.).

122. Policies addressing habitat fragmentation within productive landscapes would need to add to the creation of protected areas. In addition to land use regulations existing in some countries (e.g., Brazil), additional command-and-control and economic incentives could be devised to increase the effectiveness and efficiency of land use plans and regulations. These may include land easement mechanisms and other marked incentives to achieve land use policy goals.

3.4. Greenhouse Gas (GHG) Emission reductions

3.4.1. General aspects of GHG emissions in transport

123. Under a simplified approach, the emission of CO_2 was calculated as a proxy for the emission of all GHGs in freight transport. Because CO_2 is highly correlated to all other GHGs, and is probably the one with the highest impact, the estimate offers a good idea of the relative impact of each mode of transport on climate change. Furthermore this approach does not consider the exact loading of the different modes of transport and does not take into account future technological and efficiency improvements, and assumes the use of one principal mode per itinerary. Nonetheless, because it is a relative estimate it provides the relative position of one mode of transport with respect to another.

Table 16. Unit emission amounts per mode of transport

Mode of Transport	Grams CO_2 (per ton x km)
Road Transport (50km/h)	62.23
Road Transport (80km/h)	59.14
Railway	13.36
Existing Waterway (1,100 ton)	7.75
Existing Waterway (1,300 ton)	6.94
Existing Waterway (1,500 ton)	6.50
Waterway with efficiencies (1,500 ton)	5.66

124. It is evident that there is a large potential to reduce GHG emissions by moving freight by water. In terms of GHG emissions, barge transport can halve CO_2 emissions compared to rail transport and reduce road-based CO_2 emissions by 90 percent. These emission reductions are largely the result of the barges' higher loading factors compared to road and rail. Moving freight by barges could provide additional benefits in terms of reducing congestion as well as air pollution and traffic accidents, especially if there is a modal shift from trucks to water.

3.4.2. GHG emission reductions due to the HPP

125. A simple GHG emission model was estimated and used to determine the GHG emissions of the HPP. The model used is based on the emission of CO_2 factors presented in Table 16. The model was applied to the freight transported by the HPP, because there were insufficient data to analyze all the freight transported in the Plate Basin by other modes. However, we know that the volume of freight transported in the HPP is no more than 10 percent of the total freight moved in the basin. In this context, several scenarios were considered: (i) the HPP exists and it has an annual freight growth rate of around 6.9 percent. The horizon analyzed is 2007–2020. No freight is diverted to it from other modes; (ii) the HPP exists but it is improved, thus allowing for more efficient use; (iii) the HPP does not exist and all freight is moved by road, rail or maritime transportation; (iv) the HPP exists but all additional freight is moved by road, rail and maritime transportation; the HPP continues to move the same amount of freight as it does today. These scenarios are fictitious: they were prepared to provide a range of situations that are conservative because no freight is diverted from the existing transport modes.

126. The existing use of the HPP results in the avoidance of 11,215,743 tons of CO_2 emissions. The use of the HPP presently results in 2,895,817 tons of CO_2 emissions (Table 17); a hypothetical scenario whereby the HPP does not exist and the freight is rerouted by land transport and maritime transport would result in 14,111,559 tons of CO_2 emissions (Table 18).

Table 17. Scenario 1: HPP existing trend

Mode of Transport	Total emissions for 2010–2020 (tons of CO_2)	Cost of emissions for 2010–2020 ($US million)
Road Transport (50km/h)	-	
Road Transport (80km/h)	-	
Railway	-	
Existing Waterway (1,100 ton)	1,527,745.42	30.55
Existing Waterway (1,300 ton)	1,368,071.38	27.36
Existing Waterway (1,500 ton)	-	
Waterway with efficiencies (1,500 ton)	-	
Total:	**2,895,816.80**	**58.01**

Table 18. Scenario 2: No HPP

Mode of Transport	Total emissions for 2010–2020 (tons of CO_2)	Cost of emissions for 2010–2020 ($US million)
Road Transport (50km/h)	10,800,778.06	216.02
Road Transport (80km/h)	-	
Railway	1,880,227.31	37.60
Existing Waterway (1,100 ton)	1,430,553.94	28.61
Existing Waterway (1,300 ton)	-	
Existing Waterway (1,500 ton)	-	
Waterway with efficiencies (1,500 ton)	-	
Total:	**14,111,559.32**	**282.23**

127. If the HPP is improved, its carrying capacity per vessel will be higher, thus making it more efficient in terms of GHG emissions. In an improved efficiency scenario (Table 19), the HPP would reduce CO_2 emissions by 664,423 tons. This is a relatively modest estimate, because throughout this report we have assumed no modal shift from other modes.

Table 19. Scenario 3: HPP improved

Mode of Transport	Total emissions for 2010-2020 (tons of CO_2)	Cost of emissions for 2010-2020 ($US million)
Road Transport (50km/h)	-	
Road Transport (80km/h)	-	
Railway	-	
Existing Waterway (1,100 ton)	-	
Existing Waterway (1,300 ton)	-	
Existing Waterway (1,500 ton)	-	
Waterway with efficiencies (1,500 ton)	2,231,493.95	44.63
Total:	**2,231,493.95**	**44.63**

128. If the HPP is not improved and freight transport demand increases, the emissions of GHG may increase. In a hypothetical scenario in which freight transported by the HPP remained fixed throughout the period of analysis (Table 20), and the additional freight resulting from growth was transported by other modes, CO_2 emissions would increase to 6,366,047 tons, multiplying by almost three the result of the improved HPP scenario.

Table 20. Scenario 3: HPP fixed at 2007 level

Mode of Transport	Total emissions for 2010–2020 (tons of CO_2)	Cost of emissions for 2010–2020 ($US million)
Road Transport (50km/h)	3,522,101.61	70.44
Road Transport (80km/h)	-	
Railway	710,678.22	14.21
Existing Waterway (1,100 ton)	1,762,344.12	35.25
Existing Waterway (1,300 ton)	-	
Existing Waterway (1,500 ton)	370,922.71	7.42
Waterway with efficiencies (1,500 ton)	-	
Total:	**6,366,046.67**	**127.32**

129. Even from a conservative standpoint, assuming no modal shift toward the HPP, the HPP is clearly the most efficient mode of transport with respect to the other modes, and as a result has the least impact on climate change. As it is, the HPP is saving around 11.2 million tons of CO_2 emissions; with its improvement it would be saving around 11.9 million tons of CO_2 for the period analyzed. However, it is highly likely that some modal shift will occur to the HPP if it is improved; even if this shift is small, this would mean that the HPP is potentially saving more than 11.9 million tons of CO_2.

130. When the GHG emission reductions are monetized at US$20 per ton of CO_2, the value being saved by the existence of the HPP in the 10-year period analyzed is US$224 million. The monetized value of the GHG emissions of the HPP, if it continues functioning as it does, is US$58.01 million for the 10-year period. If the HPP did not exist, the cost of GHG emissions would increase to US$282.23. If the HPP is improved as proposed, it would reduce its GHG emissions to US$44.63 million.

131. The HPP improvement may contribute US$14 million to US$69 million in cost reductions due to GHG emissions over the 10-year period analyzed. The monetary gains in improving the HPP are limited, US$14 million for the 10-year period analyzed, as compared to an HPP following the present trend. It may also be stated that if the HPP is not improved, the deterioration of navigability conditions may make it stagnate, and in this case the cost of CO_2 emissions during the period analyzed would be US$69 million.

Table 21. Summary of GHG emissions

Scenario	Total emissions for 2010–2020 (tons of CO_2)	Cost of emissions for 2010–2020 ($US million)
No improvement present trend	**2,895,816.80**	**58.01**
No improvement and stagnation	**6,366,046.67**	**127.32**
HPP improved	**2,231,493.95**	**44.63**
No HPP	**14,111,559.32**	**282.23**

4. Institutional Feasibility

4.1. Constraints in the existing institutional setup

132. The proposed project to comprehensively improve the infrastructure of the HPP presents an unusually favorable cost-benefit ratio for an infrastructure project. However, it is not currently being implemented because it appears to be blocked. The project's IRR[33] is estimated at 25.3 percent for a 20-year timeframe (2024), exclusively considering the direct benefits. The total investment amount involved in HPP infrastructure improvements is equivalent to the transported market value of three or four full soy convoy loads.[34]

133. In recent years, the public sector in the five countries made some major progress in regulatory matters, and the private sector moved forward in fleet incorporation, improved operational efficiency, and modern port infrastructure development, but the waterway's navigability has yet to see significant progress. The public sector devised a common regulatory framework for the HPP, but it has only been partially ratified by all of the countries. Conversely, there are significant deficits in labor market training and integration, and no significant progress has been made in dredging and applied signaling for the waterways. Even with infrastructural shortcomings, the HPP's market activity level has significantly grown, reaching 14 million tons in 2008.

134. The causes of the inability to move forward with infrastructural improvements are not due to a lack of financial resources, but instead appear to lie in institutional deficiencies. Investment costs of the HPP improvements are relatively low; their dimensions in comparison with any other roadway or railway project are actually quite minor. The problems appear to lie clearly in the institutional framework. These difficulties appear in two areas: international coordination and the internal institutional weaknesses of each country. With respect to international coordination difficulties, it is worthwhile to note that the CIH's 36th meeting took place in May 2009. Despite its 15 years of experience, the organization has a deficient coordination system and lacks dynamic leadership. This phenomenon is not limited to the river transport industry because similar problems have arisen in other sectors within MERCOSUR. In practice, for more than five years the CIH has made no progress in the areas of most importance, losing the momentum it had during the first decade; multilateral mechanisms are now being replaced by bilateral mechanisms as a means of conflict resolution.

135. Some positive results recently produced by CIH may be seen in the form of a comprehensive study developed and administered by a consultant consortium. This study's main elements include technical, economic/financial, environmental, and legal/institutional issues. The study proposed an integrated implementation strategy for the HPP project. The strategy is based on a

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[33] Source: COINHI study, Alternative A-8.

[34] The transported cargo value of a 20-barge convoy carrying 1,500 tons of soy is approximately US$20 million (at a rate of US$400 per ton of soy).

supranational authority that awarded a concession for dredging and signaling, allowing the private concessionaire to charge a toll to all waterway users.

136. However, not all of the countries involved have accepted the proposal. Recent developments tend to show that integrated development of the HPP is increasingly inviable; this sets back the project's progress from an integrated framework and international negotiations, to partially supported solutions fostered by bilateral accords. In practice, Brazil did not adhere to the concept of a supranational authority, and more than one country did not internalize the proposed universal regulatory framework. Since 2004–2005, due to the impossibility of collaborating on dredging and signaling, the countries have been attempting to resolve their differences bilaterally, with little progress. Traditional uses and customs persist throughout the waterway, perpetuating the notion that each waterway section's sovereignty is exclusively national or shared between only two countries. The CIH's virtual paralysis has made it evident that the international or regional nature of the waterway has remained minimal.

137. In this context, the regulatory aspect of navigation is key because there are no common legal instruments; national regulations are the priority in each section. This exacerbates problems in the shared sections. For example, the side of the river that a navigating vessel is closer to, will determine which regulations are applicable, thus generating significant operational concerns and additional costs.

4.2. Country strategies facing a fragmented scenario

138. A fragmented approach is finally emerging for dredging and signaling. Each country is evaluating or implementing the necessary works in its sovereign sections of the rivers, and in shared sections they are examining bilateral agreements to carry out the works. Although this strategy has produced minimal results over the course of many years, it remains feasible. Two important risks are involved: (i) technical consistency may be lost (a minor risk since this particular case entails agreements on design parameters including convoy type, channel depth and width requirements); and (ii) tolls: depending on how each country decides to charge them, if very high values are chosen they may negate the project's benefits.

139. The fragmented execution of the HPP Project may lead to increased overall costs. Each section's individual contract may produce extraordinary revenues for the concessionaire, or may lead to overdimensioned projects. Moreover, the corresponding countries may attempt to use the waterway concession as a means for fiscal collection, particularly for passing traffic. These two aspects create a risk that high toll levels may end up rendering waterway transport inviable and may create tensions among countries. Under this framework, the following paragraphs will analyze the manner in which the five countries involved in the HPP are progressing, and how stakeholders are positioning themselves within the new scenario.

4.2.1. Argentina

140. Argentina has included dredging from Santa Fe to Confluencia as an extension to the pre-existing dredging and signaling contract (between Santa Fe and the Atlantic Ocean), in a process that, although still unfinished, shows some uncertainty. The two most relevant issues are: (i) the signaling design parameters that, based on ship owner and user perception, do not comply with convoy dimensions; and (ii) because information on the economic conditions of this concession is not public, there is uncertainty about future toll levels. Despite the fact that a public hearing was held on this matter, and the outlined agreement stipulates that the Government of Argentina will contribute US$75 million over a three-year period without charging tolls, there is still no certainty about the future structural level of the tolls. The agreement considers the option of extending the dredging and signaling up to Asunción, an alternative that could become practical pending the bilateral mediation between Argentina and Paraguay.

141. A recent factor that may modify the freight origin and destination matrix within the HPP is the recent Argentine resolution that suspends the exemptions of value-added tax (VAT) payment for temporary soybean import operations in the Rosario region. This resolution, besides affecting processing plants, has raised the prices of export operations in Brazil, Paraguay and Bolivia, whose traders have technically lost the option of exporting to Argentina.

4.2.2. Bolivia

142. Bolivia has not resolved the limitations it has to access the Paraguay River through the Tamengo Channel, which is in Brazilian territory. Although this issue has been discussed for over two decades under the multilateral and bilateral frameworks, no effective solution has been found. The Tamengo Channel has been contentious due to its physical characteristics, in particular its width, which is decidedly narrower than that of the Paraná and Paraguay Rivers. Most of the channel's stretch of solid foundation is covered with a layer of varying thicknesses of fine and medium sediments. This presents certain determining factors leading to the adoption of project parameters that differ from the rest of the Hidrovía's sections. Based on these limiting factors and given the fact that the water inlet impedes the air draft capabilities of watercrafts, this stretch is a bottleneck for shipments to and from Bolivia. To date, neither country has found a way to resolve these issues. The mandatory use of Brazilian pilots and convoy size are also contentious topics.

143. Growth prospects of soy and mineral iron output originating in Bolivian territory are very favorable. The demand for soy from crushing plants located in Puerto Suárez is still not being met; it requires an increase in soy production in the hinterland. The four oil-processing plants are in need of additional soy and there are plans to bring shipments from Barranca Vermelha, Mato Grosso by means of the waterway. With regard to the start-up of the Mutún mining site, the mineral exportation logistics are still undefined, and it is unknown whether exports will move through Puerto Bush (Bolivia) or through Ladário (Brazil).

4.2.3. Uruguay

144. **Under the HPP framework, Uruguay maintains a dispute with Argentina, Paraguay and Brazil because its vessels are not allowed to navigate in the HPP without pilots from each country.** Under both the multilateral and bilateral frameworks, this matter is part of the CIH agenda. Although Uruguay only participates in a limited portion of the HPP (the segment below the Uruguay River that allows convoy passage to Nueva Palmira), it has an active policy regarding the HPP because it aims to attract transshipment freight.

145. **Significant transfer infrastructure projects planned in the Nueva Palmira vicinity have been delayed, due in part to the global economic crisis as well as to administrative authorization delays.** For the moment, the new transfer terminal project of Rio Tinto in La Agraciada has been discontinued. The ADM grain transfer terminal in Barranca de los Loros (also in the Nueva Palmira vicinity) has been temporarily suspended as well. On the other hand, the elimination of VAT exemptions implemented by Argentina for temporary soy imports coming from north of the HPP will likely lead to the recovery of two million tons in the existing terminals in Nueva Palmira, which had been diverted to the port of Rosario.

4.2.4. Brazil

146. **Brazil has implemented an ongoing development policy for waterway navigation and cabotage at national level. Over the past few years, the country has maintained a favorable position on the HPP's development.** The recent National Transport and Logistics Plan favors waterway transport; with regard to the HPP, the plan previously appeared to favor road transport toward the Atlantic ports. In the exclusively Brazilian section of the HPP, the existing signaling is more functional than in the rest of the countries, although it does have two difficult passages.

147. **Although grain and oil exports from Brazil through the HPP are relatively limited, mineral exports have been extremely important but are currently uncertain due to the global crisis.** Mineral export figures totaled four million tons annually, but are falling significantly because only one of the four mines in the Corumbá area is functioning. In fact, after the announcement of the sale of the Rio Tinto mines and the fleet from Rio Tinto to Vale do Rio Doce, there has been strong uncertainty in the market concerning the continuation of the Rio Tinto expansion plans. This situation is creating major uncertainty for the HPP system's demand forecasts.

148. **In addition to this uncertainty, there is substantial concern about the considerable decline in water levels in the northern section of the Paraguay River, the most significant decline in the past four decades.** This decline is mainly affecting freight shipments to and from Brazil and Bolivia. This is causing reconsideration of railroad transport to the Cosipa terminal in Santos. It may also lead to the transport of soy by truck to Paranaguá.

149. The potential environmental impacts of dredging in the Paraguay River and the Tamengo Channel are sensitive issues in Brazilian public opinion. Nevertheless, some of the more radical standpoints have recently been rejected by the government, which has now taken up the defense of waterway navigation on environmental grounds, among others (e.g., GHG emission reductions). However, in the upper portion of the HPP, the preservation of the Pantanal is a legitimate concern and very sensitive to public opinion.

4.2.5. Paraguay

150. The Paraguay River section of the HPP, in Paraguayan territory, is considered to be the key to the regional waterway system and a crucial element to improving this landlocked country's access to the waterway. Therefore, the declining water levels are a deep concern to Paraguay. In the past two decades, Paraguay's foreign trade has turned massively to the waterway in terms of bulk solids and liquids, and containerized freight. As a result, road transport of soy to Paranaguá, and to the general freight containers destined for Montevideo and Buenos Aires, has been reduced to a minimum.[35] This justifies the concern about the low water levels: vessels that usually navigated with 10 to 11 feet of draft have lately had to settle for 7 to 8 feet, which has alarmed freight owners and transport operators. Not only is the traffic from north of Asunción feeling the effects (today this is basically temporary traffic, even though the vessels operate under the Paraguayan flag); it is highly likely that declining water levels are also affecting flows toward the south of Asunción, critical for Paraguay's international trade (fuel and container imports, various exports).

151. The demand originating around Concepción is currently growing, and the Paraguayan section of the HPP tends to not only be for passing traffic, but is also beginning to be relevant for its own exports. It is estimated that Paraguay's fertile areas are capable of doubling, and their geographic characteristics would allow two or three harvests per year. This tendency modifies the relative interest of the country and its actions with regard to waterway transport north of Asunción.

152. Paraguay is considering taking the initiative of developing its own concession in its exclusive, sovereign segment. However, the limited institutional and technical capacities may make this initiative difficult to implement. Paraguay is studying the possibility of implementing a concession of the dredging and signaling of the sovereign stretch of the Paraguay River and to hold talks with Argentina on the stretch under shared sovereignty. The Bank is supporting this study with PPIAF financing. The preliminary results of the study are encouraging; they indicate that this is a plausible solution. However, it is subject to the Paraguayan Congress's approval of changes to the concession law; such approval is not deemed easy given the political situation in Paraguay. Nonetheless, there seems to be a clear consensus in Paraguay on the urgent need to improve the navigability of the waterway.

[35] It is not this way with respect to commercial transport between Paraguay and its neighbors, conducted almost exclusively by truck transport (except bulk liquids and soy transport in the Rosario area).

153. **Although the unification of regulations could not develop as expected after Mercosur's implementation, in part due to lobbying by affected parties, some progress is taking place based on national or bilateral initiatives.** Regulations on vessel safety are increasing, particularly by Argentina´s Coast Guard (most convoys use the river section under its control); for example, these require more demanding inspections and double hulls. The fact that many rules were not unified may be due to several reasons: (i) some lack of realism in the initial meetings, based more on political will than on technical analysis; (ii) lobbying by carriers—and shippers that are becoming carriers—to avoid stricter regulations; (iii) IWT workers defending their jobs from the participation of pilots and crew from other countries, and their working conditions; and (iv) the shipyard industry trying to maintain high tariffs on used tugs and barges, in order to protect local production.

4.3. Other stakeholder positions in the new scenario

154. **Due to historical limitations in the supply and quality of transport services, freight owners have acquired a functioning fleet to avoid total dependence on transport operators. Their concerns are consequently not only about the possible reduction of business but also about a decreased use of their vessels.** In fact, a significant part of the fleet belongs to and is operated by various large freight owners (ADM, Cargill, Dreyfus, Rio Tinto, Noble). The reduction in market size is raising deep concern for their survival as operators in the short term. The causes for the decrease in market size are: (i) a lower demand for commodities due to the international crisis, (ii) decreasing river water levels, and (iii) the drought that is limiting agricultural production. Waterway operators are extremely worried about their prospects for survival in the short run. With respect to ports, there does not seem to be a high level of concern (these are physical facilities that depreciate over time). Nevertheless, industries that have invested in oilseed crushing plants do appear to be worried.

155. **Dredging firms have shown a strong interest in speeding up the HPP improvement process.** Paradoxically, the extraordinarily low river levels have created more work possibilities for this type of firms. On the one hand, in the cases where these firms are contractually obliged to maintain a pre-established depth, this water level decline can be quite a risk. It is still unclear to what degree the global crisis will affect the dredging market. Since financial conditions often tend to halt many endeavors (and release dredging capacity), there are more than a few cases in which projects have continued despite the crisis. On the other hand, various countries are experiencing union pressure from state-owned dredging enterprises and their personnel, making PPP setups in dredging and signaling more challenging.

4.4. Key issues to consider in a fragmented strategy

156. **Institutional capabilities for dealing internally with waterway transport matters in each country are very weak, from specifically technical areas to those of international relations necessary to carry out the negotiations of a project with a regional scope.** Public policies related to

waterway transport appear to have evoked little interest in comparison to other public policies, and have been far from the center of government agendas. The subsector has been given limited importance or institutional weight, and has been assigned a limited number of capable professionals. Private sector interests in these countries have consequently managed to make their interests prevail.

157. The Paraguayan Government's decision to adopt the implementation model of the HPP project in the section between Asunción and the Apa River is key. It is highly plausible that the sovereign sections belonging to Argentina and Brazil will be dredged and buoyed by their respective countries. The stretch between Asunción and the Apa River, which constitutes a large portion of the investment resources (approximately half of the HPP's total investment costs), is crucial to ensure traffic circulation that originates in or is destined for the northern part of the HPP (Brazil, Bolivia and the zone continuing on to Concepción). Bearing in mind that, with the relative institutional weakness of the waterway transport system in Paraguay for analyzing the pros and cons of the concession structure that could be developed, World Bank support will be of utmost importance.

158. In the context of fragmented decisions and institutional weakness, the multilaterals can contribute to ensuring consistency throughout the project and can appoint technical teams for each of the participating countries. In the case of providing financing, in both the public and private sectors these organizations can contribute by applying environmental safeguards.

5. Proposed strategy options

5.1. The way forward for the implementation of HPP improvements

159. The project for improvement of the HPP infrastructure continues to present an enormous potential impact on the region. The principal benefits of the waterway are reducing logistical costs, promoting competition and increasing regional trade. Equally important, the project is definitely favorable to the environment. The short decline in water levels logged in 2009 consistently highlights the fact that the improvements are designed not only to foster navigation in the region, but to help maintain the waterways in cases of extraordinarily low water levels.

160. The analysis of the evolution of institutional negotiations indicates that progress with a fragmented strategy is inevitable, country by country, since the regionally coordinated and integrated strategy has reached its apex of development and has not prospered. The regional coordination mechanisms are continually losing efficiency.

161. The private sector that takes part in the waterway navigation arena (freight owners, transport operators, terminals) has significant technical and financial capacity for contributing to the improvements and strong incentives to execute them. But the private sector is unable to act without proper government authorization. These issues require the involvement of the public sector to authorize dredging and signaling works, or to permit waterway toll charges.

162. A Bank agenda to support this project can be structured around three sets of simultaneous yet interdependent activities: (i) institutional support to all five participating countries concerning waterway navigation; (ii) technical support to promote PPP projects for dredging and signaling works in Paraguay and Brazil in order to complete the improvements north of Confluencia; and (iii) investments in supporting access infrastructure, particularly in Argentina, Paraguay and Bolivia. This agenda would be supported by the Bank together with other multilateral entities that are involved in the sector.

163. Institutional support fundamentally includes the internalization by all countries of the common regulatory framework and capacity strengthening in each country. The Bank could be instrumental in helping to resolve bottlenecks that have kept the countries from ratifying all of the Hidrovía's regulatory framework. At the same time, the HPP's technical characteristics among countries must be unified. A series of regional workshops dealing with this study could be the appropriate mechanism to jump-start this discussion.

164. The Bank could support the strengthening of institutional technical capacity in each country through specific technical assistance. There is limited technical and institutional capacity in each country regarding the HPP and river navigation in general. There is a need to create and strengthen institutions in each country and to increase the number of country technical staff in the subsector. The support should include riverway maintenance, safeguards, and concession supervision and control.

165. The project launch should take place in Paraguay, in the section between Confluencia and the Apa River, where the majority of the works are located. This is also where the country's main economic and logistical challenges are found. The first act of support for Paraguay should be technical assistance in defining the PPP strategy for dredging and signaling, both for initial operations and for maintenance. Subsequently, financial support could be offered if necessary. At present, as previously described, this technical support is ongoing and should result in the structuring of a concession scheme. The Bank may continue to be involved later on through the IFC, which may support the possible transaction and could offer a guarantee to reduce investment risks.

166. Along with project progress in Confluencia and the Apa River, dredging and signaling works should be implemented in the sections with exceptionally high and low water levels, mainly through technical rather than financial support. Argentina and Brazil have the possibility to resolve their HPP issues in shared areas and those under national jurisdiction, through concessions and other contractual forms adopted by government entities. The World Bank's role should be to concentrate on ensuring the project's consistency, and could provide technical assistance with PPIAF funding for the definition of these projects.

167. The third pillar of the proposed strategy is investment support in specific riverway access infrastructure that could enhance the use of the HPP. These investments could include roads, railways, port terminals, etc. All are defined in the "wider" HPP project as defined by IIRSA. However, a modest approach should be adopted, and the country needing the most support with regard to access to the

HPP is Bolivia, due to the difficulties presented by the Tamengo Channel. The Bank could support Bolivia through a specific investment loan in this respect.

5.2. Final considerations

168. This report clearly shows the great impact the HPP can have on the reduction of GHG emissions and transport costs in the region, and a role for the Bank through a reasonable and viable strategy. The next steps would be to disseminate this proposal to stakeholders in the Bank. This study should be disseminated to interested parties in the Bank such as the Brazil, Bolivia, Argentina, Paraguay and Uruguay CMUs, the Transport Board, the Logistics Anchor, and the Logistics Beam in LAC. The purpose of the dissemination would be to refine the proposed strategy and prepare the next steps.

169. Likewise, additional work should be carried out to deepen the analysis of the HPP's impact. Because this study was a first step and only limited funds were available, an initial estimate of GHG emissions was made. However, many refinements could be added to the calculations, in particular: (i) assumptions regarding modal shift; (ii) further analysis of vehicle and fuel efficiency; and (iii) further study on freight induction due to the existence of the HPP. This additional work should not limit the proposed dissemination, but simply be an addition that could enhance the study and could be carried out if it is agreed to pursue the proposed strategy.

170. The proposed strategy should be discussed with the authorities in each country. Due to the findings of this report, in which the importance of the HPP, its positive impact as well as its modest cost have been established, it may be stated that this is definitely a worthy and important regional project in which the Bank could become involved. It has been shown that the main reason for the inability to get the project going has been its multilateral nature. The Bank should present these findings to all countries and refine the proposed strategy with their participation. This strategy should include the improvement of the analysis and result in an investment plan with the consensus of all countries and stakeholders involved.

ANNEX 1. PUSH-TUG COST MODEL

A. Cost Structure Rationale

The cost-structure analysis of a barge convoy is formulated by considering the tug and its barges as one joint entity, as if it were one individual vessel. It is feasible to analyze them separately, in the sense that once the tug arrives at port, it leaves the barges full and returns the empty crafts to the original location. This latter operational method is more efficient, but for the purpose of the analysis, calculating in these terms is more sophisticated and goes unnecessarily beyond the scope of this task. Since the goal is to compare costs with or without the project, calculating the operation in an integrated manner should be seriously considered.

Based on the information above, a 16-barge convoy operation will be analyzed, with a maximum freight capacity of 1,500 tons and a 10-foot draft. According to these parameters and the selected itinerary matrix, the studies will proceed in a manner compatible with the previously defined terms to determine operational costs per trip and per ton, with and without the project.

To approach this analysis appropriately, a model has been constructed with the following categories:

Fixed Costs

It is understood that the essential fixed costs only cover the ship owner’s expenses, which include the following categories:

Fixed Costs
Depreciation of tugs and barges
Tugboat hull and machinery insurance
Tugboat PANDI insurance
Barge hull insurance
Barge PANDI insurance
Provison for tugboat dry-dock inspection
Provision for barge dry-dock inspection
Fleet administration costs
“Flag” fees

Variable Costs

Variable costs are those derived from the actual convoy operation. That is to say, they are the costs that the ship owner incurs only when transporting freight and handling the vessel and crew (fueling, wages, etc.).

In this analysis it has been considered, on the one hand, that in the cases where hydrocarbons and minerals are transported, the boat operates year-round. In the cases where there is a post-harvest period, as in agro-products, a period of inactivity has been considered in which no wages or operating costs are accrued. The period of operation considered in this case is estimated to be 200 days per year. In the case of the nonseasonal loads, an operational period of 350 days is assumed, taking into account a period of inactivity for maintenance.

Variable costs include the following categories:

Variable Costs
Wages
Personnel and administrative costs
Fuel costs
Lubricant costs
Repairs and maintenance
Food for crews
Agency and port fees
Navigation fees

B. Cost Structure Analysis

Each cost is defined to clarify the scope, the circumstances in which it occurs, how it is determined according to the model, and what values it may have.

Fixed Costs

a) Depreciation of Tugs and Barges

Push-tug depreciation is an important cost relative to the cost equation. The tug is a vessel with complex hydraulic and electric machinery and systems considered to be the heart of the tug-barge union. Poor maneuvering can cause the convoy to suffer a crucial breakdown, resulting in high equipment expenses. For this reason, when considered along with the dilapidation that an extended period of usage yields, the depreciation timeframe considered should not exceed 20 years.

Barges are simple vessels, without propulsion, and may or may not require covered holding areas depending on load type. Barges do not require the same crew as that of a push-tug. They have no complex machinery: hydraulic, electric or otherwise. They also lack elements sensitive to wear, and thus depreciate at a very slow rate.

Barges navigate through fresh waters, so damage due to corrosion is minor. These vessels only require dock passage once every three years for inspection and painting. Unless a barge is involved in an accident, it will have a very long shelf life.

Therefore, barge investment costs can be recovered in less than 20 years. Under this criterion, this associated value is not one of the most important or defining barge operation costs.

b) Tugboat Hull and Machinery Insurance

Tugboat insurance costs are a function of the value of each specific tugboat. In general, because of their age, existing HPP tugs have limited insurance, which does not cover machinery. The insurance only covers damage to the hull, including its attachments such as the shaft, propeller and rudder. The insurance also includes breakdown and collisions with other vessels or stationary facilities. The insurance covering a hull of this type represents approximately three percent of the overall insured value.

c) PANDI (P&I) Tug Insurance

PANDI clubs cover navigation in inland waterways similar to those covered in maritime waters. In the HPP, various clubs exist to service the fleets. A variety of companies also insure third-party liability. The costs are slightly higher than hull insurance, around five percent, and each company contracts the tug-barge set or complete fleet. Historically, within the HPP it has been possible to use PANDI insurance without the need for specific classification, obtaining certification from local enforcement authorities.

d) Barge Hull Insurance

Barges are insured only for hull damage, in a manner similar to the hull of other vessels, and at a similar rate of around three percent of the overall value.

e) PANDI Barge Insurance

The above information regarding PANDI tug insurance is also applicable to barges.

f) Precautionary Dry-dock Inspections every Three Years for Tugs

Maritime administrations under each regional flag generally use the same norms for controlling vessels, obliging tugs to dry-dock at a maximum of every three years. This makes it necessary to expect an increase in dry-dock activity during certain periods. Within the outlined costs, proportionate costs are included for these precautions, including shaft, propeller and rudder inspections. Also included are the washing and painting of the hull, which are estimated to cost around US$100,000 every three years.

g) Precautionary Dry-dock Inspections every Three Years for Barges

With respect to barges, the period for dry-docking is at a maximum of every four years. This makes it necessary to expect an increase in dry-dock activity during a specific period as well. Outlined costs for barges include dry-docking for washing and painting every four years; average costs for this are approximately US$50,000 per barge. The price depends on the location: in Paraguay it is generally more economical than in Argentina or Brazil. Uruguay does not possess the facilities in the river zone to handle this type of operation.

h) Fleet Administration Costs

These costs are defined as those essential to the structural maintenance of a basic company capable of monitoring the vessels during periods of inactivity. The costs depend on the size and scale of advantages for the company. In this regard, a basic company needs to possess the following personnel and equipment:

- A naval engineer or equivalent to be the company's technical representative when interacting with authorities;
- A operations controller who is capable of advanced maneuvering for mooring purposes;
- Three 24-hour watchmen operating in three shifts per day;
- A pickup truck;
- An office;
- An administrative clerk.

A company with this makeup would incur monthly expenses of approximately US$30,000.

i) Flag Fees

These fees include the rates charged for the registration and maintenance of a flag certification, the statute certificates, and the navigability inspections by authorities.

Variable Costs

a) Wages and Salaries

The costs of wages for Hidrovía vessels vary depending on their respective flag, because there is still no universal agreement on labor standards. These standards depend on the given country and current job market conditions. Currently, the majority of HPP vessels and tugboats are operating under the Paraguayan flag, a fact that has been duly noted in the analysis of national personnel costs. For many years, it has been known that Paraguay's crew costs were much lower than those of Argentina and Brazil.

However, Paraguayan legislation favors the incorporation of vessels under its flag and has experienced a mounting increase in charter demand. In recent years there has also been a consequent increase in the demand for Paraguayan crews; this demand eventually has equated to the same total costs as those of Argentina.

Crew members obtain their official certification aboard the vessels and progress through each category for time spent on board, including the accumulation of actual navigation days and the corresponding professional aptitude examination on the academic premises of the Navy, with the involvement of the Paraguayan Maritime Authority (the *Prefectura General Naval*).

From the understanding of the crew-member labor market, it can be concluded that the significant current demand has caused several positions to reach very high salary levels. These positions include captains, pilots and engine chiefs, especially for tugboats.

With the importance of crew demand, labor enforcement legislation made it necessary to grant additional benefits. These benefits include employing temporary crew members so that vacations are more regular for all, which means higher costs. In conclusion, as a general standard crew members are valued according to their specific position. Overtime has been considered in the calculations.

b) Fuel Consumption

Fuel consumption depends fundamentally on the technical parameters and the operations of each tugboat, which is average around 5,000 HP.

Speed

The estimated speed of a convoy is 8.0 km/h in the without-project scenario and 9.6 km/h in the with-project scenario, with both parameters averaging their respective highs and lows. These are gross time figures, which include delays and periods of inactivity that may be attributed to overnight stops or areas that require convoy disassembly.

Consumption of specific fuels

Specific fuel consumption by diesel motors varies depending on motor characteristics, although the scale of this variation is minimal. The average of 190 grams/HP/hour was used in the calculations.

Power supply by machine
It was assumed that the engines are providing 80 percent power during hours of navigation.

Daily navigation hours
Hidrovía signaling is generally inadequate. There are zones that have adequate signaling, such as the Paraguay River area under Brazilian jurisdiction. However, from south of the Apa River to Confluencia, the Paraguay River (in northern Paraguay, and from Asunción to the south) and from the Paraná River to Santa Fe, signaling is useless and complicates night-time navigation. Thus, it is common for barge convoys to navigate on average only 16 to 18 hours per day. It should be also noted that the crew is often required to buoy the passages before clearing them, creating additional delays in navigation. According to these calculations, navigation is limited to 16 hours per day.

Hourly and daily consumption is calculated at:
5,000 HP x 190 gr/h/HP x 0.86 (gr per lt. diesel) x 0.80 (%) = 653 lt. diesel per hour.
653 lts x 16 hours = 10,458 lt. Diesel per day during 16 hours of navigation.

Fuel represents a major expenditure in barge convoy operations. Most tug motors consume marine diesel oil (MDO), which is similar to the diesel used in road transport. The consumption of this fuel has been extended, leaving the use of heavy fuel oil (IFO) for low-power propeller motors. IFO-consuming tugboats are currently being incorporated into the HPP. The average price available in the region is US$0.61 per liter.

Lubricant consumption
Lubricant consumption for motors of average speed ranges from 3.5 to 4.0 Gr/HP/hour. The average price of lubricatants is US$3 per liter.

c) Repairs and Maintenance
Convoy, tug and barge maintenance is handled by in-house personnel or outsourced to a third party. The estimated annual cost for repairs and maintenance is US$360,000.

d) Crew Provision
On average, each crew member consumes the equivalent of US$6 per day.

e) Port Fees
Port and agency fees vary by port. These fees are estimated at an average of US$5,000 per vessel/trip.

f) Pilots

The use of pilots in the HPP was not considered.

g) Navigation Rates

At present, an analysis of navigation rates has not been included. This refers to the usage of the channels to the south of Santa Fe and others that aid in transport navigation, for which information is not yet available.

ANNEX 2. DETAILS OF THE INLAND WATERWAYS IN THE US AND EUROPE

A. THE UNITED STATES

In the US, the unit cost to transport commodities over inland waterways is two to three times lower than other forms of transportation.[36] The cost of transporting cargo using the inland waterway system is estimated to be US$10.67 per ton less than alternate rail or truck modes, which results in US$7 billion per year in transportation savings—a 14-to-1 return on the US$500 million invested annually in the system's operation and maintenance. Nearly 800,000 jobs result from the activities of the inland waterway system and generate a payroll of US$1.7 billion and over US$425 million in federal and state payroll taxes annually.

The US has 25,000 miles of inland and intracoastal, navigable waterways, of which 12,000 miles are commercially viable and operated and maintained by the US Army Corps of Engineers (USACE). For over 150 years, the Corps of Engineers has been responsible for planning, constructing, maintaining, improving and operating inland waterways, including harbors. This responsibility includes engineering feasibility studies, cost studies, economic analyses and development of data for congressional authorization of financing. Daily management of the locks and rivers is undertaken by the local canal authority.

This system serves 41 states and connects to 152,000 miles of rail, 460,000 miles of pipelines, and 45,000 miles of interstate highways. Annually, the system handles nearly 2.5 billion tons of cargo. Improvements to the inland water system are estimated to provide US$5.5 billion per year in cost savings compared to the cost of using rail and highway transportation alternatives. The USACE maintains 300 large commercial harbors that serve as the gateway for 98 percent of US foreign trade valued at nearly US$700 billion.

The waterway system also has 191 locks, over 600 smaller recreational and commercial harbors, and 237 active lock chambers. About 15 percent of the lock chambers are 1,000 to 1,200 feet long, 60 percent are 600 to 999 feet long, and 25 percent are less than 600 feet long. Lock widths are mostly 110 feet. The 1,200-foot locks can accommodate a convoy of 17 barges plus the tugboat, while the 600-foot locks can accommodate at most 8 barges plus the tugboat.

In the US, domestic volume of freight in 2006 reached 1billion tons. This figure includes lake, coastal, intra-port, intra-territory and internal movements. In 2006, of the 191 US ports, the coastal ports (115 in total) handled 200 million tons or 227 billion ton/miles, the Great Lakes ports (49) handled

[36] http://www.vtn.iwr.usace.army.mil/navigation/naveconomic.htm

96 million tons or 53 billion ton/miles, and the inland ports (26) handled 630 million tons or 289 billion ton/miles. The average coastal haul (from channel entrance to port) is 1,125 miles while the inland haul is 445 miles. The Corps of Engineers maintains updated monthly records of commodity movements along its waterways. From December 2007 to April 2008, US inland waterways transported on average 10 percent less compared to the same period in 2009. In the US, based on domestic volume, the Mississippi River mainly transports coal (34 percent), petroleum and its by-products (18 percent), and raw materials (20 percent).[37]

US inland traffic is projected to grow by as much as 37 percent over the next 20 years. US freight demand will increase nearly 70 percent by 2020.[38] Other sources indicate an increase of 50 percent in domestic water transport by weight by 2035 while stating an increase of 37 percent in the value of the shipments between 2006 and 2035.

For the US in 2006, approximately 41,000 vessels were registered as transporting goods in the Great Lakes, the Mississippi River system and Gulf Intracoastal Waterway, and on the Atlantic, Gulf and Pacific coasts. Of these, the largest share was for non-self-propelled barges (dry cargo) amounting to close to 30,000 barges and representing 45 million short tons of capacity. The majority of the barges (86 percent) operate on the Mississippi River and the Gulf Intracoastal Waterway. It is important to note that the construction of new vessels, and particularly of dry open barges, increased by 60 percent in 2006 over 2005.

B. EUROPE

In the European Union, inland waterway transport is considered effective and energy efficient: its energy consumption per ton-kilometer of transported goods corresponds to one-sixth of the consumption on roads and to half of that of rail transport. Its noise and gas emissions are modest. According to the EU, the total external costs of inland navigation (in terms of accidents, congestion, noise emissions, air pollution and other environmental impacts) are seven times lower than those of road transport.[39] Inland waterway transport in 2005 generated over 41,000 jobs out of an overall 8.8 million in all transport modes**.**

The European Union has approximately 37,000 km of waterways. This implies a density of 9.4 km per 1,000 km^2, twice as much as the ratio in the United States (about 4.5 km per 1,000 km^2, based on approximately 41,800 km in length, excluding the Great Lakes). The core waterway network with rivers and canals of international importance is formed by more than 12,000 kilometers of interconnected waterways, close to 450 locks and several hundred inland ports and transshipment sites. Smaller waterways make up the remainder. Although the EU's waterway density is lower than the road and rail networks, waterways connect most European economic centers.

[37] http://www.ndc.iwr.usace.army.mil/wcsc/pdf/wcusnatl06.pdf
[38] http://www.vtn.iwr.usace.army.mil/pdfs/cw_strat.pdf
[39] http://ec.europa.eu/transport/iw/overview/assets_en.htm

In 2006, the EU's inland waterways transported significantly more freight than that of US waterways, but only a fraction of that of Chinese waterways. The EU's inland waterways transported 138 billion ton/km of freight, 1.5 trillion ton/km through cabotage and approximately 40 billion passenger km in passenger transport (US waterways transported 835 billion ton/km, 385 billion in cabotage and a relatively insignificant 600 million passenger km). In comparison, China transported approximately 1.1trillion ton/km on inland waterways and nearly 4 trillion ton/km in cabotage.

The forecasts for IWT growth in the European Union are mixed. According to the Prognos European Transport Report, overall goods transport in the 15-member European Union (EU15) will grow by 42 percent between 2000 and 2015. Demand for inland waterway transport is currently expected to grow in the same period by 35 percent, compared to 41 percent growth in goods transport by road and 51 percent by rail. The TEN-STAC study claims that inland water transport for the EU15 will grow by 50 percent between 2000 and 2020. The Ecorys forecast anticipates an annual growth rate of inland water transport of slightly below 14.6 percent between 2000 and 2010; divided by commodity type, solid bulk freight continues to have the highest share in total volume, while container traffic has the highest growth potential, followed by general cargo. In light of the EU expansion, the OIR study projects an increase between 36 percent in the base scenario and 105 percent for an optimized scenario between 2000 and 2015.

In the EU, IWT of self-propelled vessels and barges has generally been declining, with the notable exceptions of Germany and Hungary. Scrapping schemes in individual member states may have contributed to this significant decrease, as well as to an increase in transport efficiency, through larger and faster vessels. Based on available data for the EU, there were around 13,000 self-propelled vessels and around 7,000 barges in 2003. There are 7,000 enterprises in six member states with a total fleet capacity of 11 million tons. It is interesting to note that the Rhine favors the use of self-propelled vessels (84 percent) while only 4 percent operate on the Danube. However, pushed barges are used relatively evenly on the two rivers, with 34 percent operating on the Rhine and 44 percent operating on the Danube.

As part of the European Transport Strategy 2010, the Trans-European Transport Networks (TEN-T) policy identified 30 priority infrastructure programs to be implemented by 2020; these were declared to be of "European interest" and receive priority funding. For the first time, two of the projects were waterway projects along the Rhine-Main-Danube axis with the overall objective of allowing the passage of vessels of up to 3,000 t + to achieve a minimum draft of 2.5 m. EU cofinancing for waterways will rise to an 11.5 percent share in the total budget in comparison to the poor 1.5 percent of the previous financing periods. "Rhine/Meuse-Main-Danube" will receive up to €190.2 million, while "Seine-Scheldt" will receive as much as €420.19 million for cross-border cooperation between Belgium and France. Support for the trans-European Transport Networks will not exceed €8.17 billion, making the leverage of €225 billion in total funds almost impossible. Hopes remain set on the Structural and Cohesion Funds and loans from the European Investment Bank to complete Europe's transport networks.

The Marco Polo program is a EU grant scheme that will spend €400 million in 2007–2013 to support sustainable and innovative transport operations. So far the program has had no success for inland shipping.

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