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Commentary

Critical environmental costs of the Paraguay-Paraná waterway project in South America

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Abstract

The proposed Paraguay-Paraná waterway project, know as "Hidrovia", would improve and develop year-round navigation by large ships and barge trains from Cáceres, Brazil, to the harbor of Nueva Palmira, Uruguay. Of particular environmental concern, the project would drastically alter the river system in the previously undeveloped reach from Cáceres to Corumbá, Brazil, and directly affect the Pantanal. The Pantanal is one of the world's largest wetlands and is important both for the biodiversity it supports and for its regulatory impact on the downstream river system. This preliminary evaluation of the project establishes a critical value for the environmental costs that, if included in the evaluation of the project, would tip the scale in favor of preserving the Pantanal rather than developing the waterway through it. It is concluded that the environmental costs may exceed this critical value and that the waterway may be uneconomical in the Pantanal. The indication is that expenditures on further feasibility studies are likely best spent by investigating the feasibility of the project downstream from the Pantanal.

Keywords: Critical value; Economic feasibility; Environmental costs

1. Introduction

The La Plata Basin countries of Argentina, Bolivia, Brazil, Paraguay and Uruguay recently formalized their interest in revitalizing navigation on the Paraguay-Paraná river system with a project commonly known as "Hidrovia". Their interest in Hidrovia has been stimulated by the formation of the Southern Cone Common Market (MERCOSUR) and the desire to integrate and promote the economies of the member countries. Financing for the project would be provided by the Inter-American Development Bank (IDB).

The Paraná River and its major tributary, the Paraguay River, comprise the second largest river system in South America (Bonetto, 1986a). It links the interior of South America with the deep-water ports along the lower reaches of the Paraná and La Plata rivers. The river system stretches 3442 km from Cáceres in the Brazilian state of Mato Grosso, to Nueva Palmira, Uruguay in the Paraná delta. As shown in Fig. 1, it connects Argentina, Bolivia, Brazil, Paraguay and Uruguay.

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Fig. 1. Map of Paraguay-Paraná waterway.

The ports along the Waterway serve as hubs for regional and nonregional trade in agricultural production and ores, including soybeans, manganese and iron. Indeed, it is the potential shipment of soybean production from Brazil that largely motivates the development of the upper reaches of the Hidrovia project. Even in its current state of disrepair, it is estimated that 4 to 6 million tons of goods are transported on the waterway annually.

The formulation of Hidrovia receiving the most attention proposes to improve and develop the navigation system from Cáceres, Brazil, to the harbor of Nueva Palmira, Uruguay. This transportation system would serve considerable portions of Argentina, Paraguay and Brazil and would provide direct access to the Atlantic Ocean by Bolivia. It is expected that by allowing year-round navigability by large ships and barge trains, Hidrovia will provide a cheap alternative for the transport of goods throughout the region. The project includes dredging, course changes, correction and stabilization of navigation channels, and regulation of water flows. Of particular concern, it would drastically alter the river from Cáceres to Corumbá and directly affect the Pantanal, including the Pantanal National Park of Brazil.

The Pantanal is an immense plain located in the states of Mato Grosso and Mato Grosso do Sul in southwest Brazil. It is considered to be one of the world's largest wetlands with an estimated area of 140000 km^2 that floods annually between January and June. The Pantanal is recognized internationally for the richness of its wildlife (Alho et al., 1988). Moreover, the Pantanal has been considered a conservation priority in the Constitution of Brazil.

The Pantanal also functions as a large impoundment that slows down the flow of water coming from the upland drainage basin. As a result, it releases more uniform discharges and delays the annual rises of the lower Paraguay by about 6 months (Soldano, 1947). This lag not only is important in maintaining the Pantanal's rich biodiversity through periodic flooding, but is also beneficial to navigation given that it shortens the low-water season along the Paraguay-Paraná system.

The purpose of this paper is to provide a preliminary economic assessment of the environmental impacts of Hidrovia. Given the current availability of information, our analysis is limited to identifying the likely environmental costs and the critical economic value they must have in order for Hidrovia to be judged uneconomical. Indeed, this approach may be the paper's major contribution to the current debate over Hidrovia. Furthermore, we wish to alert concerned parties to the potential environmental costs of Hidrovia, the sensitivity of the feasibility of Hidrovia to inclusion of these costs, and to balance the more publicized trade benefits of Hidrovia.

2. Environmental risks

Construction and operation of Hidrovia will have a number of severe and complex negative impacts on the environment of the region and,

particularly, the Pantanal. A detailed accounting of these impacts is contained in Bucher et al. (1993). The following discussion is limited to providing a brief synthesis of the likely environmental impacts.

2.1. Loss of the "sponge" effect of the Pantanal

Straightening, dredging and consolidating river channels from Cáceres to Corumbá will alter the hydrology of the Pantanal with two major consequences. First, the speed with which water flows through the Pantanal will be increased. As a consequence, the flooding regime within the Pantanal may be changed and the flushing and water exchange with the wetlands lateral to the tributary channels decreased. The end result would be a decrease in biodiversity within the Pantanal, about which more will be said later.

Second, reducing the sponge effect of the Pantanal will reduce the stability of water flow through the Paraguay River (Arduino, 1990). The faster transit of floodwaters through the Pantanal may increase the chances of an overlap of the peak flooding periods of the Paraná and Paraguay rivers. As a consequence, the risk of both catastrophic rises and extreme lows in water levels after the confluence of the two rivers at Corrientes will be increased (Aisiks, 1984). Flooding losses will be increased and the navigable period of the river will be decreased.

2.2. Increased siltation and coastal erosion

Navigation by large barge convoys will increase erosion of the river's shoreline and bottom. This, in turn, will raise the amount of suspended solids in the river, which will decrease aquatic organisms and water quality for human and industrial uses. In addition, induced development, particularly that of soybean production, will increase soil erosion and, as a consequence, siltation of the river.

2.3. Increased pollution

Increased pollution from several sources resulting from urban and industrial development and eventual navigation accidents will inevitably affect the water quality. Various forms of mining and mineral extraction already present in the Pantanal will likely expand and, thus, increase the possibility of the release of environmentally active chemicals.

2.4. Loss of biodiversity

The combination of changes in the hydrological regime, habitat loss and degradation, resource over-exploitation, spread of exotic species, and chemical and organic pollution have been considered critical factors in freshwater extinctions by Allan and Flecker (1993). All of the above factors are likely to increase if Hidrovia becomes operational. Of great importance is landscape simplification resulting from dredging, channelization, channel straightening, deforestation and changes in the flooding regime, which are likely to reduce the present diversity of wetland habitats and vegetation types, particularly those that are dependent on periodic flooding disturbances in the Pantanal.

A special case of biodiversity loss is the impact on fish species. Many fish depend upon a complex pattern of breeding and feeding migrations between the mainstream and temporary ponds which are triggered by seasonal flooding. These fish will likely be affected by changes in the hydrological regime (Bonetto, 1986b; Cordiviola de Yuan, 1992). Large fish are likely to be the most severely affected, including some fish of considerable economic importance such as the Jaú (*Paulicea lutkeni*), Dourado (*Salminus maxillosus*), and Surubim (*Pseudoplatystoma coruscans*). Subsistence, sport and commercial fishing will, therefore, be affected (Allan and Flecker, 1993; Bonetto, 1986b).

Physical changes in the rivers and alterations of the hydrological regime may also increase the mobility of floating vegetation, particularly water hyacinths. Accumulation of floating vegetation at critical points may not only affect navigability, but also cause limnological problems including massive fish mortality due to oxygen depletion. On the other hand, control of floating vegetation coupled with changes in the hydrological regime

may have the opposite effect, resulting in a drastic reduction of the water hyacinth's productivity which in turn may cause a decrease in energy flow and productivity throughout the whole ecosystem (Neiff, 1986; Poi de Neiff and Neiff, 1988).

2.5. Expansion of vector-borne diseases

Hidrovia will promote communication and exchange of goods and people, encouraging large-scale migrations and settlements in a vast region, a large proportion of which is in the tropics. Such a substantial increase in traveling and migrations may create health problems, particularly those associated with vector-borne diseases. The two basic factors associated with this potential risk are: (a) changes in the natural conditions that favor the expansion of vectors, and (b) massive immigrations of relatively poor people from areas where the diseases are endemic.

Local, non-immune populations will be exposed to these diseases and allow transmission to escalate, as has already occurred in the Amazon region. Likely diseases that will be transmitted, in declining order of risk, are malaria, yellow fever, dengue, and forest and urban forms of leishmaniasis. In addition, two species of snails considered to be potential vectors of schistosomiasis occur in the basin: *Biomphalaria straminea* and *B. tenagophila* (Moretto, 1980; Bonetto and Wais, 1992).

2.6. Induced development

As with any new road in frontier regions, the greatest environmental impacts caused by Hidrovia probably will be indirect, given the rapid development process that may follow the start of operations in the waterway (Cano, 1991). Given the history of similar projects in other regions of Latin America, it is unlikely that adequate planning, extension and law enforcement will be ready in the area before a rapid development produced by Hidrovia causes a major environmental impact.

Indirect impacts may include: (a) expansion of agriculture into marginal lands that will increase soil erosion and agro-chemical pollution, (b) an increase in extensive, poorly managed cattle ranching that will favor overgrazing followed by vegetation degradation and soil erosion, (c) an increase in mining activities at Mutún in Bolivia and Urucúm in Brazil, and possibly an increase in forest exploitation for wood and charcoal production for the steel mills, and (d) unplanned urban and industrial development with associated pollution due to inadequate sewage treatment and garbage disposal facilities.

While these costs may be considered to be associated with the benefits of development, it is important that they be subtracted from those benefits in conducting feasibility studies. Moreover, these induced effects will likely result in increased sediment reaching the rivers and, thus, an increase in Hidrovia's maintenance costs.

3. Economic feasibility

The basis for current discussions of the economics of the Hidrovia project is a preliminary feasibility study conducted by a Brazilian engineering firm (Internave Engenharia, 1992). Their study presumes to show a positive net return from the project. This calculation, however, is sensitive to the underlying assumptions of the analysis and to the inclusion (or lack thereof) of all relevant costs, particularly environmental costs of the project.

The economic analysis conducted by Internave is limited to a simple analysis of benefits resulting from savings in transportation costs and the construction, maintenance and equipment costs necessary for the project. Estimates of savings in shipping costs are made for two scenarios, one without MERCOSUR and one with MERCOSUR. The scenario without MERCOSUR assumes that growth in shipping will continue at current rates, while the scenario with MERCOSUR assumes that growth in shipping will accelerate with the formation of MERCOSUR.

Using the data presented in the Internave (1992) report, we find that the internal rate of

Table 1
Sensitivity of internal rate of return to environmental costs

Increase in project costs with environmental impacts (%)	Internal rate of return with MERCOSUR (%)	Internal rate of return without MERCOSUR (%)
0	14	6
10	12	4
20	11	2
30	9	0
40	7	−2
50	6	−4

return [1] (IRR) of the Hidrovia Project is 6 percent without MERCOSUR and 14 percent with MERCOSUR. Interestingly, these rates differ significantly from those calculated by Internave (1992), which used the same numbers as we did to arrive at an IRR of 16 percent without MERCOSUR and 23 percent with MERCOSUR. The cause of these differences could not be found, though it is worth noting that numerous calculation errors were found in the Internave report and it is assumed that this is simply another computational error (Bucher et al., 1993).

More important than the arithmetic errors in the Internave study is the omission of significant environmental costs likely to result from Hidrovia. As Table 1 shows, if environmental costs increase the overall costs of the project, the IRR of the project will fall. [2]

Assuming that MERCOSUR is successful in stimulating growth in the region, then Table 1 indicates that a 10 percent increase in project net costs will cause the IRR to fall from 14 percent to 12 percent. A 20 percent increase in net costs will cause the IRR to decline to 11 percent. IDB does not consider projects with an IRR of less than 12 percent to be feasible. That is, a less than 20 percent increase in net costs would make Hidrovia uneconomical, even with MERCOSUR. Without MERCOSUR, the IRR of Hidrovia fails to meet IDB's guidelines even without considering the environmental costs.

A 20 percent increase in project costs is equivalent to approximately US$40 million per year over the life of the project. [3] That is, if environmental costs, net of the production and employment benefits of the project, are equal to at least US$40 million per year, then even with a successful MERCOSUR, the project would have an IRR of less than 12 percent and is not feasible under the IDB guidelines.

It seems very likely that environmental costs will total at least US$40 million per year. For example, the expansion of soybean production in areas adjacent to the Pantanal will likely increase soil erosion and, as a consequence, sedimentation in the waterway. Galinkin et al. (1994) estimate that soil erosion resulting from expanded soybean production will increase dredging costs by $39.6 million per year. [4]

Even if the Galinkin et al. (1994) estimates are too high, additional costs to commercial and sport fishing, the loss of biodiversity and ecotourism, increased downstream flooding losses due to the alteration of the hydrology of the Paraguay-Paraná and the sponge effect of the Pantanal, and the spread of tropical diseases will likely

[1]. While we are well aware of the shortcomings of internal rate of return calculations for judging the economic feasibility of projects (see, for example, Zerbe and Dively, 1994), we nevertheless use this criterion in order to be consistent with the methodology used by the Inter-American Development Bank (IDB).

[2] While this paper is primarily concerned with the environmental impacts of Hidrovia, it should be noted that the project will likely also produce external economic benefits in the form of increased production and employment. The values of these external benefits should also be included in the analysis. Therefore, Table 1 should be interpreted as the increases in net costs that would result in varying internal rates of return.

[3] The time pattern of costs will alter both the internal rate of return and the critical level of environmental costs. Indeed, the same effect on the IRR of the project could result from smaller aggregate environmental impacts if those impacts are concentrated during the initial time periods.

[4] This amount, however, is likely too high. Galinkin et al. (1994) use average erosion rates for Brazil, not rates specific to the area in question. Moreover, it seems to be assumed that all eroded soil reaches the river and that the consequent silt must be removed. Of course, only a portion of the eroded soil will reach the river and, of this portion, only a portion is deposited and requires removal.

have a cumulative cost in excess of US$40 million per year (see, for example, Clark et al., 1982; Barbier et al., 1994; Lindberg, 1991).

4. Conclusions

It is inevitable that Hidrovia will cause several environmental impacts, both direct and indirect, that may affect large regions. Of greatest concern, in our opinion, are those impacts to the Pantanal, particularly with regard to its role both as a reservoir of biodiversity and in the regulation of downstream flows.

This preliminary examination suggests that extreme care should be taken in altering this complex and diverse region, given the potential for causing major ecological and hydrological impacts and biodiversity losses. While economic values of environmental costs have not been measured, it seems that net environmental costs of US$40 million per year are well within the range of likely values, given the severity of the expected damages. That is, using IDB's criterion for economic feasibility, the Hidrovia Project, as currently conceived, may not be economically feasible when environmental costs are included.

Indeed, while alerting concerned parties to the potential environmental consequences of Hidrovia was our primary objective, the approach of computing a critical value for these environmental costs may be our major contribution. These "back of the envelope" calculations indicate the questionable feasibility of the project in the reach from Cáceres to Corumbá. Perhaps the improvements proposed for the lower reaches of the Paraguay River are economically justified, but the decision does not seem close for the upper reach entailing the Pantanal. Use of such a critical value approach should contribute to reducing the costs of feasibility studies by concentrating the investigation on those possibilities having the greatest likelihood of being feasible.

Finally, it should be noted that Hidrovia is not the only means of moving production to markets and of encouraging trade. Nor is Hidrovia the only means of stimulating regional and national economic growth. The fact that alternative modes of transport have reduced the role of river transportation indicates the competitiveness of these alternatives. While some costs may be greater for improving alternative modes, other costs may be less. Indeed, the additional environmental costs of improving road or rail systems are likely less than those associated with the proposed waterway alterations.

The feasibility study of Hidrovia should be expanded to include alternative transportation system improvements. The questions asked here about Hidrovia must also be asked about the alternative transportation modes if the environmentally and economically least-cost alternative of achieving the desired level of performance is to be found. A balanced analysis that explicitly includes environmental benefits and costs of all the alternatives is needed to determine the most efficient alternative.

Improving the integrated transportation system of the southern cone countries has the potential to produce significant economic benefits. But it is important that this economic gain not result in even greater environmental losses. The welfare of these countries, as well as that of the world, rests on more than just economic development and should not be improved at the sacrifice of their natural environments unless the benefits of trade exceed the costs. An integrative perspective of regional development is necessary when considering engineering projects that will affect a large proportion of the South American continent.

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