Ministério dos Transportes

PHE

Plano Hidroviário Estratégico

Inland Waterways Strategic Plan






Produto 4 - Relatório de Elaboração e Avaliação de Estratégias

Product 4 - Elaboration and Evaluation of Strategies Report

2013

Consórcio

ARCADIS logos

English Version

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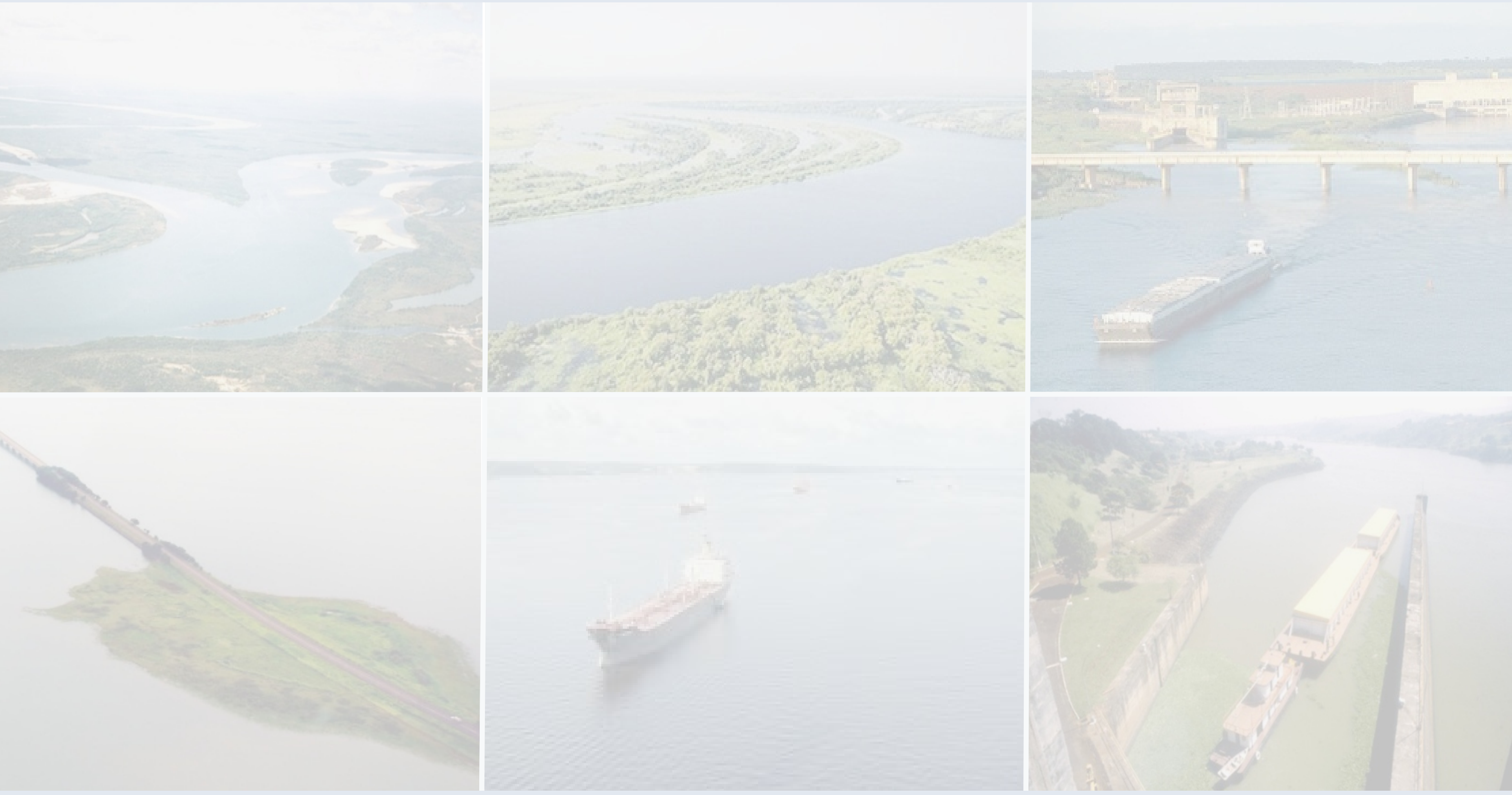

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República Federativa do Brasil

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INDEX

MANAGEMENT SUMMARY

The Federal Government of Brazil intends to improve the inland water transport (IWT) sector by increasing its reliability and the amount of transported cargo, as well as expanding the waterway network. The Ministry of Transport (MT) contracted the ARCADIS logos consortium to develop a Strategic Inland Waterway Plan (PHE – Plano Hidroviário Estratégico) to improve the IWT.

This report contains Step D of the PHE; the Elaboration and Evaluation of Strategies. The objectives of Step D are identified as: a) The elaboration and evaluation of several strategies to enable a feasible and sustainable development of the Brazilian waterways and to minimize the negative social and environmental effects. b) The comparative analysis of these strategies. c) The selection of the preferred strategy including a set of measures.

The process of elaboration and evaluation of strategies to reach the preferred strategy were:

a) Set main goal and sub-goals;
b) Set starting point (current situation, baseline, general context and assumptions);
c) Define Alternative Development Strategies;
d) Develop and undertake Cost-Benefits Analysis;
e) Undertake Multi-Criteria Analysis - Comparison and evaluation;
f) Select preferred strategy based on ranking of strategies and discussion with MT;
g) Evaluation of how the preferred strategy contributes to the main goal.

In order to develop strategies, first, the forecasts for transport volumes were calculated and the fleet requirements defined. By comparing the requirements to the current situation, physical measures for the rivers and for the transport system were defined and grouped into various strategies. All strategies were then compared in a Cost-Benefit Analysis and a Multi-Criteria Analysis, which supported the decision of the preferred strategy.

Main Goal and Sub-Goals

The preliminary main goal defined was:

To accommodate at least 110 million tons of cargo by inland waterway transport in 2031.

This goal is deemed both ambitious and realistic because:

- It is 4 to 5 times the current inland water cargo flow;
- It is based on realistic forecasts for commodities suited for IWT (large bulk flows (agricultural, ores), long distance);
- The production areas for those commodities are within limited distance to inland waterways.

The goal of MT is to improve the quality and expand the waterways network of Brazil in order to optimize its commercial potential and, therefore, more rivers should be navigable and the currently navigable rivers should be improved. In addition to physical improvements in the waterways, it is of equal importance to increase the reliability of the transport system. An effective and efficient system demands guaranteeing that the necessary maintenance work is regularly done, adequate river information is provided and the other elements of the transport chain are upgraded to support the expected growth. This leads to two sub-goals:

1. ***Improved and expanded Brazilian navigable inland waterway network.***
2. ***Improved and reliable transport system.***

Set Starting Point

Several challenges to overcome and opportunities to take with the IWT improvement were identified, related mainly to the following issues: cargo transport, passenger transport, navigability conditions, social and environmental aspects, advantages of IWT, institutional framework, regulatory system, waterway management system (operation) and intermodality (integration).

For the comparison of the strategies a baseline situation was defined; a situation in which the investments and maintenance costs for inland waterways in Brazil have been reduced to a minimum.

Many assumptions were made by the expert team for the selection of cargo types, transport forecast, modal split and route selection, costs and benefits calculations, responsibilities distribution, strategy selection and convoy sizes, capacity and purchase cost. The study comprised all waterways that already accommodate cargo flows of 50.000 tons per year or more or have potential for such flows. Furthermore, bulk cargo with low value per ton was considered the most suitable for large scale transportation on inland waterways, especially if transported over large distances.

Development Strategies

Aiming at reaching the goals, first a baseline and three strategies were defined, varying from: maintaining and some additional investment, up to a top quality Brazilian inland waterways transport system, which are:

- Baseline: Investments and maintenance reduced to zero, with exception to Paraná-Tietê Waterway System; IWS only in the natural waterways and Paraná-Tietê Waterway;

- Maintenance+: Maintenance of the waterways with current commercial navigation, in addition of a few investments;

- Expansion (A and B): A strategy (A) involving the rivers most promising from a transport cost point of view and a strategy (B) involving the rivers with less restrictions for implementation. Top Quality: Expansion of all waterways with potential, and significantly quality improvement of the waterways network and the systems of locks, to allow larger cargo flows.

During a workshop with the Ministry of Transport staff, the following additional combinations were also prepared, leading to alternatives 4 to 8:

- Alternative 4: Expansion of all potential waterways without the "top quality" status;
- Alternative 5: Maintenance + in addition of one river section;
- Alternative 6: Moderate expansion with "top quality";
- Alternative 7: Expansion B in addition of one extra waterway section;
- Alternative 8: Expansion A in addition of one extra waterway section.

The addition of these five new strategies, decided in the workshop with MT, represents the fine-tuning between, on the one hand the technical and expert point of view and, on the other hand, the political and public-interest point of view.

Relevant physical aspects of the selected sections of the rivers were analysed and physical measures were identified for each strategy, hence ensuring the navigability on these sections. In addition, recommendations were made in order to achieve a more reliable system and, consequently, enable the main goal to be reached. Improving the transport system and its reliability depends on two main aspects:

a) Improvement of elements of the transport chain to enable their sufficient capacity and a high quality service in the transport system;

b) Improvement of the institutional framework that is required to provide support, incentives and integration to the system, both for passenger and cargo.

Cost-Benefits Analysis

The Cost-Benefit Analysis (CBA) had two purposes: a) To determine whether a proposed project or program is a sound investment/decision (justification/feasibility) and b) To provide a basis for comparing and ranking strategies. The total expected costs of each option are compared with total expected benefits, to determine whether the benefits outweigh the costs, and by how much.

The comparison of the benefit/cost ratio of the strategies and the baseline situation shows that both Maintenance+ strategy and the Expansion 2B have B/C ratios > 1, hence being efficient strategies. The other strategies (Expansion 2A and TQ) result in less positive B/C ratios, however with a (far) higher IWT volume compared to the main goal.

Multi-Criteria Analysis - Comparison and Evaluation

The results of the Cost-Benefit Analysis were included in a Multi-Criteria Analysis (MCA), which considered environmental, economic, social and institutional criteria and whose output was a ranking of the alternatives. This ranking provides the elements and analytics necessary in order to support the decision over which strategy to choose.

THE MCA was structured in four dimensions: Economic Sustainability, Institutional Cohesion, Environmental Sustainability and Social Sustainability. For each dimension objectives and criteria were developed.

The highest-ranking strategy is Alt. 8, especially for its well-performing score under the economic dimension. Moreover, it is also a high-scoring strategy under the institutional dimension, albeit not the highest. Under the environmental and social sustainability dimensions the strategy also scores well, but never the highest. Overall, it ranked first because it provides a clear balance between the dimensions involved in the decision-making process.

The results from the MCA show that IWT is an overall solid and must-do to increase transport systems in Brazil. This conclusion arises from two complementary facts: the one strategy that stands out on the upper side is Alt. 8, which contains an increment of waterways to the already navigable ones. On the other hand, Maintenance+ scores almost lowest.

Selection and Description of Preferred Strategy

The selection of the preferred strategy by MT was done in three steps:

1. The preliminary results for the Baseline, Maintenance+, Expand A and B and Top Quality were presented and discussed. This preliminary ranking showed three equaly high scoring strategies. With the 'best' building blocks of these strategies the technical teams of the MT and ARCADIS combined routes and measures to develop additional alternatives (the Workshop Strategies).

2. The technical team of ARCADIS processed the Workshop Strategies and fine-tuned the all the strategies in the CBA and the MCA (optimalisation). The results were discussed. The MT selected a preliminary preferred strategy.

3. During a final meeting with MT final improvements were made to the preliminary preferred strategy to form a new Workshop Strategy. Again the CBA and MCA were run and updated. This preferred strategy was approved for further elaboration in the Masterplan.

The Preferred Strategy is a slight addition to strategy Expansion 2b by adding one extra waterway section - from Itaituba to Cachoeira Rasteira on the Tapajós - Teles Pires River-system. This strategy then contains the following waterways:

a) Amazon e Solimões (Santarém - Manaus – Coari) (Santarém – Almeirim) (Almeirim – Santana) (Almeirim - Rio Tocantins)

b) Madeira (Itacoatiara - Porto Velho)

c) Tapajós e Teles Pires (Santarém – Itaituba) (Itaituba – Cachoeira Rasteira)

d) Tocantins (Vila do Conde – Marabá) (Marabá – Miracema do Tocantins)

e) São Francisco (Petrolina – Ibotirama) (Ibotirama – Bom Jesus da Lapa) (Bom Jesus da Lapa – Pirapora)

f) Paraguay (Foz rio Apa – Corumbá) (Corumbá – Cáceres)

g) Paraná – Tietê (Três Lagoas - Pereira Barreto) (São Simão –Anhembi)

h) Hidrovia do Sul (Rio Grande - Estrela) (Rio Grande – Cachoeira do Sul)

The implementation of the measures will require changes in public structures and will affect the interests of all parties involved. It is of paramount importance to involve all parts in the decision making process, as follows: a) Government acts consistent and stimulates the use of inland waterways through financial incentives and legislation and b) Decisions on the improvement of waterways are taken in such a way that the interests of all parties involved are being considered. The resulting cooperation model is based on two pillars: a National **Task Force** IWT Development and **Regional Development Group**.

Evaluation of Main Goal

The present value of costs and benefits as well as the benefit/cost ratio of the preferred strategy were calculated. The values are derived from comparing the preferred strategy with the baseline situation. The benefit/cost ratio of the preferred strategy is just below one (0.94). In an international perspective, the calculated b/c score is remarkably good for IWT investments. In e.g. The Netherlands, an acclaimed IWT country, such ratios seldom surpass 0.4.

The preferred Strategy will, according to the forecasts, lead to a transport volume of 120 million tons on inland waterways in Brazil in 2031, surpassing the preliminary set target of 110 million tons. The current modal share of IWT for the main relevant commodities (soy, soy meal, corn and fertilizers) is approximately 9% in terms of tonkilometers (in terms of volume and distance). For 2031 the modal share is expected to move towards 40% for these commodities, more than four times the current share.

1 INTRODUCTION

1.1 BACKGROUND

The Federal Government of Brazil intends to increase the inland water transport (IWT) sector, and consequently increase its contribution to the sustainable development of the Brazilian economy.

Therefore, the Ministry of Transport (MT) started the project ‘Plano Hidroviário Estratégico’ (PHE) in July 2012.

The aim of the PHE project is to prepare a strategic plan for the development of IWT in the period until 2031. This strategic plan will be used by the Ministry to communicate with stakeholders and other government officials involved in IWT. It focuses on MT’s activities regarding IWT and the integration of MT waterway activities with those of other sectors concerning the use of water resources.

The strategic plan is prepared by the Consortium ARCADIS LOGOS through a joint effort with the Transport Planning team of the Ministry of Transport.

The project is divided into the following research activities:

- Step A: Elaboration of Work Plan;
- Step B: Stakeholder Consultations;
- Step C: Assessment and Diagnosis;
- Step D: Elaboration and Evaluation of Strategies;
- Step E: Formulation of the Draft Strategic Plan;
- Step F: Preparation of the Final Strategic Plan.

This report contains Step D; the Elaboration and Evaluation of Strategies.

1.2 OBJECTIVES ELABORATION AND EVALUATION OF STRATEGIES

The Terms of Reference of the PHE mentions that the Elaboration and Evaluation of Strategies report should contain the elaborated strategies, as well as the results of calculations. The report should also detail necessary investments in infrastructure.

Therefore, the objectives of Step D are identified as:

- The elaboration and evaluation of several strategies to enable a feasible and sustainable development of the Brazilian waterways and to minimize the negative social and environmental effects..
- The comparative (quantitative and qualitative) analysis of these strategies.
- The selection of the preferred strategy including a set of measures.

Step D will be used as input for the next step (E): Formulation of the draft strategic plan.

The Elaboration and Evaluation of Strategies follows the Analysis and Diagnosis report, in which strengths, opportunities, weaknesses and threats of the IWT system were indicated. The weaknesses were not only the inadequate infrastructure, but also major reliability problems, the sub-optimal use of present waterways due to the absence of appropriate waterway management for instance, as compared to the international benchmarks.

To select the best strategies and investments, it is important to take the needs and demands of companies that are (potential) users for the waterways into account. The major markets for IWT are dominated by large producing companies that transport commodities at long distances for export or import. Road, and to a lesser extent, rail transport are the competitors for inland water transport.

The main advantage of IWT is the low cost per ton.km as well as the fact that the basic waterway infrastructure is available. The main problem is that the basic waterway infrastructure of the waterways does not guarantee navigation up to the required standards. Improvement of the waterways will contribute significantly to the efficiency and reliability of the transport system. The transport costs from the major production areas in Brazil to the seaports constitute a significant part of the total cost of products. Decreasing these costs will mean a significant increase of the competitiveness of these Brazilian export products. Furthermore there is a shift towards more just in time delivery of commodities, which demands reliable transport system, that provides the certainty that the cargo will arrive the destination, at the right time, at the agreed costs.

The Development and Evaluation of Strategies was executed based on the considerations described above.

2 PROCESS STEPS

2.1 OVERALL PROCESS STEPS

The overall working process of Step D is visualised in figure 2.1.1 below. The starting point for Step D is based on the SWOT analysis and stakeholder analysis of Step B +C. The results of Step D will be used as input for the next step; Step E: Formulation of the draft strategic plan.

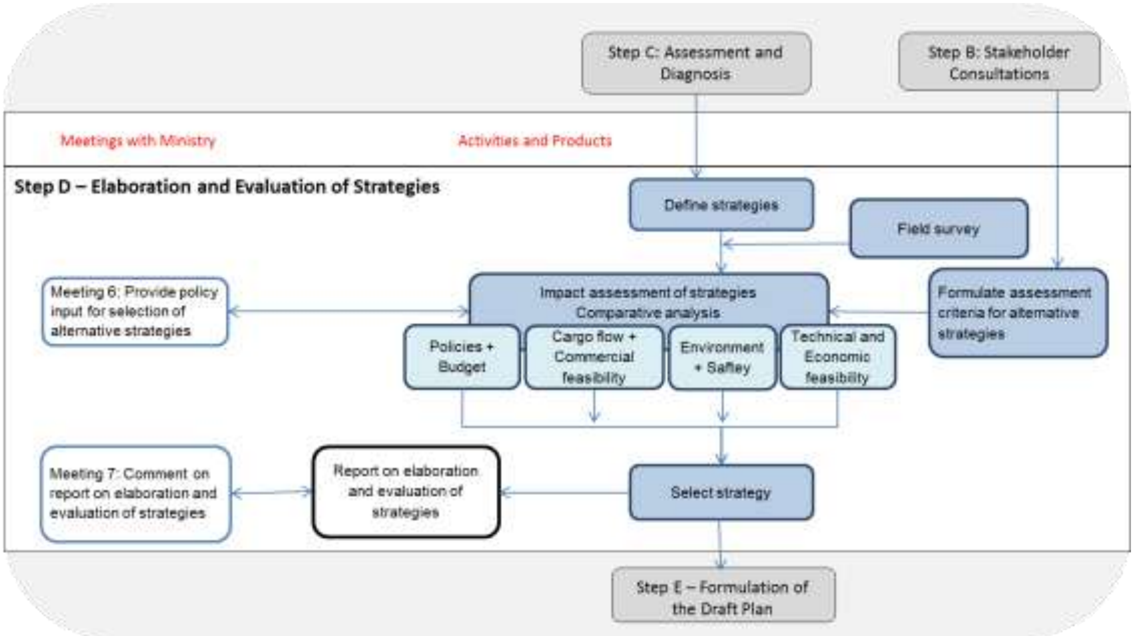

Figure 2.1.1 - The Working Process: Step D

2.2 PROCESS FOR DEVELOPING STRATEGIES

2.2.1 General Approach for the Development of Strategies

The process for development of strategies can be carried out bottom-up and top-down. Both approaches were combined in this project (see figure 2.2.1).

Initially, a bottom-up approach was applied to identify the needs and ideas for key improvements in the waterway system and national policy. The Assessment and Diagnosis and the Stakeholder Consultation provided the major strengths and weaknesses, opportunities and threats.

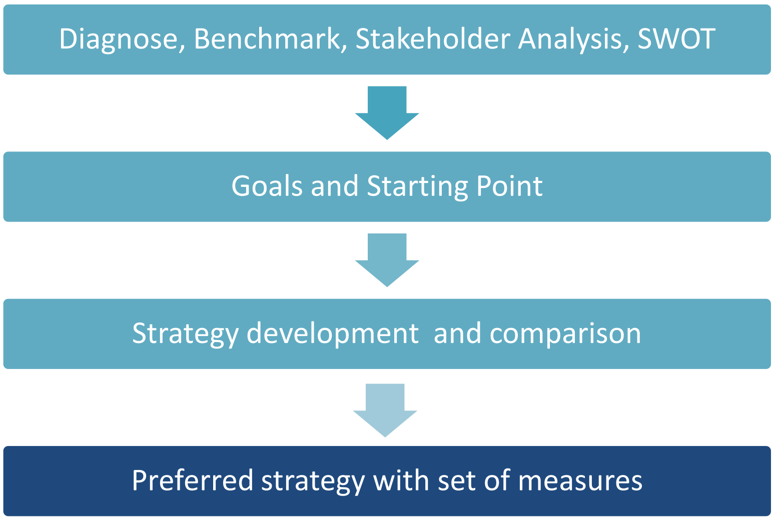

Figure 2.2.1 - The top-down process for preparing the strategies

From the identification of strengths and weakness, opportunities and threats of IWT, the strategy development started with the top-down approach. This top-down process for preparing the strategies is visualized in Figure 2.2.1. First, the experts determined a main goal and sub-goals for 2031, based on Step B (Stakeholder Consultation) and Step C (Assessment and Diagnosis). The expert team then set the starting point for the strategy development, being the current situation, baseline, issues and opportunities and assumptions. The information for the starting point also originates mainly from Step B and Step C. Strategies were developed to reach the main goal. The list of measures from Step C was further developed and improved. The measures were grouped together into logical sub-groups and assigned to the different strategies. The different strategies needed to be compared and evaluated in order to select a preferred strategy. The preferred strategy is accompanied by a set of measures that can be the basis of an action plan.

2.2.2 Workshop 1 with Ministry of Transport

A workshop was held with the Ministry of Transport and Arcadis Logos in São Paulo, which consisted of the kick-off of the Step D Elaboration and Evaluation of Strategies. The aim of this workshop was to discuss and confirm:

- Preliminary main goal and sub-goals
- Starting point and assumptions
- Criteria for comparison
- General idea about measures and strategies

The outcome of this meeting provided direction to the strategy development.

The conclusions of the meeting were reported on a presentation with the sub-goals and ideas about potentially effective measures. The sheet with measures is included in Annex A. These measures compliment the Long list of measures from the Diagnosis report (Step C). Suggestions were used to further improve the goals, assumptions, strategies and criteria.

2.2.3 Process Steps

The process steps (Figure 2.2.2) to reach the preferred strategy were:

a) Set main goal and sub-goals;

b) Set starting point (current situation, baseline, issues and oportunities and assumptions);

c) Define Alternative Development Strategies;

d) Develop and undertake Cost-Benefits Analysis;

e) Undertake Multi-Criteria Analysis - Comparison and evaluation;

f) Select preferred strategy based on ranking of strategies and discussion with MT;

g) Evaluation of how the preferred strategy contributes to the main goal.

Figure 2.2.2 - Process steps

Figure 2.2.3 shows the data stream of how the preferred strategy was calculated. In order to develop strategies, first the forecasts for transport volumes were calculated in detail. This amount of cargo needs to be transported by a suitable fleet. Therefore, fleet requirements were defined. The fleet requirements give rise to adjustments to the waterways and the transport system. These are the required measures that are described in this report. The costs of these measures (investment costs, transport costs and maintenance costs) were determined for all strategies. All strategies were then compared in a Cost-Benefit Analysis and a Multi-Criteria Analysis, which provided the basis for selecting a preferred strategy.

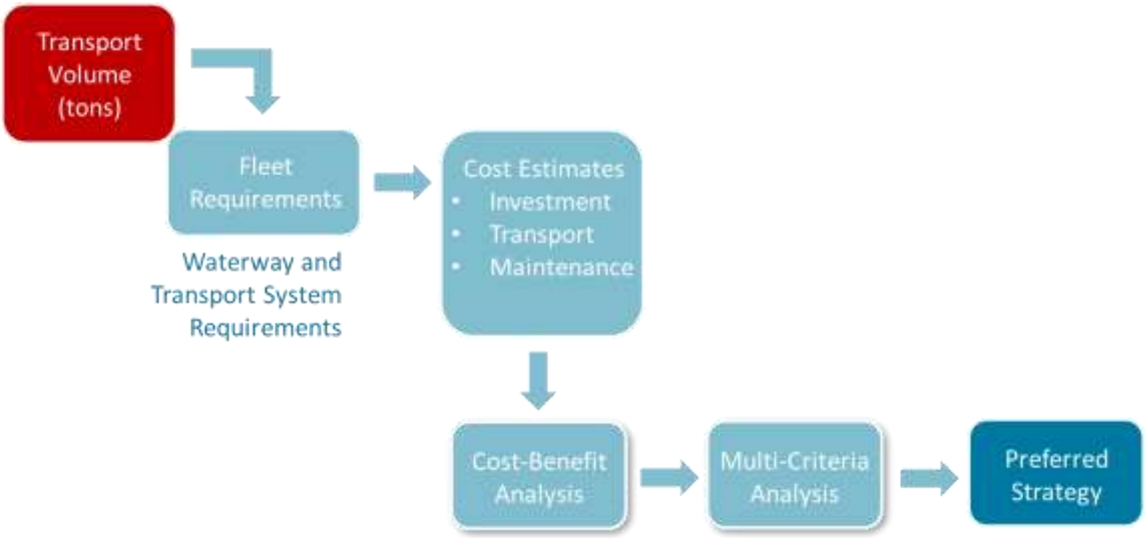

Figure 2.2.3 - Data Stream to Calculate Preferred Strategy

2.3 SET GOALS

The expert team determined a realistic goal for the long term based on the forecasts done during the Assessment and Diagnosis. From this goal the expert team developed sub-goalsto bring more focus to the strategy development.

The definition of the main goal was carried out in four steps:

- Firstly, the Terms of Reference (ToR) was analyzed, in order to perceive what the Ministry of Transport was aiming at.
- Secondly, as the ToR mentioned that the PNLT should serve as basis to the PHE, this study was also evaluated and considered in this process; one of the PNLT goals was to increase the IWT modal split from 13% to 29%.
- Thirdly, the results of the forecasts for the Inland waterway transport from the Analysis and Diagnosis phase of the PHE project were analysed.
- Finally, the above was discussed during workshop 1 with the Ministry of Transport, which resulted into one goal that would be suitable for the PHE project.

The goals solely related to modal split and to the increase of navigable river sections were not considered of greater relevance in the project, due to the fact that these do not necessary lead to absolute increase of cargo transport over the rivers. The potential amount of cargo that could be transported on inland waterways in 2031 was considered by the experts of ARCADIS and the technical team of the MT as the best type of main goal for PHE.

The main goal and sub-goals are described in Chapter 3.

2.4 SET STARTING POINT

2.4.1 Current and Baseline Situation

As a starting point to the Elaboration and Evaluation of Strategies the baseline situation was elaborated. The baseline situation describes what is likely to happen, if no policy changes will be implemented in the future.1 A clear definition of the baseline situation is important for the comparison of the strategies and to calculate the effect of a policy change.

2.4.2 General Context

Another important starting point for the elaboration of strategies is the analysis of issues and opportunities. Therefore, the main issues and opportunities of the Analysis and Diagnosis phase were summarized and combined with the SWOT analysis - the macro SWOT and those of the waterway systems. During the first workshop, the main elements of the issues and opportunities analysis were selected.

The baseline situation and the problem analysis are described in Chapter 4.

2.4.3 Assumptions

To be able to compare the strategies, the experts had to make assumptions for their assessment. These assumptions were discussed with and confirmed by the MT. The assumptions for the strategies are mentioned in Chapter 4 to provide a framework and direction for the development of the strategies.

2.5 DEFINE DEVELOPMENT STRATEGIES

In the context of this plan, a strategy is a set of measures, projects or activities aimed at reaching the main goal.

A basic requirement to accommodate more inland waterway transport in 2031 is to improve and expand the inland waterway network. More navigable waterway routes must be available in order to compete with road and rail transport. Improving and expanding the waterway system alone is not enough to increase the amount of cargo transport over inland waterways. Additional measures are required to further improve the quality of the Inland Waterways Transport system. The elements of the transport chain need to be adjusted to meet future cargo potential and a supportive institutional framework needs to be encouraged.

In this Strategies Report a clear distinction is made between:

[1] The baseline situation can also be referred to as 'reference scenario'.

1. Strategy to improve and expand the Brazilian navigable inland waterway network, and;

2. Strategy to improve the Transport System and its reliability.

1) Strategy to improve and expand the Brazilian navigable inland waterway network

A number of strategies were developed in Chapter 5 to find the best way to physically improve and expand the inland waterway network. The core of developing the strategies was therefore the selection of the best rivers and best routes to improve and expand the Brazilian navigable inland waterway network. Alternative Development Strategies were defined ranging from maintaining the current waterway system at a low ambition level to a high ambition level of improvement and expansion for the waterway system. The Strategies were aimed at forming the best plan possible, considering that each of the strategies will reach a certain amount of tonnage by 2031 with a certain investment needed and pondering many dimensions of society (economical, environmental, social, political) to this complex development strategy.

A field survey was undertaken, for which the methodology and results are recorded in the Assessment and Diagnosis Report. The results of the field survey were important for the development of the sets of measures.

The needed investment costs are estimated for a strategic purpose. The level of detail of the cost estimations is aimed at comparing strategies. When a certain measure will be executed a more detailed project-cost estimation is required.

2) Strategy to improve the transport system and its reliability

The institutional measures required to support and enable the selected strategy to be implemented in order to reach the defined goal were explored. These measures apply generally to all selected rivers and are, although equally part of each strategy, therefore not relevant to the comparison between the Alternative Development Strategies. These intitutional measures are therefore not regarded in the Cost-Benefit Analysis and Multi-Criteria Analysis, but were instead described separately in Chapter 9.

2.6 DEVELOP AND EXECUTE COST-BENEFITS ANALYSIS

The Cost-Benefit Analysis (CBA) in Chapter 6 was the backbone for the comparison of the Development Strategies. The CBA had two purposes:

- To determine whether a proposed project or program is a sound investment/decision (justification/feasibility);
- To provide a basis for comparing and ranking strategies.

The analysis made it possible to compare (investment) strategies between waterway systems as well as within a waterway system itself.

A Cost-Benefit Analysis (CBA) estimates and totals up the equivalent discounted money value of the benefits and costs to the community of measures to establish whether they are worthwhile.

The total expected costs of each option are compared with total expected benefits to determine whether the benefits outweigh the costs, and by how much.

Note that only the physical measures at regional were compared in the CBA. The costs and benefits of the macro level (institutional) measures were not included into the CBA because:

- For the purpose of this project it is very complex to determine costs and benefits of macro level measures and allocate them to specific waterway systems.
- For the purpose of selecting a preferred strategy it adds no value to the comparison to include costs and benefits of macro level measures, since they would be the same for all Alternative Development Strategies. It would not change the outcome of the comparison.

2.7 MULTI-CRITERIA ANALYSIS - COMPARISON AND EVALUATION

In making the decision whether to invest significantly in upgrading a waterway or not, and which river, there are not only very complex issues involving multiple criteria, but there are also multiple parties who are deeply affected by the consequences. The Strategies will be compared and evaluated in the MCA, since other criteria, besides money, are important to make a decision on waterway investments. The recommended strategy should be based on a broader set of objectives. This larger set of objectives includes institutional considerations, as well as ensuring social and environmental sustainability. In order to account for the different dimensions of the implied decision of waterway development, the results of the Cost-Benefit Analysis are complemented with a Multi-Criteria Analysis (MCA). Both analytical tools combined yield solid results that provide a complete set of support for the decision making process.

Note that the MCA only compares the Development Strategies at regional level. Since the institutional measures are at a macro level, it is not possible to compare them with the measures that can be taken at regional level.

The MCA is described in Chapter 7.

2.8 SELECT, DESCRIBE AND EVALUATE THE PREFERRED STRATEGY

2.8.1 Select and Describe Preferred Strategy

The ranking of the strategies will show how much the Development Strategies contribute to the main goal, while also providing a ranking based on institutional cohesion and the social-environmental sensitivities. Each alternative set of waterway developments results in a different length of navigable waterways, different investment costs, different transport costs, different environmental disturbances, etc. Therefore, value judgments are involved, such as the political importance of developing a certain waterway or the relative importance of the agricultural commodities trade for the country's development. Exactly due to this diversity of attributes and choices regarding the decision-making process, several workshops and discussions were conducted with the MT in order to discuss the hierarchical framework built, to discuss the criteria and decide upon the weights and to select their Preferred Strategy.

The selection of the preferred strategy by MT was elaborated in three steps. First, the preliminary results for the comparison of four main strategies for investments in rivers were presented, as well as a proposal for the institutional setting. This preliminary ranking showed three equally high scoring strategies. With that information, the MT selected some routes and combined variations on the main strategies for investments in order to develop the best mix of measures for the different waterways. The technical teams of ARCADIS and the MT also fine-tuned the weights of the criteria. The technical team of ARCADIS processed the CBA and the MCA with these new weights of criteria and the variations on the strategies (optimalisation).

Then, a conference call meeting was held with the technical teams of ARCADIS and the technical team of MT to discuss the results of the comparison of all strategies, including the new combinations that were developed during the workshop, with the new weights of criteria. The MT selected a preliminary preferred strategy during that meeting. After that, during a final meeting with MT some final adjustments were made to the preliminary preferred strategy and this preferred strategy, including the Institutional measures, was confirmed.

The end result of the Elaboration of Strategies phase was a preferred strategy, containing a set of measures that can be the basis for the Master Plan. For the Preferred Strategy the hardware measures at regional level and the institutional measures for the supportive framework of governance (macro level) are integrated to one complete set of measures. The preferred strategy can be one of the Alternative Development Strategies, but may also be a composed different combination.

2.8.2 Description of Preferred Strategy

The preferred strategy is described and the relation to the Master Plan is given in Chapters 8 and 9.

2.8.3 Evaluation of Main Goal

The last step in choosing the best strategy is an evaluation of the main goal.

Is the preferred strategy ambitious enough to reach the main goal? If not, why not? Is it necessary to adjust the main goal or are more measures necessary? These are the questions that will be answered in the evaluation. The evaluation is described in Chapter 10.

3 MAIN GOAL AND SUB-GOALS

Aiming to guide the process of elaboration of Development Strategies, shown in Figure 3.1, one long-term goal was set, as well as sub-goals, that will contribute to reach the goal. The definition of the objective and goals contributed to the selection of the main aspects to be addressed in the process.

Figure 3.1 - Process Steps – Set Main Goal and Sub Goals

3.1 MAIN GOAL

The expected growth of the Brazilian economy is manifested in increased exports of cargo produced in the country. The Brazilian transport sector has to deal with this increasing demand to transport bulk cargo, on large distances, mainly to be exported via sea ports. These commodities are very suitable to be transported via inland waterways. Agricultural products (soy, corn, wood, pulp, and ethanol), iron ore, steal, chemical products and oil products are currently transported more by barges in Brazil. Selecting and improving the situation on IWT for those cargo types, forms a basis for a solid inland waterway system. The waterways users group can be enlarged by transporters of regional cargo and passenger transport. The inland waterway transport could result in lower logistic costs and higher competitiveness for the Brazilian products in the international markets.

The Assessment and Diagnosis Report shows the potential growth associated to commodities exports for Brazil until 2031. Table 3.1.1 shows the forecast of transport volumes for IWT per river. The forecast shows a potential substantial increase in the total transported amount of cargo over inland waterways. The overview shows a total of 110 million tons in 2031. The cargo volume consists mainly of agricultural products (soy, corn, wood, pulp, ethanol), iron ore, chemical (fertilisers) and oil products.

The selected Strategy should accommodate this growth by facilitating the capacity and the quality of the inland waterways network.

The preliminary main goal is as follows:

To accommodate at least 110 million tons of cargo by inland waterway transport in 2031.

This goal is deemed both ambitious and realistic because:

- It is 4 to 5 times the current inland water cargo flow;
- It is based on realistic forecasts for commodities suited for IWT (large bulk flows (agricultural, ores), long distance);
- The production areas for those commodities are within limited distance to inland waterways.

In the slipstream of an improved IWT system, based on the cargo flows mentioned above, other flows may follow. However, for the definition of the main goal, the cautious approach of potential IWT cargo demand was decided.

Table 3.1.1 - Forecasts IWT Brazil (in 1.000 tons)

	2015	2023	2031
Amazon	3.170	4.684	5.933
Madeira/ Tapajós	7.619	9.907	11.954
Tocantins/ Parnaíba	16.626	32.261	50.521
São Francisco	53	58	61
Paraná – Tietê	7.482	15.338	17.954
Hidrovia Do Sul	5.250	7026	9367
Rio Uruguay	0	0	0
Rio Paraguay	7.702	10.871	14.883
Total	**47.902**	**80.145**	**110.673**

Passenger transport by inland waterways is also expected to increase, especially in the Amazon Region. This is due to the economic and population growth of the region and the investments in waterways by the Brazilian Government. The quality (safety and comfort) of passenger IWT should be permanently enhanced.

For the Development and Evaluation of Strategies the expert team has chosen the definition of the main goal that considers the volume to be transported by waterways in 2031. Another possibility would have been to define a share in the modal split (the share of the modes in total transport). However, the share of modal split is not an easy goal to define precisely, because not all segments in transport really compete with each other. It is obvious that waterway transport cannot compete in city distribution of final products (e.g. food). The main markets for competition are import and export markets. But even here it is hard to see how IWT can compete with a dedicated rail connection from the mine to the port for exports over sea (Carejas line). The same is true if a plant is located on a waterway and the commodities are exported via a seaport, accessible by water (iron ore export via the Paraguay river).

The main competing markets are exports of imports of commodities that are produced in a number of locations. From there transport to terminals and ports is necessary. From the terminals exports go via ports to destinations overseas. In the PHE project agriculture transport chains compete for commodities like soy, soymeal, corn (exports) and fertilizers (imports).

In general comparing transport volume (in tons) is not very useful. Mainly because transshipment takes place and the same tons are counted double. A far better indicator is the transport performance (in ton-kilometers) because in this way the tons and the kilometers are taken into account.

3.2 DEFINITION OF SUB-DOALS

The strategy should accommodate the growth of inland waterway transport by facilitating the capacity and the quality of the inland waterway's network. The axes for this strategy are two sub-goals, both equally important to reach the main goal.

Figure 3.2.1 – Main and sub-goals

The first sub-goal is formulated as follows:

Improved and expanded Brazilian navigable inland waterway network.

Brazil currently has an extensive network of navigable rivers or with the potential to become navigable. The goal of MT is to improve the quality and expand the waterways network of Brazil in order to optimize its commercial potential and, therefore, more rivers should be navigable and the currently navigable rivers should be improved.

The potential waterway net estimated by "Plano Nacional de Viação" - PNV is about 42,000 km. From that ANTAQ estimated that only 21.000[2] . corresponds to currently economically navigable routes, based on the records of the use of the waterways by Empresa Brasileira de Navegação, in the provision of cargo transport services and inland waterway passenger and mixed (passenger and cargo).

The PHE (Plano Hidroviário Estratégico) focuses on the rivers that can facilitate / optimize the logistics of the Brazilian economy for the cargo that is most suitable for inland waterway transport. These commodities require the waterways that connect the inland to the main ports, since it is mostly import and export of major commodities and passenger based on the values of current and future production/transport. Thus, from the count held by ANTAQ only 6,500 kilometers of rivers are considered relevant and currently used for such cargo flows.

To be able to use the waterway network to its full commercial potential, more rivers should be navigable and currently navigable rivers should be improved. The main existing waterways should be improved and the waterway network should be expanded with more than 3.000km (46% of increase compared to the relevant by stretches of rivers, which are not yet used for this large scale transport of cargo.

The waterways should have a basic navigability condition and this means that, in most cases, a convoy of 2x2 barges should be able to use the waterway. For a number of waterways this is not the case in the current situation.

The second sub-goal is formulated as follows:

Improved and reliable transport system.

In addition to physical improvements in the waterways, it is of equal importance to increase the reliability of the transport system. An effective and efficient system demands guaranteeing that the necessary maintenance work is regularly done, adequate river information is provided and the other elements of the transport chain are upgraded to support the expected growth. This leads to the second sub-goal: "An improved and reliable transport system to accommodate the increase in transport volume and the expected increase in passenger transport by IWT in 2031."

[2] ANTAQ, NAVEGAÇÃO INTERIOR, SUPERINTENDÊNCIA DE NAVEGAÇÃO INTERIOR – SNI 3º TRIM/2012

3.2.1 Sub-goal 1 - Improved and Expanded Brazilian Navigable Inland Waterway Network

In order to increase the yearly cargo load by inland waterways, the network of navigable waterway needs to be improved and expanded. To achieve that, the following demands must be met:

A. Expand the length of navigable waterway;

B. Increase the quality of waterways: better suitable for larger vessel size/larger convoys.

Important for commercial navigability (the transport of cargo) is the presence of economic viable routes and sufficient length of navigable waterway in order to make the transport by water an attractive option. In addition the dimensions (depth, width, radius) of the waterway need to be sufficient to navigate with commercial sized vessels/convoys. Stream velocities and seasonal variations of water levels must be within acceptable limits. Of course, the waterways must be free of obstacles such as dams without locks/sluices, rocks and sand banks. Bridges and power lines must be high enough for the vessels to navigate underneath.

In general the commercial convoys sizes in Brazil have formations between 2-by-2 barges (22m x128m) and 4-by-5 barges (55m x 268m), with barges of 60m long and 11m width, and a wide range of push boats, that varies from 28m (big convoys) to 18 m (small convoys). The size for each waterway is limited by the dimensions of the structures along the rivers, including locks, as well as the waterway characteristics.

The strategies and measures are aimed at selecting the best routes and making those routes navigable for commercial transport.

3.2.2 Sub-goal 2 - Improved and Reliable Transport System

An improved and reliable transport system is required to accommodate the increase in transport volume and the expected increase in passenger transport by IWT in 2031. To increase the quality and reliability of the transport system the following demands must be met:

A. The transport chain for both cargo and passengers must have sufficient capacity and all the elements of the transport system must be reliable and of high quality. In addition, passenger transport must be safe and comfortable. Encouraging IWT should ideally be done using the latest technology, research and innovations of the shipbuilding industry.

B. The institutional framework must be improved in order to ensure the required support to the necessary civil works and to the system operation; the incentives efficiency, as well as encourage environmental sustainability and integration of the system.

Elements of the Transport Chain

Bringing cargo from one place to another must be seen as a logistic chain, where every element affects another: the total chain is as strong as its weakest link. For example, a delay during navigation in the waterway due to lack of information about its conditions will affect the logistics (loading and unloading) at the terminal. A longer waiting time and higher costs are the consequence.

In the inland waterway transport chain between origin (production area of the cargo) and destination (in the situation under consideration the destination is generally the sea port where the cargo is loaded in a sea-going vessel) the following activities or chain steps can be distinguished:

- Pre-haulage from the production area/origin to the inland terminal;
- Storage of the cargo at the inland terminal;
- Loading of the barges;
- Transport by barge to the sea terminal;
- Unloading of the barges at the sea terminal;
- Storage of the cargo at the sea terminal.

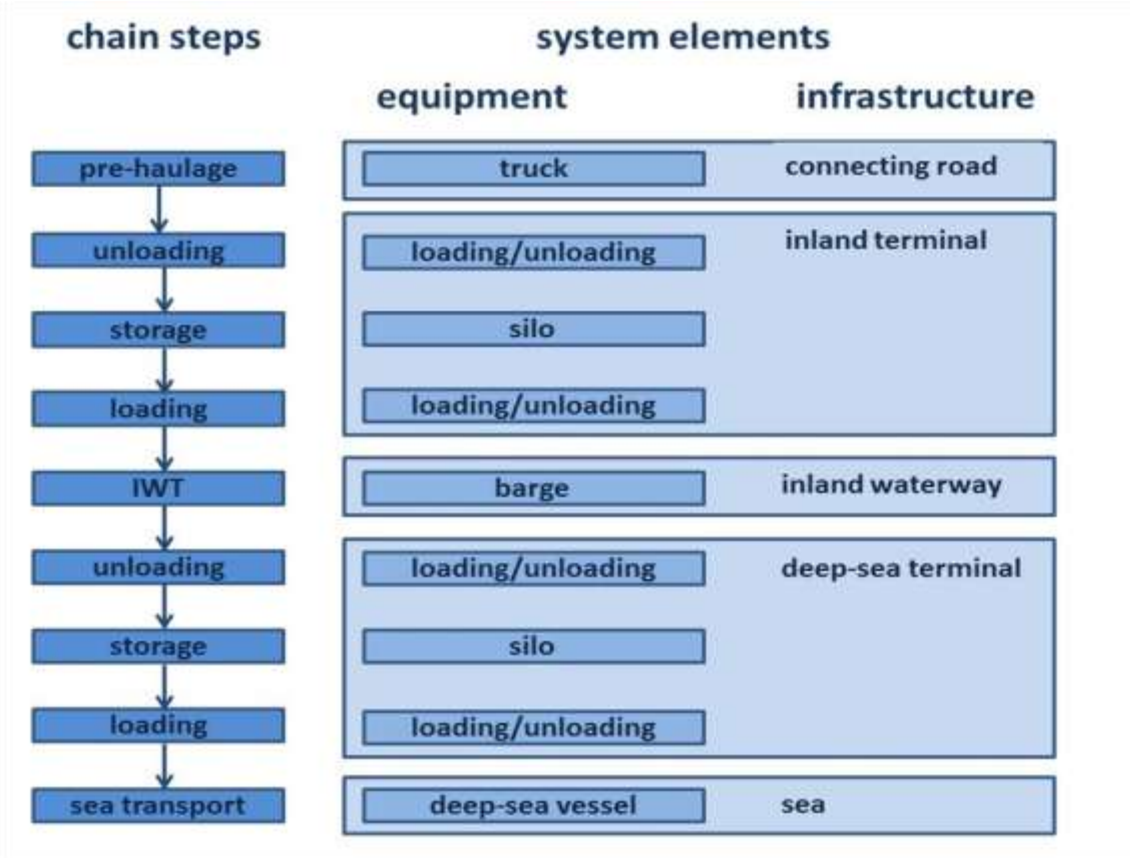

Figure 3.2.2 - Inland Waterway Transport Chain Between Origin (Production Area of the Cargo) and Destination

The transport system elements are required to execute the different chain steps and can roughly be divided into:

- Equipment (trucks, train, loading and unloading equipment, silo's, barges and deep-sea vessels) and;
- Infrastructure (connecting roads and railroads between production area and inland port, inland terminals, inland waterways, deep-sea terminals and sea-ways).

Looking at the transport chain, it is also important to mention that sufficient qualified personnel are a prime requirement for any development in the sector. Qualified truck drivers, terminal operators and crews determine the efficiency and effectiveness of the transport chain.

Supportive Institutional Framework

Providing a supportive framework for IWT development is essential to enable growth to the IWT sector. An integrated government planning system carefully coordinates the requirements of different stakeholders. The IWT development needs to be connected with:

- Intermodal/Multimodal development
- Rail and road development
- Ports and port facilities
- Hydroelectricity
- Irrigation
- Spatial planning
- Environment
- Fiscal system
- Storage System

Integrated government planning will detect the conflicting demands and design the mechanisms to console the conflicts and to arrive at optimal holistic results. Adequate financial incentives will stimulate the development of IWT as a link in the intermodal transport chain.

Once the investments in the improvement of the navigability have been made, effective waterway management aims at sustaining the improved navigability.

4 STARTING POINT

In this chapter the starting point for the Elaboration and Evaluation of Strategies is described in Figure 4.1. First the main results of the Analysis and Diagnosis phase are summarized in the paragraph issues and opportunities. Second the baseline situation describes what is likely to happen, if no policy changes will be implemented in the future. Finally all the assumptions for the strategy development, comparison and selection are listed in one overview.

Figure 4.1 – Process steps – Set Starting Point

4.1 GENERAL CONTEXT

The strategies aim to solve the issues that restrain the development of IWT and take advantage of the opportunities that will occur in the future. This chapter provides a summary of the main issues and opportunities identified in the assessment and diagnosis phase of this plan and mentioned in the interviews with stakeholders.

4.1.1 Cargo transport

About 25 million tons was transported on inland waterways in Brazil in 2011. This cargo flow was distributed over a limited number of waterways and the majority was transported over long distances (over 500 km). Given the potential of commodities suited for the transport on inland waterways in Brazil (large volumes of bulk cargo over long distances) many opportunities were identified for the development of IWT.

Exports of Brazil have grown considerably in the last decade and almost all exports use seaports to reach the main importing countries, like China and western European countries. The transport on inland waterways of the main agricultural products like soy, soymeal and corn was exclusively export orientated and this was also true for iron ore and manganese, two other important commodities for inland waterways. The most important domestic flows are the chemical products and oil on the Amazon. In the Amazon region no consistent alternative for inland waterway transport is structured, therefore, almost all transport is based on waterways.

When the forecasts for production and exports of important commodities are considered, the prospects for inland waterways in Brazil are very good.

The agricultural production of soy and corn, the two main crops in Brazil, will continue to expand until 2031, the forecast horizon. For example, in Mato Grosso, where the export of soy, soymeal and corn currently experiences problems, especially in the harvest season in the transport to ports like Santos and Paranagua due to heavy traffic congestion and capacity problems in the port (waiting times can be as long as 30 days), but the export of Mato Grosso is still predicted to increase 67% by 2031 (FIESP_ARCADIS forecasts). This illustrates highlight the necessity of taking drastic measures. One of these measures is increasing the share of IWT by improving existing routes and creating new ones, not only for Mato Grosso, but also for other main producing areas in the south and new producing areas in the Northeast (MATOPIBA).

Import of commodities will increase as well, again based on FIESP forecasts. An example is the transport of fertilizers, which are important for agriculture and are mainly imported. Although the share of domestic production of fertilizer is predicted to grow to about 50% of domestic use (FIESP), imports will also still grow and inland waterway transport can play a role in the cargo transport from seaports to the hinterland.

The Amazon River and the Lagoa dos Patos in the south play an important role in short sea transport (between ports in Brazil through a sea route). The Amazon River up to Itacoatiara is even used for deep sea vessels.

CARTOGRAPHIC ITEMS

- State Capital
- Borders
- Rivers Studied
- Water Surface
- Seaport
- IWT Terminal
- Main Highways
- Existent Railroads
- IWT in Current Operation

REFERENCES

Sources:
- Integrated Cartographic Base from Brazil - IBGE, 2010
- ANA, 2010
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ESCALA GRÁFICA

0 162,5 325 650 km

GEOGRAPHIC COORDINATE SYSTEM, HORIZONTAL DATUM: SAD69

LOCATION

MINISTRY OF TRANSPORT

ARCADIS logos

INLAND WATERWAYS STRATEGIC PLAN

IWT IN CURRENT OPERATION

EXECUTED BY:	SCALE:	SHEET:	DATE:
ARCADIS logos	1:17.000.000	- BRASIL -	2013

Current Inland waterway transport of chemical products, oil and coal and Ro-Ro transport will steadily increase. The production of oil and chemical products will grow at approximately the growth of GDP (5% until 2022 and 3% afterwards till 2031). For the forecasts it is assumed that the growth rate will be 5% till 2023 and 3% from 2023 to 2031. Iron ore and other ores (mainly manganese) also show growing exports (mainly to China). The export of iron ore, for example, is expected to grow from 330 million tons in 2011 to 829 million tons in 2031 (source PNM). Especially the transport on the Paraguay River could profit from growing production and other rivers like the Tocantins River can function as an additional export route, beside the Carajás rail track.

Another potential projects for developing inland waterway transport is the construction of new plants and systems that will be built near waterways to profit from a cheaper and reliable transport mode. In most cases this will not be a gradual growth, like in the agriculture sector, but once a plant is ready for production, the maximum production capacity will soon be reached. It is important to point out that these investments mostly generate big flows. Key examples are the steel plant in Marabá, the pulp factories in Três Lagoas and Guaíba and the ethanol system in the states of Sao Paulo and Mato Grosso do Sul. This will increase waterway transport on respectively the Tocantins River, the Paraná – Tietê Rivers and the Lagoa dos Patos significantly. It is likely that, once these investments in plants are realized other companies may follow. Therefore, the waterways should be improved “just in time” to accommodate the new demand for waterway transport.

4.1.2 Passenger transport

Passenger transport on inland waterways in most parts of Brazil only occurs under special conditions being, for example, an alternative transport mode in some cities to overcome traffic congestion in rush hours.

In the Amazon region, however, passenger transport on waterways is very important, with currently 6 million long distance passengers and an expected growth of 40% up till 2031. Also short distance (ferry) services are important is this area, with an equal amount of passengers. The main reasons for this particularity in this region are its extensive river system and the limited number of roads in this vast area. For a large number of destinations transport on waterways is the only means of transport.

Inland waterway passenger transport should be safe, reliable and comfortable and in order to improve the level of service, renewal of the fleet and terminals for passenger transport are urgently required.

Concerning the fleet renewal, it is observed that due to the low fare levels and the high costs of renewal, investment capacity of the private transport operators is falling short. As inland waterway passenger transport in the Amazon region can be considered as a public service from a socio economic point of view, the improvement of the service level can be seen as a case for public intervention. This service could be given in concession to private companies though. Fiscal or other financial instruments (e.g. tax cuts for investments in fleet) could boast investments in fleet renewal and other service improvements, by private transport operators, especially in the dominant IWT region, the Amazon.

4.1.3 Navigability Conditions

The Brazilian rivers studied in this plan have distinct characteristics in terms of their physical conditions of navigability and this is the result of different topographical, geomorphologic and hydro-meteorological characteristics along the river basins.

The most favorable rivers for navigation are generally those with features of lower course or lowlands, characterized by a gentle slope and are fairly regular and large. Their main obstacles are areas with sand banks. Within the national scenario, the main rivers of lowlands that have extensive stretches with favorable characteristics for navigation, and without the need for major interventions, are the Amazon, Solimões, Trombetas, Madeira, Paraguay and Jacuí Rivers, Lagoa dos Patos, and the downstream sections of Tocantins and Tapajós rivers. All these rivers already have commercial navigation in varying levels of intensity.

There are also the rivers of tableland or in upland, which have more restrictive conditions for navigation, featuring sections with natural obstacles such as leaps, rapids, rocky indents and outcrops and shallow depths stretches, and also sections with more satisfying navigability conditions. In the river sections with these characteristics commercial navigation is possible in most cases during the flood season, when the water levels are higher. During droughts, however, the navigation conditions are too restrictive, when natural bottlenecks emerge in the river bed. In these rivers the necessary hydraulic works and interventions involve considerable investments.

The main upland rivers that have navigable stretches are: Paraná, Tietê and São Francisco. Several interventions have already been made to allow the current navigability conditions. Besides the rivers mentioned above, the rivers with more potential for the development of waterways are the Tocantins, Araguaia, Tapajos, Teles Pires, Parnaíba and Uruguay. To be able to navigate at a reasonable scale these waterways need engineering works (mainly dams).

4.1.4 Social and Environmental Aspects

The waterway transport is the most suitable for more sensitive areas, because of its lower impact on the environment when compared to roads and railways. Even though it is necessary that the planning of the engineering works, needed for making the development of this mode, is done with the minimum impact on the environment. In the case of the Paraguay, Uruguay, Amazon and Madeira waterway systems the planning of works must also consider the interests of neighboring countries.

Rivers located in areas of particular importance to biodiversity conservation, such as the Amazon biome (Amazonas, Solimões, Trombetas and Madeira Rivers) and wetland (Paraguay River) are already used for the transport between local communities and even for the cargo transport.

Although already used for commercial navigation nowadays, Amazon and Madeira waterway systems have in their surroundings legally protected areas, where the presence of indigenous lands and protected areas and other areas of conservation interest are highlighted. A similar situation is observed in the Paraguay system, located in an area of importance for biodiversity conservation (Pantanal Biome). And, although Teles Pires-Tapajós waterway system is not yet used for commercial navigation, it crosses an important conservation area not only for biodiversity preservation purposes, but also due to traditional communities living close to the rivers (Munduruku, Apiacás and Kayabi Indigenous communities, among others); mainly on the area that surrounds the confluence of Juruena and Teles Pires rivers. It is important to emphasize that all future interventions to provide additional capacity for navigation purposes to these rivers needs to take these protected areas into account while planning to avoid/minimize potential social and environmental impacts.

In the Tocantins-Araguaia waterway system the presence of Bananal Island needs special attention. This island is the largest river island in the world and delimits two arms of the Araguaia, being the smaller arm known as Javaés River. This island, the transition zone between the Amazon and the Cerrado biome, concentrates great biodiversity and legally protected areas, indigenous land (Karajá, Javaé and Xambioá Indigenous Reserves, among others), and was established by UNESCO as a Biosphere Reserve.

The rivers included in the semi-arid region (São Francisco and Parnaíba Rivers) deserve special attention. Dams and projects for flow adjustments, necessary to ensure the viability of the waterway, need to be evaluated together with the other uses of water resources to ensure that the development of waterways do not impact the water availability in nearby regions.

Waterway systems on the southern region (South, Uruguay and Tietê-Paraná) are located at a more anthropized area and environmental and social vulnerable areas are less spread. Worth mentioning on Paraná river are two important national parks (Parque Nacional do Iguaçu and Parque Nacional Ilha Grande), that are conservancy areas of integral protection (legally protected areas). The lakes in the South waterway system (Lagoa Mirim and Lagoa dos Patos) have a great importance for biodiversity conservation.

4.1.5 Advantages of inland waterways transport

Inland waterway transport has many advantages over other modalities. This mode is considered to be energy efficient and environmental friendly.

Although marine engines are usually a bit bigger than lorry engines, vessels carry much more cargo at once. Per ton, vessels will show a lower fuel consumption and environmental impact.

Table 4.1.1 Emission indices for road, rail and IWT (2011)3

	Road	Rail	IWT
CO2	100	11	6
Nox	100	86	29
SO2	100	25	31
PM10	100	78	71

In Table **4.**4.1.1 the emission of different modes is compared for a truck (23 tons), a train (2.500 tons) and a convoy (12.000 tons), excluding pre-haulage and end-haulage. The figures favor rail and IWT transport.

In the future all modes of transport will be more environmentally friendly due to better engines. For road this is especially the case for NO_x and PM_{10}. The fuel use will not go down drastically. This implies that CO_2 emission will be at the same level as currently. For IWT the possibilities will be especially in lower fuel use (less CO_2).

Regarding social opportunities, this mode is considered to safe, reliable and less expensive. Congestion on the roads is a major concern in certain regions, especially close to big cities, and has its impact on the reliability of the road transport. Inland waterway transport is a reliable way of transport. In Europe whether for reliability, on-time delivery or customer friendliness, inland navigation is always awarded high if not the highest of all the modes of transport[4].

Table 4.1.2 Cost comparison in R$ per ton and indices (road transport = 100%)

km	Road	Rail	IWT	Road	Rail	IWT
	R$ per ton			Indices		
100	49.46	13.0	5.04	100	26	10
250	73.42	25.5	9.50	100	35	13
500	113.36	43.0	16.94	100	38	15
1000	193.23	72.0	31.81	100	37	16
2000	353.31	120.0	61.56	100	34	17

In Table **4.1.2**4.1.2 a cost comparison[5] is given for different modes for a number of distances (in km). Comparing transport costs is not straightforward because all modes have their own characteristics. The costs are for bulk transport in trucks, bulk trains and 2x2 convoys (with four locks in the waterway for all distances). According to the cost models, IWT cost is about

[3] Source Stream 2.0 (CE 2008)
[4] The power of inland navigation, the future of freight transport and inland navigation in Europe 2013 – 2014 (page 24)
[5] The sources fort his comparison are the cost models from the University of Sao Paulo (road + IWT) and PNLT (rail).

10 to 17% of road costs. This does not include transshipment costs[6]. Rail transport is about twice as expensive as waterway transport.

4.1.6 Institutional Framework

The legal-institutional framework was analyzed in the diagnosis phase with a focus on the following topics: the constitutional principles of the Brazilian environmental law, the national environmental policy, the national policy on water resources, a historical approach of the port sector, a historical approach of the waterway sector important aspects regarding international rivers.

- It was observed that the structure of the waterway management is inefficient, because of:
  - The separation of the management of ports and waterways;
  - Organization of the waterways managements mainly under DNIT's structure, a department notably focused on the road management;
  - The fragility of the instrument (agreement) that ties the Waterways Administrations to DNIT / DAQ via CODOMAR;
  - Recent changes in ANTAQ's role, that moved from the Ministry of Transport to SEP;
- The multiple uses of water resources are not managed centrally.
- The investments in waterways in Brazil have a low priority.
- There is a need to differentiate among licensing process for engineering works required to enable a waterway and for maritime structures.
- Participation of EPL with regard to the planning of integrated logistics for the country is yet new and CONIT could give further support in integrating actions among different interests associated to the waterways feasibility.
- Concerning passenger transport, regulators (DNIT/ANTAQ/SETRAN/CPH) overlap.

4.1.7 Regulatory Aspects

IWT regulations were identified as relevant when related to the following aspects: ship building, crew, taxes and terminals.

It has been pointed by some stakeholders that there are no big ship building players on the inland shipyards market, which may lead to difficulties in expanding their production when higher demands are expected. It has also been stated that the problem is not related to the shipyards themselves, but to the financial agents that spend more than a year to approve the projects, expiring the credit.

[6] For more complex routes including more than one mode of transport, transshipment costs and the costs of pre-haulage and/or end haulage have to be included. The transshipment costs have been estimated as R$ 5 per transshipment.

Another point of attention to the inland navigation regards the crew. The shipping companies are already experiencing a lack of qualified personnel in this area, mainly due to the competition with the offshore market, which also undergoes the same problem. It has been mentioned that there are initiatives to set up courses for training people to this activity (as the law allows courses outside the Navy, but with their approval), however, it has been proved to be difficult to establish them.

The Brazilian fiscal system was also stressed as a problem to develop the IWT by some stakeholders, as in some cases the taxation process leads to additional costs to IWT transport (e.g. in the case of transshipment between modes), but this might not be a general problem. Some problems in the inland terminals were also pointed out. The need for new terminals have been identified by some stakeholders, but the former process to obtain authorization for private terminals was rather slow, with a lot of requirements to be met. Because the new ports legislation is not yet regulated, some projects are delayed. Although this ports/terminals issue is highly important for the IWT development, measures for improving ports and terminals is not within the scope of this project.

4.1.8 Waterway Management System (Operation)

The information systems related to the waterways are often not available, and in general, not concentrated into one authority or well connected.

In the Tietê-Paraná waterway the information system is more organized. Data regarding the waterway situation is provided by the hydro-power plant operator, the DH (Departamento Hidroviário) and the Navy. The shipping companies must also supply several authorities (Navy, Power Plant operator, ANTAQ, and others) with data that concerns their voyage, but not in a centralized and electronic way. Comparing the Brazilian and European/American situation, it has become clear that this type of process in Brazil is not very efficient.

4.1.9 Intermodality

It is expected that the importance of intermodal transport chains, that include IWT, will increase in the near future. The most important reason is the expected cost increase of road transport. With that, it can also be expected that long distance road transport will decrease gradually encouraging a growth path for integrated transport chains.

Increased use of intermodal transport with IWT has a number of implications for the cooperation between modalities. In the first place the costs of transshipment will decrease. In the calculations R$ five (5) per ton is used for transshipment (information from ADM and Raizen in stakeholders interviews).

Most of the potential commodities to be transported on waterways have an overseas final destination, which makes the export port the final point. The choice of a deep sea port defines the route that will be used to transport the cargo, and therefore the logistics chain.

In general, the pre-haulage is done by means of trucks that often used roads under bad traffic conditions (not paved, with several holes), increasing transit time and therefore the total cost.

Besides that, transshipment increases the total cost, as not all the waterways reach the deep sea ports, so not only the pre-haulage is necessary, but also an end-haulage. In some cases, specifically, the Tietê-Paraná waterway, an additional tax is charged over this operation, due to the change of the transport mode.

4.2 BASELINE SITUATION

4.2.1 Definition of Baseline

The strategies, as described in the next chapters, will be compared with the baseline situation[7]. In this case the baseline situation is defined as a situation in which the investments and maintenance costs for inland waterways in Brazil have been reduced to a minimum, assuming that if an inland waterway policy will not be implemented in the current political setting, the attention for waterways will decrease and the situation will worsen due to minimal attention.

The baseline situation is composed of the following components:

A. The current (2011) situation concerning:

  1. Waterway sections used as inland transport waterways;
  2. Inland waterways transport system;

B. Autonomous developments of production and transport demand (goods and passengers), leading to changes in the level and composition of the inland waterways between the current situation (2011) and the furthest plan year (2031).

C. Inland waterways investment and maintenance expenditures.

These components (A1, A2, B and C) are further explained below.

A1) Current waterway sections used as inland transport waterways

- Madeira (Porto Velho - Itacoatiara)
- Paraná – Tietê (São Simao – Pederneiras/ Anhembi)
- Hidrovia do Sul (Estrela – Rio Grande)
- Paraguay (downstream Corumbá)
- Tapajos (until Itaituba)
- Amazonas (Coari – Manaus) (Manaus – Belém)
- São Francisco (Petrolina - Ibotirama)

These waterways currently have a basic level of navigability, enabling the currently used 2x2, 2x3 or 4x5 convoys (barges predominantly with 60m long and 11m width) and/or passenger vessels, depending on the specific river.

[7] The baseline situation can also be referred to as 'reference alternative'.

CONVENÇÕES CARTOGRÁFICAS	REFERÊNCIAS	LOCALIZAÇÃO DA FOLHA	
Capital Estadual Limite político adm. Hidrovia Massa d'água Seaport IWT terminal Rivers current situation	Fontes: - Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010 - ANA, 2010 - PNTL, 2010 ESCALA GRÁFICA 0 120 240 480 km SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL: SAD69	Oceano Pacífico Oceano Atlântico	MINISTÉRIO DOS TRANSPORTES ARCADIS logos **PLANO HIDROVIÁRIO ESTRATÉGICO - PHE** IWT RIVERS CURRENT SITUATION EXECUTADO POR: ARCADIS logos ESCALA: 1:17.000.000 FOLHA: - BRASIL - DATA: 2013

A2) Current inland waterways transport system

- The majority of the terminals in operation for cargo handling are private terminals. Public terminals are in general not in a good condition and predominantly destined for passenger transport. Both the public and private sectors are investing in terminals.
- Equipment is privately owned and operated; this can be either the shippers (production companies) themselves or transportation companies.
- Waterways infrastructure is, in general, publicly owned, maintained and operated, the exception are the locks, that whenever are associated to a hydropower dam, is maintained by the private sector that has the concession of the hydropower operation, as well as the lock operation.

B) Autonomous production and transport development

- Concerning the development of inland waterways passengers transport, the autonomous economic and population growth in the relevant regions (mainly Amazon) is the dominant factor.
- The forecast of production and export of commodities is following the projections of economic growth in Brazil. Please refer to the Diagnosis report for more details.
- The expected growth of total transport and the share of inland waterways transport follows the forecast of production and export of commodities. Complete overview of growth expectation and more details are elaborated in the Diagnosis report.

C) Inland waterways investment and maintenance expenditures

- The projected investment in waterways, as stated in official policy documents (e.g. PAC) is taken into account.
- Maintenance of inland waterways is rather different between river systems, ranging from properly maintained to overdue maintenance.
- For some waterway sections on which currently transport takes place, overdue maintenance in the baseline situation is assumed to seriously impede waterways transport, eventually leading to a less or non-viable waterway. This holds for:
    - Madeira (Porto Velho - Itacoatiara)
    - Hidrovia do Sul (Jacui - Taquiri)
    - Sao Francisco (Petrolina – Ibotirama)

For the rivers mentioned the expert team assumed that maintenance cannot be regarded as standard policy. It is assumed that maintenance on the Tietê is regularly done.

CONVENÇÕES CARTOGRÁFICAS	REFERÊNCIAS	LOCALIZAÇÃO DA FOLHA
Capital Estadual; Baseline; Limite político adm.; Hidrovia; Massa d'água; Seaport; IWT terminal	Fontes: - Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010 - ANA, 2010 - PNTL, 2010	

ESCALA GRÁFICA: 0 120 240 480 km

SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL: SAD69

MINISTÉRIO DOS TRANSPORTES

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PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS BASELINE

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
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4.2.2 Baseline Transport Volumes and Transport Costs on Inland Waterways

In total approximately 25 million tons of cargo is currently being transported by inland waterways (See Assessment and Diagnosis Report). For passengers the current amount is approximately 5.4 million people on long distance routes between the main cities in the Amazon region. Another 6.6 million passengers used ferries to cross the rivers in the Amazon Basin.

The defined baseline implies that waterway transport only will take place on a restricted number of natural waterways like: the Amazon River, the Paraguay River (From Ladário to the south), and the Lagoa dos Patos (in the far south). The only exception is the Paraná-Tietê. For this waterway we expect maintenance to remain on the same level as in 2011 (without the extension to Salto). The load forecasts for 2031 are the basis for estimating the amount of transport on waterways for the baseline.

In the following tables (Tables 4.2.1, 4.2.2 and 4.2.3) are presented the cargo volumes expected in the waterways, at baseline, considering three areas of growth: natural growth (organic growth) of current loads carried in waterways, with the exception of agricultural products; growth due to investments in specific projects and, growth of agricultural production.

In Table 4.2.1 is presented the forecasts for organic growth8 (for baseline) of the load volume in the natural navigable waterways.

Table 4.2.1 - Expected transport volumes 2031 for existing flows (excluding agricultural) in tons * 1000

Waterways	Baseline (2031)
Amazon	11.466
Madeira	-
Sao Francisco	61
Paraguay	14.883
Hidrovia do Sul	1.618
Total	**28.028**

The Madeira is not maintained and will therefore have no transport in 2031. For the Hidrovia do Sul only a part of total transport will be affected. This is transport on the Jacui and Taquari. This is mainly transport of chemical products, oil, coal and wood. In 2031 over two million tons are expected to shift to other modes. On the Sao Francisco a small amount of cottonseed is transported.

In Table 4.2.2 the expected load volumes from investments in plants and systems is given for the Tocantins, Paraná-Tietê and Hidrovia do Sul.

[8] Without agricultural commodities like soy, corn and/or fertilizers

Table 4.2.2 - Expected transport volumes 2031 from investments in plants and systems (in tons * 1.000)

Rivers	Baseline
Tocantins	-
Paraná-Tietê	15.988
Hidrovia do Sul	2.199
Total	**18.187**

The main difference is transport on the Tocantins River. As no investments will take place in the River, other modes of transport have to be used for the transport related to the steel plant in Marabá. The transport flow by waterway between Marabá and Vila do Conde will not be realized in 2031. In the Hidrovia do Sul no transport will take place on the Taquari -Jacui Rivers.

In Table 4.2.3 the expected volumes of agricultural products to be transported by waterways (at baseline) are distributed between the rivers Paraná-Tietê, Paraguay and South Waterway.

Table 4.2.3 - Agricultural products for baseline 2031 (in tons * 1.000)

Waterway	Baseline
Madeira	0
Tapajós	0
Araguaía	0
Tocantins	0
Parnaíba	0
Sao Francisco	0
Paraná-Tietê	7.091
Paraguay	1.307
Hidrovia do Sul*	2.479
Total	**10.877**

** Hidrovia do Sul is not calculated with modal split model. The forecasts for the Hidrovia do Sul are taken from the diagnoses forecasts, because there is no competition between waterways as in e.g. Mato Grosso.*

The total volume of load expected to grow in these different aspects are presented in Table 4.2.4. With very modest maintenance costs (only for the Paraná – Tietê maintenance is anticipated) total transport volume in the Baseline will be about 57 million tons. Halve of this amount is from autonomous growth on the Amazon and the Paraguay River. The projects on the Paraná – Tietê (ethanol and wood/pulp) are responsible for another 18 million tons. The amount of agricultural products will be about 10.9 million tons on the Paraná Tiete and the Lagoa dos Patos.

Table 4.2.4 - Overview of total transport volumes for baseline, in 2031 (in tons * 1000)

Transport flow	Baseline
Organic growth	28.028
Projects	18.187
Agriculture products	10.877
Total	**57.092**

Table 4.2.5 features a comparison of the total volume of cargo transported currently (2011) with those expected at baseline in 2031, by waterway system. It was chosen to group the Amazon, Madeira and Tapajós WS due to the integration and overlapping routes in these rivers, avoiding duplication of volumes. The volumes do not consider the amount of cargo transported over short distances (eg, petroleum products on the Amazon River and sand in the river Tietê).

Table 4.2.5 – Comparison of total transportation volumes at baseline, in 2011 and 2031, in the waterways (in 1.000 tons)

Waterway System	Baseline (2011)	Baseline (2031)
Amazonas, Madeira e Tapajós	8.940	11.466
Tocantins	0	0
Sao Francisco	50	61
Parana Tiete	1.999	23.079
Paraguai	3.746	16.190
Hidrovia do Sul	5.442	6.296
Total	**20.176**	**57.092**

The transport of passengers by inland waterways is expected to grow, especially in the Amazon Region. This is due to the economic and population growth of the region and the investments in waterways by the Brazilian Government (especially in Tapajós River). The Assessment and Diagnosis Report gives an overview of current passenger transport and a short/medium/long term expectation (see Table 4.2.6). This means a growth between 2011 and 2031 of 2,2 mn. of passengers travelling long distance IWT.

Table 4.2.6 - Overview of long distance Passenger Transport (in mn. passengers)

Passenger Transport in the Amazon	Baseline
2011	5,4
2015	6,0
2023	6,9
2031	7,6

Table 4.2.6 only concerns the main long distance transport. The total volume of passengers on long-distance routes is currently 5.4 million and 7.6 million passenger journeys are expected in these waterways in 2031. The total of short distance travelers (ferries) in the Amazon is 6.6 million in 2011. The expert team expects this number to be stable due to two forces in opposite directions: first the population will grow steadily (this would increase the number of crossings) on the other hand one can expect more bridges to be build (like the one in Manaus), which would lower the number of crossing by boat. The expert team assumes these two forces to be in balance.

Note that in the Baseline only four rivers will be used for IWT: the Amazon, the Paraguay River, the Paraná-Tietê, and the Lagoa dos Patos.

Conclusion: in the Baseline in 2031 a projected cargo volume on inland waterways of approximately 57 million tons is expected. For passengers travelling long distance the expected increase is 2,2 mn. passengers.

In order to compare the transport costs it was necessary to calculate the transport costs in the Baseline. To do this, assumptions had to be made about the used modes of transport if IWT is not available. A good example of this is the ALPA steel plant in Marabá. The plant is designed to use IWT as its most important mode of transport. The location of the plant, directly at the Tocantins River is a clear indication of this. If waterway transport is not available, as is assumed in the Baseline alternative, other modes of transport should be used. For coal and steel rail transport is the next best solution. In some cases (e.g. transport between Porto Velho and Itacoatiara) rail transport is not available as an alternative. This transport can, in the absence of IWT, only be carried out by road transport. Total transport costs for the Baseline are given in Table 4.2.7.

Table 4.2.7 - Transport costs in Baseline (in R$ * 1000)

Year	Baseline
2011	R$ 16.555
2015	R$ 22.178
2023	R$ 36.628
2031	R$ 58.762
2045	R$ 58.762

4.3 ASSUMPTIONS

For the development and evaluation of strategies, the main assumptions made are presented below, grouped in different relevant activities:

- Selection of cargo types
- Transport forecast, modal split and route selection
- Costs/benefits

- Responsibilities distribution
- Strategy selection
- Convoy sizes, capacities and purchase cost

The assumptions were based on information gathered in meetings with stakeholders (see Stakeholders Consultation Report), on the assessments conducted along the stage of diagnosis (see Assessment and Diagnosis Report) and also on the experience of the experts, both in projects in Brazil and abroad.

4.3.1 Selection of Cargo Types

- Bulk cargo with low value per ton is most suitable for large scale transportation on inland waterways, especially if transported over large distances. From that respect the following commodities are deemed relevant for inland waterways transport in Brazil, present or future:
  - Soy, soymeal
  - Sugarcane, sugar and ethanol
  - Corn
  - Wood and pulp
  - Ore and stee
  - Coal
  - Fertilizers
  - Containers and RoRo
- These cargo types will be the engine for the development of transport over water in general, in the slipstream of which other types of cargo and passenger transport may also use the expanded and properly maintained waterways.

4.3.2 Transport Forecast, Modal Split and Route Selection

- The forecast of production and export of commodities is following the projections of economic growth in Brazil;
- Transport forecasts from the diagnosis phase form the basis for the transport flows in the strategy phase (see Assessment and Diagnose Report);
- Routes are selected by a model based on the three least cost-routes per micro-region, taking into account all inland transport modes and chains (road, rail and inland waterways) (For more detailed information, see Chapter 6, item 6.1, Cost/Benefit Methodology);
- Transport costs are the main driver for choosing these routes;
- Existing and new transport routes were considered;

- Concerning inland waterways, all waterways have been taken into account that already accommodate cargo flows of 50.000 tons per year or more or have potential for such flows.
- Locations of the terminals can be the following:
  - Close to the production areas (maximum cargo potential);
  - Close to the (sea)ports of destination (least investment cost).
- PNLT 2011 has served as a reference and checkpoint for the transport forecasts;
- PAC1 and PAC2 completed in 2031.

4.3.3 Costs/Benefits

- Costs for road transport and inland waterway transport are calculated according to models constructed by the University of São Paulo (For more information, see Annex IX – Assessment and Diagnose Report);
- Determining transport costs:
  - The transport costs for rail are taken from PNLT;
  - Transhipment costs are 5 reais per ton.
- Investment and maintenance costs:
  - Cost estimations are including tax;
  - Annual maintenance cost: infrastructure (dams, locks, etc.) 4 %, waterway works (dredging etc,) 3%.
- Discount rate is 6.25 %, taken from Long Term Interest Rate in Brazil (same rate adopted in PNLT);
- It is assumed that waterways investments will be executed in 6 years' time, starting in 2015. Hence benefits derived from these investments (transport costs savings etc.) will start from 2021 onwards until 2045;
- No return cargo has been taken into account (hence a conservative approach concerning transport costs);
- A division is made between competing flows and dedicated flows. Competing flows are defined as flows with two or more competing transport chains (rail versus IWT versus road, but sometimes also amongst IWT itself if multiple waterways may serve the same hinterland). Dedicated flows are only transported by IWT. An example of competing flows is the export of soy from Mato Grosso to Europe or China, while transport of ethanol on the Paraná – Tietê River is a dedicated flow;
- The waterways have been designed for 2-way traffic, however, for critical sections not longer than 2 km, 1-way traffic is deemed to be permissible;

- Cost of barges are dependent on current barge size on waterways;
- Unit cost of dredging: 15 R$/m³;
- Unit costs of rock demolition: between 300 and 600 R$/m³;
- The minimum width for the navigable channel in the waterway s was based on PIANC standards;
- The costs of the physical interventions and the locks are based on several sources. A more detailed explanation of the costs considered in this Plan is described in Annex B.

4.3.4 Responsibilities Distribution

- Public investments are required on elements that will be used by several different stakeholders that need large amounts of money, do not have a feasible private business case and are long term investments. Therefore the Government, in principle, is funding:
  - Waterway maintenance;
  - Waterways improvement.
- Private sector is in principle responsible for investment and maintenance of logistic facilities (terminals, fleet, equipment, staffing etc.);
- Government is in charge of spatial planning.

4.3.5 Strategy Selection

- The investments into the IWT need to benefit the society of Brazil. Public investments are e prioritized in order to focus on the measures with the largest public benefit concomitant with the least negative social and environmental impacts;
- Social and environmental effects and restrictions should be considered along with the (private) economic impact;
- Finally, future hydroelectricity development - another government policy area - may interfere or impede inland navigation altogether.

4.3.6 Convoy Sizes, Capacities and Purchase Cost

The following assumptions were addopted to determine the capacity of the barges and the required power of the push-boats.

Capacity of the barges

A standard barge has been assumed for the majority of the waterways. The dimensions of the standard barge are presented in Table 4.3.1. The capacity of a barge has been estimated to be 0,75 x L x B x T in which L, B and T are the length, the beam and the draught respectively. The factor of 0,75 is rather low to allow for the relatively small draught of the barges. An analysis of barge prices as presented by the Centro de Inovação em Sistemas Logísticos da Escola Politécnica da Universidade de São Paulo resulted in the following relations:

- Unit price of a barge is: 750 - capacity*0,15 (R$/ton);
- The unit price of a barge for ore transport is 30% higher.

In a number of waterways convoys or self-propelled barges with different dimensions have been assumed, to better cope with the natural conditions of these waterways:

- For the Amazon no depth restrictions have been assumed. The resulting minimal draught is 4,0m;
- On the São Francisco the barge dimensions are limited due to the dimensions of the lock in Sobradinho and the limited depth in the waterway. The resulting barge dimensions are also presented in Table 4.3.1;
- On the Lagoa dos Patos section of the Hidrovia do Sul the wave conditions are such that navigation with barges is not feasible. Self-propelled barges are used on this waterway. The dimensions are presented in Table 4.3.1. For these vessels the investment costs have been determined separately.

Table 4.3.1 - Standard barges

		All other waterways	Amazone	São Francisco	Lagoa dos Patos	
Length	L	60	60	50	110	m
Beam	B	11	11	8	16	m
Draught	T	2,5	4,0	1,8	4,5	m
Capacity		1.196	1.914	540	5.400	tons
Cost		682.535	885.991	361.260	7.142.000	R$

Power of the push-boats

An analysis of the push-boats currently in operation showed that If the convoy is bigger than or equal to 4x4 barges, the length of the push-boat is 28 m. For smaller convoys the length of the push-boat is 18 to 22 m. The same analysis indicated that the power of the push boat is 200+capacity*0,123.

An analysis of push-boat prices as presented by the Centro de Inovação em Sistemas Logísticos da Escola Politécnica da Universidade de São Paulo resulted in the following relation:

- Total push-boat price is 3.200 x power (R$).

5 DEFINITION OF DEVELOPMENT STRATEGIES

5.1 INTRODUCTION

From the definition of the objective and sub-goals, based on the information collected and on the assessments conducted throughout the stages of Stakeholder Consultation and the Assessment and Diagnosis, were defined the strategies of development that would enable the expansion and improvement of the Brazilian waterways network. This process is illustrated in Figure 5.1.

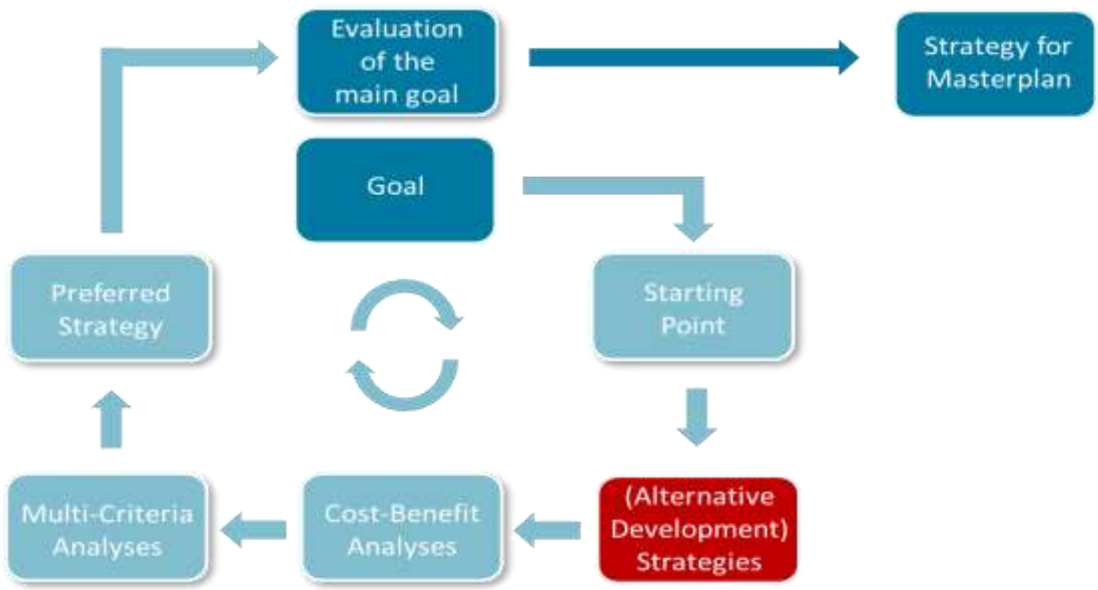

Figure 5.1 – Process Steps – Definition of Development Strategies

In the context of this plan, a strategy is a set of measures, projects or activities aimed at reaching the (preliminary) goal of 110 million tons in 2031. In general the 'hardware' and the 'software' elements of the transport system can be distinguished:

- Hardware can be described as the more physical, tangible elements (the waterway infrastructure, dams, locks, vessels etc.).
- The software can be defined as the catalyst to make the hardware work accordingly, like supportive government, fiscal measures and integrated planning (waterway management, taxes, incentives, legislation). How measures can be executed – public initiative and / or public private cooperation – and the access to sufficient financial means is part of the software.

Both hardware and software are needed to have an efficient and effective transport system; they cannot be seen separately.

Therefore, in this report a clear distinction is made between:

1. Strategy to improve and expand the Brazilian navigable inland waterway network (hardware), and;

2. Strategy to improve the reliability of the Transport System (software).

In this chapter the range of physical interventions required in the rivers covered in the development strategies is presented. Four main development strategies were developed and its components form the whole spectrum of possibilities; they are the building blocks for additional development strategies in the search for the preferred strategy.

The section 5.2 describes the methodology of the elaboration of the strategies, and the process adopted for them. It explains how normative convoy sizes were used to determine hardware measures.

The section 5.3 presents the definition of the Baseline and Development Strategies, in which the range of strategies is fully described. The section 5.4 goes on to explain the physical measures for the rivers sections considered in the Strategies.

The assessment of Development Strategies was done using a Cost-Benefit model and a Multi-Criteria Analysis. This is further explained in Chapters 6 and 7, respectively.

The improvement of the reliability of the transport system applies to both cargo and passenger transport on inland waterways irrespective of any of the Development Strategies. In that respect the 'software' measures are not relevant for the comparison between the Development Strategies. For that reason they are not taken into account in the Cost-Benefit Analysis and Multi-Criteria Analysis, but are instead described separately in Chapter 9. The selection and description of the selected strategy is described in Chapter 8.

5.2 METHODOLOGY OF DEFINITION OF DEVELOPMENT STRATEGIES

5.2.1 Development of Strategies and Measures

A basis requirement to accommodate at least 110 million tons of cargo via inland waterway transport in 2031 is to expand the inland waterway network. More navigable waterway routes must be available in order to compete with road and rail transport. The core of developing the strategies was therefore the selection of the best waterways and best routes to expand the Brazilian navigable inland waterway network.

Based on the assumption mentioned in Chapter 3, *'all waterways have been taken into account that already accommodate cargo flows of 50.000 tons per year or more or have potential for such flows'*, the waterways that were considered for the strategies are:

- Amazon, Solimões e Negro
- Madeira
- Tapajós e Teles Pires
- Tocantins
- Araguaia
- Parnaíba

- São Francisco
- Paraguay
- Paraná e Tietê
- Hidrovia do Sul (Lagoa dos Patos, Triunfo e Jacuí)

CONVENÇÕES CARTOGRÁFICAS

- Capital Estadual
- Limite político adm.
- Hidrovia
- Massa d'água
- Seaport
- IWT terminal
- Rivers for development of strategies

REFERÊNCIAS

Fontes:
- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010
- ANA, 2010
- PNTL, 2010

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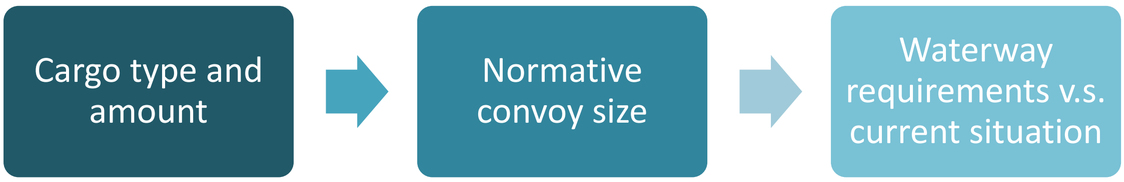
For the definition of the Development Strategies three different levels of ambition were adopted:

1. Maintenance+ - Maintain waterways currently used for IWT ;
2. Expansion (A and B) - Expand the waterway network by enabling navigability of waterways that are most interesting for private sector activities. Expansion has two variations (a strategy (A) involving the rivers most promising from a transport cost point of view and a strategy (B) involving the rivers with less restrictions for implementation.;
3. Top Quality - Further increase of the quality of the waterways/locks to enable larger volume cargo loads.

These strategies are the basis for sets of general and waterway specific (infrastructural) measures. Of course, more and more comprehensive measures are required for the highest quality level. By working with these three levels of ambition, the whole spectrum of possibilities is explored.

Each of the Development Strategies consists of a set of hardware regional measures. These physical measures are aimed at ensuring the navigability by increasing depth and width of the waterways and building or improving sluices/locks at dams, adapting bridges and improving guidance.



To determine the required waterway improvement works the size of the vessels that will navigate on the waterway in the future had to be selected. Based on the size of these vessels the required dimensions of the waterway and the locks were determined:

- Length, width and depth of lock chambers
- Depth and width of river cross sections
- Minimum radius of river bends

In selecting the vessel sizes, two different situations have been considered:

- A minimum convoy size for the Expansion Strategy. This minimum required convoy size differs per waterway.
- An increased realistic maximum size of the convoy for the Top Quality Strategy. Again, this size differs per waterway.

In determining the convoy sizes the following considerations played a role:

- For a waterway that is presently being navigated the current normative convoy size was selected for both strategies. The dimensions of the largest vessel presently sailing on the waterway were taken as normative, with the exception of the sections Santarém - Itaituba (Tapajós river) and Petrolina - Ibotirama (São Francisco river).

- For waterways that are not yet being navigated 2x2 convoys where considered to be the standard convoy, with barges of 60m long and 11 m width (see Chapter 4, item 4.3.6).

- Based on expert judgment it has been decided that for the Tapajos and the Tocantins the realistic maximum convoy size could be increased to 3x2.

The normative convoy sizes provide an excellent basis for determining the required investment costs for upgrading a waterway to the required standard.

During the further development stages detailed design studies should be made, such as the optimization of the design convoy configuration. Increased convoy size and resulting transport cost savings versus bigger locks and wider waterways can only be made looking at all operational aspects in the transport chain, like splitting up convoys in locks and changing convoy sizes between locks. The type of information as well as the level of detail that is required for this optimization can only be attained in a further development stage.

The design specifications for the upgrading of the service level of the waterways have been derived from the "Richtlijnen Vaarwegen", the Dutch guidelines for the design and operation of inland waterways. To guarantee a smooth and uninterrupted traffic flow the specifications for the design of the waterways must guarantee two way traffic. This specification has been eased in exceptional situations where for critical sections not longer than 2 km, one-way traffic has been deemed to be permissible.

The design specifications deal with aspects such as: water depth in the channel, width of straight sections, additional width in curved sections and minimal waterway bend radius, which are summarized in table 5.2.1.

The width is defined as the minimal width in the keel plane of a loaded vessel for 1- or 2-way straight sections.

Table 5.2.1 Design specifications

Depth	d	1,3	Draught T
Minimal bend radius	R	4,0	Length L
Minimal width 2-way	w2	3,0	Beam B
Minimal width 1-way	w1	2,0	Beam B
Additional width in bends	wb	0,6	L*L/R

Based on these design specifications the required waterway dimensions have been determined for the selected normative convoys or vessels. The required dimensions were compared with the current waterway dimensions in order to determine the physical measures that are necessary to bring the waterway to the required quality. A selection of possible physical measures is given in Table 5.2.2.

Physically improving and expanding the waterway system alone is not enough to increase the amount of cargo transport over inland waterways. Additional measures are required to further improve the transport system and its reliability. The elements of the transport chain should be adjusted to meet future cargo potential. Measures are aimed at improving the transport system by improving connectivity for pre- and end-haulage, ports and inland terminals, fleet and crew. Measures that are necessary to improve the transport system are following those to improve the navigability. In this report the measures needed for the increase of transport system and its reliability are presented in Table 5.2.2. More details of these measures will be presented in the Masterplan Report.

Table 5.2.2 –Measures to improve the navigability and the transport system and its reliability

NAVIGABILITY	Infrastructure & facilities
River bed	Regularization of waterway bed Rectification bed Widening margins Dredging rock blasting
Locks/sluices	Construction of a system of locks and sluices Improvement of existing sluices and locks
Channels	Correction channels Overthrow channels
Dams	Construction of dams with sluices or lock systems
Bridges	Raising and widening of bridge wills Reconstruction of bridges Widening and heightening the spans of bridges
Guidance	Beaconing Guideposts
TRANSPORT SYSTEM	**Superstructure**
Connectivity for pre- and end-haulage	Construction of roads between production areas and inland ports
Ports and Inland Terminals	Construction of quay walls, jetties, terminal equipment and storage
Fleet	Construction of barges and push boats
Crew	Provision of sufficient educated crew members

5.2.2 Methodology of Cost Estimations

Only the public investments for improvement of the navigability were calculated per measure. The investment costs of the measures provided essential input to the Cost-Benefit Analysis.

Annex B provides a description of the criteria and considerations adopted to determine the physical interventions on the waterways, in order to ensure and improve the navigability conditions of the waterways selected for the strategies. Moreover, it presents the considerations utilized for the estimation of the costs involved in the proposed physical interventions and additional lock systems.

The required investment costs are estimated for a strategic purpose. The level of detail of the cost estimations is suitable for comparing strategies. For this strategic phase of the project the most accurate cost estimates possible were made. However, when a certain measure will be executed a more detailed project-cost estimation is required. This may lead to some variation in the costs of a certain measure. Investment costs are depenend on local circumstances. Costs of dredging and rock demolition, for example, may vary between regions, when a region already has the necessary equipment such as dredgers. For the cost estimations of the locks the materials, user specifications and life span were taken into account.

The maintenance costs have been calculated as a percentage of the investment costs. The percentages were estimated on the basis of experiences in Europe and Brazil. For locks and other constructions a percentage of four (4%) has been used. For other activities a percentage of 3% is used in the calculations. The maintenance costs start right after the investments have finished. In the cost benefit analyses this is in the year 2021, as the investments take place in the period 2015 – 2020.

For the Madeira River and the Hidrovia do Sul maintenance costs have been taken into account without investment costs. The main reason is that maintenance is (long) overdue in those waterways. Without including these maintenance costs IWT will not be possible on these waterways.

The investment costs for the measures in the logistic system - for example new fleet, docks, terminals, extra staff, facilities - are assumed to be incorporated in the transport costs via depreciation of the facilities and are therefore not calculated per individual measure. The (change in) transport costs have been input for the Cost-Benefit models.

5.3 DEFINITION OF BASELINE AND DEVELOPMENT STRATEGIES

To reach the goals, a baseline and three strategies (Maintenance+ Expansion and Top Quality have been defined. In the following illustration the baseline and the three development strategies are characterized in more detail:

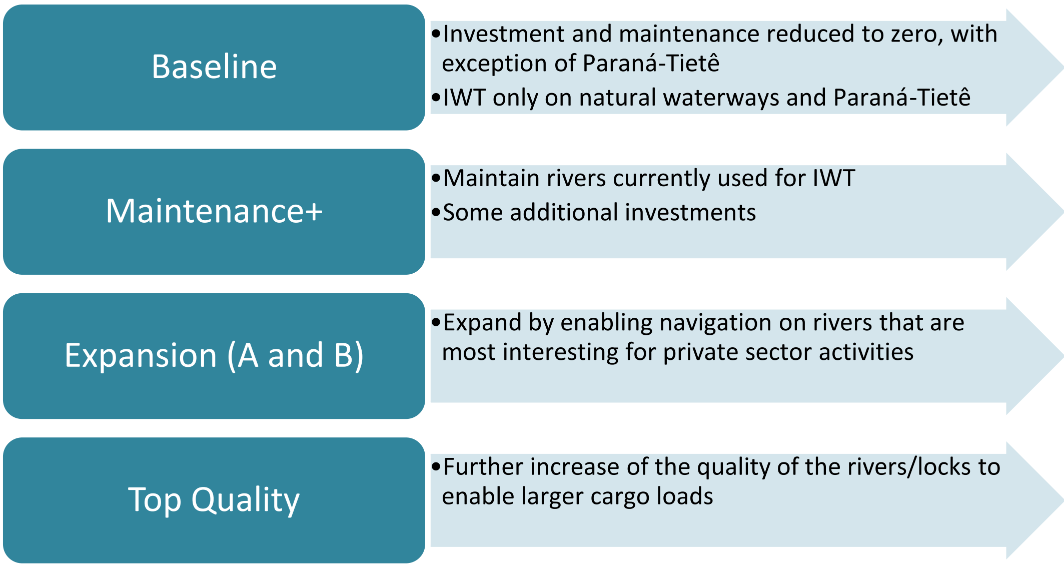


Figure 5.3.1: Definition of Baseline and Development Strategies

The strategy Expansion is divided into two sub strategies (A and B) with different starting points for waterway selection. This will be explained later in this paragraph.

5.3.1 Baseline

The baseline is defined as the future situation in which the investment and maintenance costs for the currently used inland waterways in Brazil have been reduced to a minimum. This baseline serves as a reference for assessing the impact of the Alternative Development Strategies and preferred strategy. In the baseline, waterway transport will only take place on a restricted number of natural waterways like: the Amazon River, the Paraguay River (From Ladário to the south), and the Lagoa dos Patos (in the far south of the country – see Map **IWT Rivers Baseline**). The only exception is the (currently navigated sections of) Paraná-Tietê. For this waterway we expect maintenance to remain on the same level as in 2011.

CONVENÇÕES CARTOGRÁFICAS	REFERÊNCIAS	LOCALIZAÇÃO DA FOLHA
Capital Estadual Baseline Limite político adm. Hidrovia Massa d'água Seaport IWT terminal	Fontes: - Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010 - ANA, 2010 - PNTL, 2010 ESCALA GRÁFICA 0 120 240 480 km SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL: SAD69	

MINISTÉRIO DOS TRANSPORTES

ARCADIS logos

PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS BASELINE

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
ARCADIS logos	1:17.000.000	- BRASIL -	2013

5.3.2 Maintenance+

The basic idea of the Maintenance + strategy is to foster the current inland water transport, providing the rivers with current navigation with a higher quality of service (see Map **IWT Rivers Maintenance +**). Current inland water transport on Brazilian waterways is approximately 25 million tons, however, the cargo distribution per river however differs significantly. These current waterways will be maintained properly on a basic level, enabling the currently used 2x2, 2x3, 4x4 or 4x5 barge convoys (for dimensions specifications, see Chapter 4, item 4.3.6), depending on the specific river. There will be no further expansion of transport capacity of these rivers apart from the section in the Tocantins River between Marabá and Vila do Conde.

Selected rivers

Based on the assumptions in Chapter 4 the following rivers are part of this strategy:

Amazon, Solimões and Negro (Belém – Manaus) (Manaus – Coari)

Amazon River is fully navigable in all his sections. However there are two sections that can be difficult to navigate: a) The section between Manaus and Coari, which has mobile sandbanks. b) The connection between Amazon River and Pará River, along Breves channel, where narrow sections and poor signaling infrastructure cause problems. In this strategy investments are proposed to improve the conditions of navigation.

Madeira (Porto Velho - Itacoatiara)

Porto Velho is the most upstream located inland port. In fact, it is the only port in the Madeira River. Current transport on the Madeira exists between Porto Velho and Manaus, Itacoatiara, Santarém, Itaituba, Coari and Belém; both upstream and downstream. In the dry season (low water level), transport on the section between Porto Velho and Itacoatiara is hampered by sandbanks, rocks and rapids. The problem is that during dry season the water level decreases too much (about 10 m) and some natural bottlenecks (rocky outcrops, sandbars, high velocities) may appear in some sections of the river, specially between Humaitá e Porto Velho cities. The cause of the problems is overdue maintenance. In this strategy these bottlenecks will be removed and the river will be maintained properly on a basic level which is minimal requirement for convoys of 4 by 5 barges to continue navigating the river.

Tapajós (Santarém – Itaituba)

Transport on the section between Itaituba and Santarém is hampered by rock and sedimentation problems. The water level variation is not that significant, but there are a few natural obstacles (sand bars and rocks mainly) in this section that result in local problems for navigation, especially during the dry season. In this strategy these natural obstructions will be removed and the river will be maintained accordingly on a basic level so convoys of 2 by 2 barges can navigate the river.

Tocantins (Marabá-Vila do Conde)

In this strategy in the Tocantins River a main stretch is considered to be navigable, between Vila do Conde and Marabá. Currently no transport is possible due to the rocks Pedral do Lourenco. Since 2010 the locks of Tucuruí are in operation as a start for making the river navigable until Marabá. In this strategy, the rocks Pedral do Lourenço will be removed in order to make the investments in the locks of Tucuruí fully operational. Furthermore, in this strategy, the river will be maintained accordingly on a basic level so convoys of 2 by 2 barges can navigate the river.

São Francisco (Petrolina – Ibotirama)

Since the river is not navigable downstream of Juazeiro/Petrolina and there is no direct connection to the sea, only transport upstream to Pirapora is interesting. In this strategy the section between Petrolina and Ibotirama will be used for inland water transport. Bottlenecks that hamper navigation are rocks, sandbars, meandering river parts and low depths. These bottlenecks will be removed and the river will be maintained accordingly on a basic level so convoys of 2 by 2 barges can continue navigating the river.

Paraguay (downstream Corumbá)

The Brazilian section of the Paraguay River with current transport is between Corumbá and Foz rio Apa (Porto Murtinho). Bridges too narrow for convoys to pass on this section. In the Maintenance+ strategy these bridges will be widened and the river will be maintained on a basic level so convoys of 4 by 4 barges can continue navigating the river.

Paraná – Tietê (São Simão – Pederneiras/ Anhembi)

Currently inland waterway transport exists between São Simão and Pederneiras / Anhembi. From Pederneiras cargo is transported to Santos by rail. From Anhembi cargo is transported to Santos by road. In this strategy the river will be maintained on a basic level so convoys of 2 by 2 barges can continue navigating the river. No further investments are needed.

Hidrovia do Sul: Lagoa dos Patos, Jacuí and Taquari (Estrela/ Cachoeira do Sul – Rio Grande)

The South Waterway System has enough infrastructures to allow navigation between Estrela (Taquari River) and Rio Grande (Lagoa dos Patos). However, the current transport is affected by some natural obstacles like riverbanks, river islands and rocks, especially during low water level periods and caused by overdue maintenance. The existing locks were constructed with dimensions of 17m x 120m, according to the self-propelled barges. Between Rio Grande and Porto Alegre no convoys can sail because of waves in Lagoa dos Patos. On this stretch self-propelled barges are used. In the Maintenance+ strategy no interventions are expected, because the navigation of self-propelled barges is not impeded by the obstacles.

CONVENÇÕES CARTOGRÁFICAS

- Capital Estadual
- Limite político adm.
- Hidrovia
- Massa d'água
- Seaport
- IWT terminal
- Baseline
- Rivers Maintenance +

REFERÊNCIAS

Fontes:
- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010
- ANA, 2010
- PNTL, 2010

ESCALA GRÁFICA
0 120 240 480 km
SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL SAD69

LOCALIZAÇÃO DA FOLHA

MINISTÉRIO DOS TRANSPORTES

ARCADIS logos

PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS MAINTENANCE+

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
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5.3.2.1 Elements transport system

Mainenance+ focuses on the improvement of the current system. In the Maintenance+ strategy no new ports, terminals and new roads or connection rail will be developed. Current ports need to be maintained. Overdue maintenance measures will be taken in account. Further investments for river improvement are not part of this strategy. The waterway will retain its current navigability for the current convoy sizes.

5.3.3 Expansion

The expansion strategy starts with the rivers selected in the Maintenance+ strategy:

- Madeira (Porto Velho - Itacoatiara)
- Paraná – Tietê (São Simao – Pederneiras/ Anhembi)
- Hidrovia do Sul: Lagoa dos Patos, Jacuí and Taquari (Estrela/ Cachoeira do Sul – Rio Grande)
- Paraguay (downstream Corumbá)
- Tocantins (Marabá-Vila do Conde)
- Amazon, Solimões and Negro (Coari – Manaus) (Manaus – Belém)
- Tapajós (Santarem – Itaituba)
- São Francisco (Petrolina – Ibotirama)

In *addition* to these waterways, basic navigability (2x2 barge convoys) is guaranteed for a *further* set of waterways, based on an assessment of their potential for IWT. Two types of expansion strategies are distinguished: a strategy (A) involving the rivers most promising from a transport cost point of view and a strategy (B) involving the rivers with less restrictions for implementation. Since some rivers have more or less the same catchment area, in the preferred strategy, a selection may have to be made in order to prevent too much overlap.

5.3.3.1 Expansion A

In the Expansion A strategy, the most promising waterways, from a transport (costs) point of view, are added to the rivers included in the Maintenance+ strategy (see Map **IWT Rivers Expansion A**). An important factor influencing total transport costs are the costs of pre and end haulage. An inland terminal located in the center of a production area, leads to reducing distances for pre haulage and lower transport costs as a consequence. From this point of view, five river sections are added.

Tapajos and Teles Pires (Itaituba to Cachoeira Rasteira)

In the future the Tapajós River can play an important role in the exports from and imports to Mato Grosso. The river has an excellent location near the production regions. From the diagnosis analysis it becomes clear that the potentially most important commodity groups for inland shipping on the Tapajós River are: soy, soymeal and corn (exports) and fertilizers (imports).

A new terminal is proposed downstream of Cachoeira Rasteira, in the municipality of Apiacás in Mato Grosso. The construction of a road connecting the future terminal to the existing road infrastructure is necessary. This new road will cross an indigenous area and this may hamper its implementation. The region has limited options for the implemention of a terminal along the Teles Pires River. In the recent released Study of Macro Location of Terminals in Brazil (Antaq, 2013), Antaq suggested the municipality of Paranáíta for the location of a new terminal but this requires the construction of an extra dam/lock, increasing the investments and also causing environmental conflicts in the area. In Annex F the locations of terminals and the most pressing social and environmental issues are presented.

On several parts of the river navigation is hampered by rocks and rapids. There are three planned dams without locks that will block navigation. Measures are proposed to remove or overcome these bottlenecks to make navigation for convoys with 2 by 2 barges possible. The river will be maintained accordingly on a basic level so these convoys can continue navigating the river.

Araguaia (Marabá to Aruanã)

The Araguaia River is characterized by low depth sections, rapids, high sedimentation process and environmental constraints. These physical characteristics of the Araguaia River make navigation impossible along this segment today. The location of the river, however, is excellent. The waterway transport forecast made for the Araguaia River, elaborated in the Assessment and Diagnose Report, is based on the exports from the States of Goiás, Mato Grosso and from the region called Matopiba, composed by Maranhão, Tocantins, Piauí a west Bahia States. The total potential for the Araguaia River concerning agricultural commodities is equal to the potential of the Tocantins River, once the influence zone for both rivers is the same. The location of the Araguaia River for exports from Goiás and Mato Grosso is better, while the location of the Tocantins River is better for the exports from the Matopiba region. In expansion B strategy the Tocantins is included.

A number of locations for new inland ports and terminals have been selected. These are (in following upstream order) Conceição do Araguaia, São Felix and Aruanã. When a new port is located in Conceição do Araguaia, less investments in the waterway are necessary, compared to more upstream locations. However, because the distances for pre haulage (for exported commodities) and end haulage (for imported commodities) by road are longer to the main producing areas in Goiás and Mato Grosso, the total transport costs are higher and the benefits lower. Aruanã as a new port is located in Goiás and near Mato Grosso. The transport costs for pre and end haulage are lower, but large investments are needed to make the Araguaia navigable up to Aruanã. Current navigation on the Araguaia River is impossible due to sandbanks, river islands, rocky outcrops and low depths. Also, two dams are planned but without the provision of locks. To make the river navigable, the natural bottlenecks need to be removed and the dams should have locks. In Araguaia River civil works and maintenance services will be held to allow navigation of convoys 2x2 (see section 4.3.6) along the river.

Parnaíba and Balsas (Between Teresina and Balsas/ Santa Filomena)

Currently, no transport exists on the Parnaíba River. However, the Parnaíba River's location near the upcoming agricultural production region of Matopiba is excellent. The main question will be whether the Parnaíba River will be the main transport route for this flows, or the Tocantins River. In strategy Expansion A the Parnaíba River is selected. In expansion B the Tocantins extension is chosen.

Since the Parnaíba River has no seaport, Terresina is selected as the most downstream inland port. From Terresina rail or road can be used to reach São Luis or Fortaleza. Upstream two locations for ports near the production region are selected: Balsas (Balsas River) and Santa Filomena (Parnaíba River). Navigation on the Parnaíba River is difficult due to the high sedimentation process, causing sandbanks, river islands and sections with low depths. There are also several dams planned with no locks. Between Balsas and Teresina five dams and between Santa Filomena and Terresina seven dams. To make navigation possible, investments in locks are needed. The river will be maintained properly on a basic level so convoys 2x2 (dimensions – see Chapter 4, item 4.3.6) can navigate the river.

São Francisco (Ibotirama – Pirapora)

Currently, there is only little inland waterway transport on the São Francisco river between Petrolina and Ibotirama due to bad navigability conditions of the river. However, the river is located well near the upcoming agricultural production region of Matopiba. The Tocantins and Parnaiba will compete for the northern microregions of Matopiba due to their excellent location. However, the São Francisco is located conveniently near the southern microregions, like Santa Maria da Vitoria and Barreiras. The São Francisco has no seaport and many natural obstacles downstream. Improving navigability further upstream to Pirapora is, therefore, chosen in this strategy. From Pirapora cargo can be transported by rail to the seaport of Vitoria. This river section has sand banks, fluvial islands, winding sections and sections with low depths, which need to be removed. Work is needed to stabilize the riverbed, dredging, rock demolition, signaling and margin recovery.

Paraná - Tietê (extension from Anhembi to Salto)

Transport on the Paraná – Tietê River is currently possible up to Anhembi for convoys of 2 by 2 barges. From Pederneiras the cargo can be either transported by train or road to Santos, from Anhembi, only by road. In the Expansion strategy the navigability of the Tietê is extended to Salto. From this location the distance for road transport to Santos is shorter, with lower transport costs as a consequence. Currently, the State of São Paulo is investigating this extension. To make navigation of convoys of 2 by 2 barges (see section 4.3.6) between Anhembi and Salto possible, several measures are needed. Current navigation is hampered by silting and sinuosity problems. Also, the existing locks are too small and need to be doubled. Another problem is that some bridges are too small for convoys to pass. These bridges are widened and heightened in this strategy. The river will be maintained on a basic level so these convoys can continue navigating the river.

CONVENÇÕES CARTOGRÁFICAS

- Capital Estadual
- Limite político adm.
- Hidrovia
- Massa d'água
- Seaport
- IWT terminal
- Baseline
- Rivers Maintenance +
- Rivers Expansion A

REFERÊNCIAS

Fontes:
- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010
- ANA, 2010
- PNTL, 2010

ESCALA GRÁFICA: 0 120 240 480 km

SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL SAD69

LOCALIZAÇÃO DA FOLHA

Oceano Atlântico

MINISTÉRIO DOS TRANSPORTES

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PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS EXPANSION A

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
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5.3.3.2 Expansion B

In the Expansion B strategy, different rivers than Expansion A are selected. The Expansion B strategy comprises of the rivers of Maintenance+ with the addition of several waterways considered to be relatively easy to improve (see Map **IWT Rivers Expansion B**). Improvements of these rivers are expected to have the least restrictions for implemention (information based on the Stakeholder Consultation), so development on a relatively short term may be possible. From this point of view the following three rivers are added.

Tocantins (Marabá to Miracema do Tocantins)

As mentioned before, the Parnaíba and Tocantins River compete for transport for the agricultural region of Matopiba. In the Expansion B strategy an additional section of the Tocantins river is selected. Already in the Maintenance+ strategy transport until Marabá is expected. Several investments in the river have already been done (Tucurui locks since 2010 in operation), so contribution of both private and public parties is expected when enlarging the navigability more upstream. In the Expansion B strategy navigability is extended until Miracema do Tocantins. This port is located near the Matopiba region. Current problems for navigating the section between Marabá and Miracema do Tocantins are sandbanks, river islands and low depths. Also, three dams without locks are planned. To make this section navigable for convoys of 2 by 2 barges (see section 4.3.6) measures are needed. These measures contain building locks, dredging and stabilizing the fairway.

São Francisco (Ibotirama – Pirapora)

There is only limited inland waterway transport on the São Francisco river between Petrolina and Ibotirama due to bad navigability conditions of the river. However, the river is located well near the upcoming agricultural production region of Matopiba. The Tocantins and Parnaiba will compete for the northern microregions of Matopiba due to their excellent location. However, the São Francisco is located well near the southern microregions like Santa Maria da Vitoria and Barreiras. The São Francisco has no seaport and many natural obstacles downstream. Improving navigability further upstream to Pirapora is chosen in this strategy. From Pirapora cargo can be transported by rail to the seaport of Vitoria. This river section has sand banks, fluvial islands, winding sections and low depths, which need to be removed. Work is needed to stabilize the riverbed, dredging, rock demolition, signaling and margin recovery.

Paraguay (Cáceres - Corumbá)

On the Rio Paraguay, currently, transport exists of mainly iron ore over a long distance from Corumbá to San Nicolas (Argentine). The most promising commodities are soy, soy meal and corn. Origin of these commodities is Mato Grosso. In the Expansion B strategy a port more upstream is selected. Cáceres is the most inland located Mato Grosso port. Navigation on the river section between Cáceres and Corumbá is hampered by several natural bottlenecks. Especially during dry season the river has low depths and small bend radius on several locations. To make the river navigable for convoys of 3 by 2 barges (see section 4.3.6) straightening the riverbed and fairway as well as dredging is necessary.

In addition, this section is meandering, with nips, silting and low depths, especially between Port Morrinhos (MT) and Cáceres (MS), with 140 km of extension, during the dry season. Bed rectification, dredging, rock removal and rectification of channels is required.

Paraná - Tietê (extension from Anhembi to Salto)

Currently transport on the Paraná – Tietê River is possible up to Anhembi for convoys of 2 by 2 barges (see section 4.3.6). From Pederneiras the cargo can be either transported by train or road to Santos, from Anhembi, only by road. In the Expansion strategy the navigability of the Tietê is extended to Salto. From this location the distance for road transport to Santos is shorter, with lower transport costs as a consequence. Currently, the State of São Paulo is investigating this extension. To make navigation of convoys of 2 by 2 barges between Anhembi and Salto possible, several measures are needed. Current navigation is hampered by silting and sinuosity problems. In addition, existing locks are too small and need to be doubled. Some bridges are too small for convoys to pass. These bridges are widened and heightened. The river will be maintained accordingly on a basic level so these convoys can continue navigating the river.

CONVENÇÕES CARTOGRÁFICAS

- Capital Estadual
- Limite político adm.
- Massa d'água
- Seaport
- IWT terminal
- Baseline
- Rivers Maintenance + Hidrovia
- Rivers Expansion B

REFERÊNCIAS

Fontes:
- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010
- ANA, 2010
- PNTL, 2010

ESCALA GRÁFICA: 0 120 240 480 km

SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL: SAD69

LOCALIZAÇÃO DA FOLHA

MINISTÉRIO DOS TRANSPORTES

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PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS EXPANSION B

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ARCADIS logos	1:17.000.000	- BRASIL -	2013

5.3.3.3 Elements of Transport System for Expand A and B

In addition to measures in the rivers as mentioned before, investments in the transport system are necessary for the total logistic chain to work. These improvements are generally the same for Expansion A and B strategy. Measures are similar, only different rivers are selected. As river navigation is expanded new inland ports and terminals (upstream) are needed for transshipment. By selecting the location for new ports and internal terminals, the current road infrastructure is taken into account. However in some cases new investments enabling pre and end haulage are inevitable. In the Expansion A strategy more investments are needed, compared to Expansion B. Expanding river navigability implies more cargo. To accommodate this cargo, enlarging the current fleet is needed. For this reason, the ship building industry needs expansion. Finally, qualified personnel is needed to navigate on these rivers. So a modernized education system is needed to train crew.

5.3.4 Top quality

The selection of rivers is all the river (sections) of Expansion strategy A and B together (see Map **IWT Rivers Top Quality**). The difference with the other strategies is the size of the convoys that can be accommodated. To enable navigation for larger convoys, current lock capacity should be increased and certain sections of the rivers should be further dredged. To improve the efficiency, effectiveness and reliability of the water transport, double locks at all locations are provided. This would reduce the transport costs, but increase the costs of investments, maintenance and social and environmental impact. The limits are caused by the expected costs. If dredging and widening of the waterway at a section of more than 300 km is expected, this is assumed unlikely to be executed. It is taken into account that more options would induce distribution of cargo on the different rivers, leading to suboptimal results per river. These limits provide the “ceiling” for this top quality alternative and are based on the expert judgment, resulting from the Analysis and Diagnosis phase and the Stakeholder consultation phase. This leads to the following top quality package:

- Amazon: retain capacity at 4x5
- Madeira: retain capacity at 4x5
- Tapajós: increased capacity from 2x2 to 3x2 (double locks)
- Tocantins: increased capacity from 2x2 3x2 (double locks)
- Araguaia: retain capacity at 2x2 (double locks)
- Parnaíba: retain capacity at 2x2 (double locks)
- Sao Francisco: increased capacity from 2x2 to 2x4
- Paraguay: retain capacity:
  - Between Foz rio Apa and Corumbá 4x4
  - Between Corumbá and Cáceres 3x2
- Tietê- Paraná: retain capacity at 2x2 (double locks)
- Hidrovias do Sul: retain capacity at self-propelled barges (double locks) the dimensions of the barges can be read insection 4.3..6

CONVENÇÕES CARTOGRÁFICAS		REFERÊNCIAS	LOCALIZAÇÃO DA FOLHA
Capital Estadual	Baseline	Fontes:	
Limite político adm.	Rivers Maintenance + Hidrovia	- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010	
Massa d'água	Rivers Top Quality	- ANA, 2010	
Seaport		- PNTL, 2010	
IWT terminal			

MINISTÉRIO DOS TRANSPORTES

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PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS TOP QUALITY

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
ARCADIS logos	1:17.000.000	- BRASIL -	2013

5.3.4.1 Elements Transport System for Top Quality

In addition to measures in the rivers as mentioned before, also investments in the transport system are necessary for the total logistic chain to work. The Top Quality strategy is Expansion A and B combined. Compared to the Expansion strategies, for the Top Quality strategy some river sections need to accomodate larger convoy sizes or locks are doubled. Measures on the elements of the transport system do not differ much from the Expansion strategies. As river navigation is expanded new inland ports and terminals (upstream) are needed for transshipment. The selection of the location for new ports and inland terminals is the same as in the Expansion strategies, so the current infrastructure is taken into account. However, in some cases new investments enabling for pre and end haulage are inevitable. Expanding river navigability implies more cargo. To accommodate this cargo, enlarging the current fleet is needed. On some rivers larger convoys are possible compared to the Expansion strategies, so the ship building industry needs to adapt on these convoys. Finally, qualified personnel are needed to navigate these rivers with larger convoys and personnel needs to handle double lock capacity. Therefore, a modernized education system is needed to train crew.

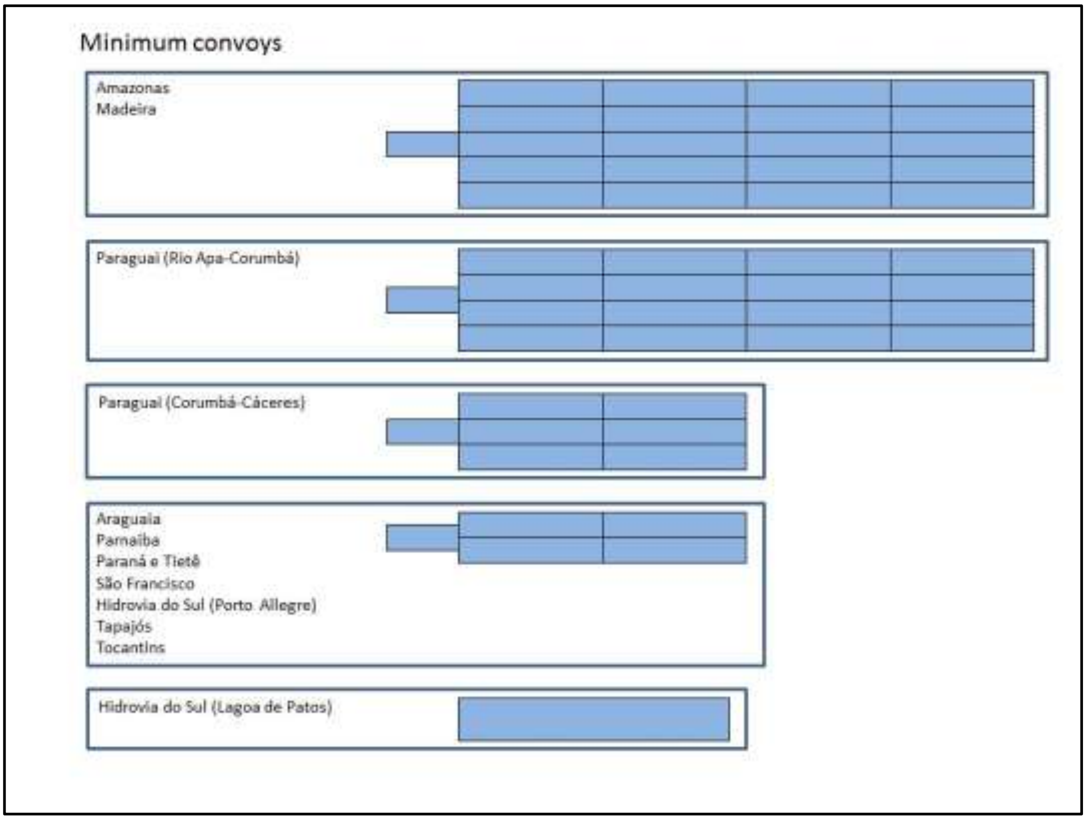
5.3.5 Overview of strategies

An overview of the normative convoys is given in Table 5.3.1 (dimensions of the barges – see Chapter 4, item 4.3.6). Figure 5.3.2 presents the minimum and maximum convoys for the different waterways. In the definition for this report an ***a x b*** convoy is a convoy that is ***a*** barges long and ***b*** barges wide.

Table 5.3.1 - Normative convoys

		Convoy Sizes	
Waterway systems	Waterway sections	Minimum Required	Realistic Maximum
Amazon e Solimões	Santarém - Manaus - Coari	4x5	4x5
	Santarém – Almeirim	4x5	4x5
	Almeirim – Santana	4x5	4x5
	Almeirim - Rio Tocantins	4x5	4x5
Madeira	Itacoatiara - Porto Velho	4x5	4x5
Tapajós e Teles Pires	Santarém – Itaituba	2x2	3x2
	Itaituba - Cachoeira Rasteira	2x2	3x2
Tocantins	Vila do Conde - Marabá	2x2	3x2
	Marabá – Miracema	2x2-	3x2
Araguaia	Marabá – Conceição	2x2	2x2
	Conceição - São Felix	2x2	2x2
	São Felix – Aruaña	2x2	2x2
Parnaíba	Teresina – Uruçui	2x2	2x2
	Uruçui - Santa Filomena	2x2	2x2
	Uruçui – Balsas	2x2	2x2
São Francisco	Petrolina – Ibotirama	2x2	2x4
	Ibotirama – Pirapora	2x2	2x4
Paraguay	Foz rio Apa – Corumbá	4x4	4x4
	Corumbá – Cáceres	3x2	3x2
Paraná e Tietê	Três Lagoas - Pereira Barreto	2x2	2x2
	São Simão - Pereira Barreto	2x2	2x2
	Pereira Barreto - Anhembi	2x2	2x2
	Anhembi – Salto	2x2	2x2
Hidrovia do Sul	Rio Grande - Porto Alegre	SP*	SP*
	Porto Alegre - Triunfo	SP*	SP*
	Triunfo - Cachoeira do Sul	SP*	SP*
	Triunfo - Estrela	SP*	SP*

SP On the section Rio Grande - Porto Alegre convoys cannot sail due to high waves. Transport is done by self-propelled barges.*



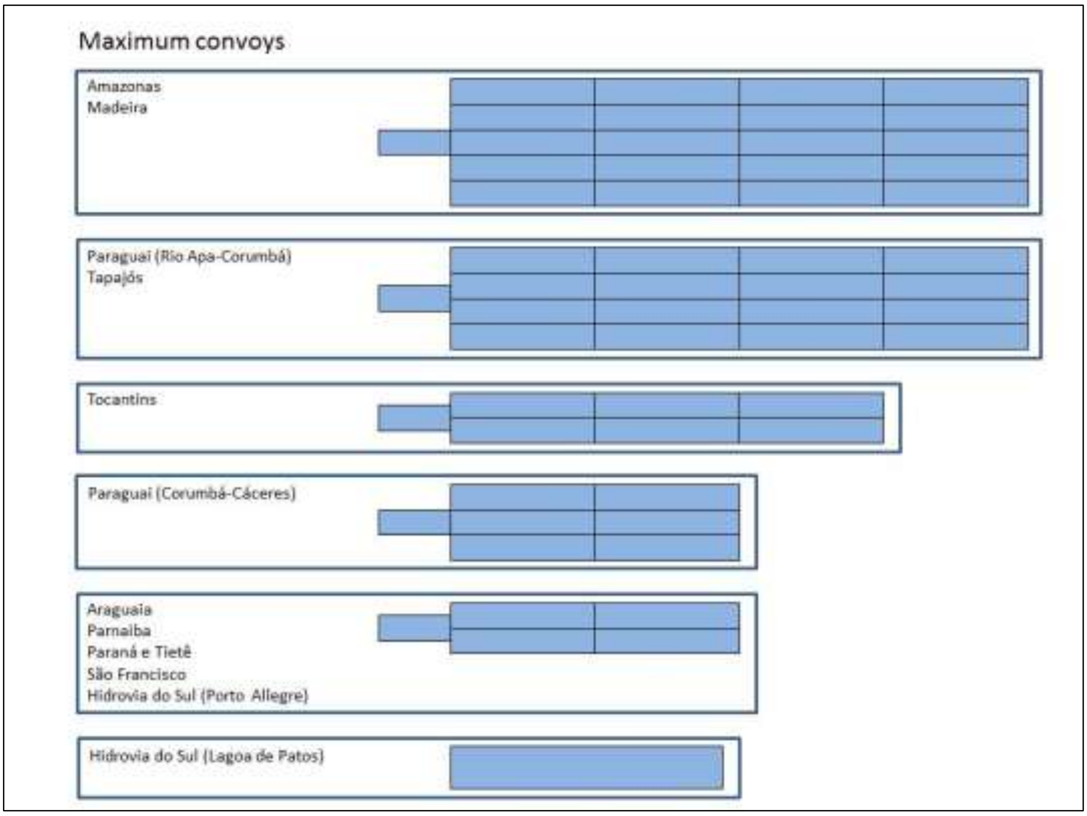


Figure 5.3.2 – Minimum and Maximum Convoys for the Different Waterways

Table 5.3.2 gives an overview of the strategies. For every river section the convoy sizes are normative for the strategy. Measures to make this section navigable are based on these convoys.

Table 5.3.2 – Overview of Strategies

		Maintenance+	Expansion		Top Quality
Waterway systems	Waterway sections	1	2a	2b	3
Amazon e Solimões	Santarém - Manaus - Coari	4x5	4x5	4x5	4x5
	Santarém – Almeirim	4x5	4x5	4x5	4x5
	Almeirim – Santana	4x5	4x5	4x5	4x5
	Almeirim - Rio Tocantins	4x5	4x5	4x5	4x5
Madeira	Itacoatiara - Porto Velho	4x5	4x5	4x5	4x5
Tapajós e Teles Pires	Santarém – Itaituba	2x2	2x2	2x2	3x2
	Itaituba - Cachoeira Rasteira	-	2x2 (SL)	-	3x2 (DL)
Tocantins	Vila do Conde - Marabá	2x2	2x2	2x2	3x2(DL)
	Marabá – Miracema	-	-	2x2 (SL)	3x2(DL)
Araguaia	Marabá – Conceição	-	2x2 (SL)	-	2x2 (DL)
	Conceição - São Felix	-	2x2	-	2x2
	São Felix – Aruaña	-	2x2	-	2x2
Parnaíba	Teresina – Uruçui	-	2x2 (SL)	-	2x2 (DL)
	Uruçui - Santa Filomena	-	2x2 (SL)	-	2x2 (DL)
	Uruçui – Balsas	-	2x2 (SL)	-	2x2 (DL)
São Francisco	Petrolina – Ibotirama	2x2	2x2	2x2	2x4
	Ibotirama – Pirapora	-	2x2	2x2	2x4
Paraguay	Foz rio Apa – Corumbá	4x4	4x4	4x4	4x4
	Corumbá – Cáceres	-	-	3x2	3x2
Paraná e Tietê	Três Lagoas - Pereira Barreto	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)
	São Simão - Pereira Barreto	2x2	2x2	2x2	2x2
	Pereira Barreto - Anhembi	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)
	Anhembi – Salto	-	2x2 (SL)	-	2x2 (DL)
Hidrovia do Sul	Rio Grande - Porto Alegre	SP	SP	SP	SP
	Porto Alegre - Triunfo	SP	SP	SP	SP
	Triunfo - Cachoeira do Sul	SP	SP	SP	SP (SL+)
	Triunfo - Estrela	SP	SP	SP	SP (SL+)

Notes:

1) SP: self-propelled barges.
2) (SL): implementation of one lock in every dam planned.
3) (SL+): implementation of one extra lock in every dam with a lock.
4) (DL): implementation of two locks in every dam planned.

5.3.6 Alternative Strategies

Workshop 2 with MT was built around the four core strategies previously described (Maintenance+, Expand 2a and 2b and Top Quality). From the analysis of each of the components of the strategies, different public-interest aspects were discussed. Tthe considerations from a value-perspective over some waterways and some waterway sections created a new set of alternative strategies.

- Workshop Strategy 1 (Alt. 4): Expand all waterways without “top quality”;
- Workshop Strategy 2 (Alt. 5): Maintenance+ with the addition of one extra stretch;
- Workshop Strategy 3 (Alt. 6): Some expansion but with "top quality" quality;
- Workshop Strategy 4 (Alt. 7): Expansion 2b with the addition of one extra waterway system;
- Workshop Strategy 5 (Alt. 8): Expansion 2b with the addition of one extra waterway stretch.

The addition to these five new strategies, herein named "workshop strategies", represent the fine-tuning between, on the one hand the technical and expert point of view and, on the other hand, the political and public-interest point of view. The comparable overall set of nine strategies, thus, spans a wide range of views and portray the complexity of waterway development in Brazil. Especially, it portrays the possible steps towards development of the secotr, since the strategies have between them a combination of waterway-systems and waterway-sections.

Since they are variations from the four core strategies, a brief description is presented.

Workshop Strategy 1 (Alt. 4)

This alternative strategy entails the development of all waterways, just as in Top Quality, but without the infrastructure enhancements of Top Quality (i.e: double locks and dredging at certain sections in order to increase reliability and larger convoys).

This leads to the combination of rivers sections that is presented in Table 5.3.3.

Table 5.3.3 - Rivers and Sections Improved in the Alternative 4 (Workshop alt. 1)

Rivers	Sections
▪ Amazonas and Solimões	– Santarém - Manaus - Coari – Santarém - Almeirim – Almeirim - Santana – Almeirim - Rio Tocantins
▪ Madeira	– Itacoatiara - Porto Velho
▪ Tapajós and Teles Pires	– Santarém - Itaituba – Itaituba - Cachoeira Rasteira
▪ Tocantins	– Vila do Conde - Marabá – Marabá - Miracema
▪ Araguaia	– Marabá - Conceição – Conceição - São Felix – São Felix - Aruaña
▪ Parnaíba	– Teresina - Uruçui – Uruçui - Santa Filomena – Uruçui - Balsas
▪ São Francisco	– Petrolina - Ibotirama – Ibotirama - Pirapora
▪ Paraguai	– Foz rio Apa - Corumbá/Ladário – Corumbá/Ladário - Cáceres
▪ Paraná and Tietê	– Três Lagoas - Pereira Barreto – São Simão - Pereira Barreto – Pereira Barreto - Anhembi – Anhembi - Salto
▪ Hidrovia do Sul	– Rio Grande - Porto Alegre – Porto Alegre - Triunfo – Triunfo - Cachoeira do Sul – Triunfo - Estrela

Workshop Strategy 2 (Alt. 5)

This alternative strategy is a set in between Maintenance+ and Expand 2b. It is Maintenance+ with the addition of the section from Marabá to Miracema on the Tocantins and the exclusion of the section on the Paraguay River from Corumbá to Cáceres from the Expand 2b strategy.

This leads to a combination of waterways and sections that is presented in Table 5.4.3.

Table 5.3.4 - Rivers and Sections improved in the Alternative 5 (Workshop alt. 2)

Rivers	Sections
▪ Amazonas and Solimões	– Santarém - Manaus - Coari – Santarém - Almeirim – Almeirim - Santana – Almeirim - Rio Tocantins
▪ Madeira	– Itacoatiara - Porto Velho
▪ Tapajós and Teles Pires	– Santarém - Itaituba
▪ Tocantins	– Vila do Conde - Marabá – Marabá - Miracema
▪ São Francisco	– Petrolina - Ibotirama
▪ Paraguai	– Foz rio Apa – Corumbá/Ladário
▪ Paraná and Tietê	– Três Lagoas - Pereira Barreto – São Simão - Pereira Barreto – Pereira Barreto - Anhembi
▪ Hidrovia do Sul	– Rio Grande - Porto Alegre – Porto Alegre - Triunfo – Triunfo - Cachoeira do Sul – Triunfo - Estrela

Workshop Strategy 3 (Alt. 6)

This alternative strategy selects a few waterways for expansion but increases the capacity and reliability of those that are already navigable by going for double locks and insuring enough draft over some sections. It is a strategy with much to invest but without the boldness of developing all waterways of Top Quality. It is a strategy for growth between Expand 2a and Expand 2b.

This leads to the combination of rivers sections and quality level that presented in Table5.3.5.

Table 5.3.5 - Rivers and Sections improved in the Alternative 6 (Workshop alt. 3)

Rivers	Sections
▪ Amazonas and Solimões	– Santarém - Manaus - Coari – Santarém - Almeirim – Almeirim - Santana – Almeirim - Rio Tocantins
▪ Madeira	– Itacoatiara - Porto Velho
▪ Tapajós and Teles Pires	– Santarém – Itaituba – Itaituba - Cachoeira Rasteira
▪ Tocantins	– Vila do Conde - Marabá – Marabá - Miracema
▪ São Francisco	– Petrolina - Ibotirama
▪ Araguaia	– Marabá - Conceição
▪ Paraguai	– Foz rio Apa – Corumbá/Ladário
▪ Paraná and Tietê	– Três Lagoas - Pereira Barreto (double Locks) – São Simão - Pereira Barreto (double Locks) – Pereira Barreto - Anhembi (double Locks)
▪ Hidrovia do Sul	– Rio Grande - Porto Alegre (double Locks) – Porto Alegre - Triunfo (double Locks) – Triunfo - Cachoeira do Sul (double Locks) – Triunfo - Estrela (double Locks)

Workshop Strategy 4 (Alt. 7)

This alternative strategy is a slight expansion over Expansion 2b by adding one extra waterway system. It develops less waterway sections than Expand 2a, but aims at finding the best combination under an economic rationale. All waterways are developed without Top Quality (i.e: double locks and dredging at certain sections in order to increase reliability and larger convoys).

This leads to the combination of rivers sections and quality level that is presented in Table 5.3.6.

Tabela 5.3.6: Rivers and Sections improved in the Alternative 7 (Workshop alt. 4)

Rivers	Sections
▪ Amazonas and Solimões	– Santarém - Manaus - Coari – Santarém - Almeirim – Almeirim - Santana – Almeirim - Rio Tocantins
▪ Madeira	– Itacoatiara - Porto Velho
▪ Tapajós and Teles Pires	– Santarém – Itaituba – Itaituba - Cachoeira Rasteira
▪ Tocantins	– Vila do Conde - Marabá – Marabá - Miracema
▪ São Francisco	– Petrolina – Ibotirama – Ibotirama – Pirapora
▪ Araguaia	– Marabá - Conceição
▪ Paraguai	– Foz rio Apa – Corumbá/Ladário – Corumbá/Ladário - Cáceres
▪ Paraná and Tietê	– Três Lagoas - Pereira Barreto – São Simão - Pereira Barreto – Pereira Barreto - Anhembi
▪ Hidrovia do Sul	– Rio Grande - Porto Alegre Porto Alegre - Triunfo – Triunfo - Cachoeira do Sul – Triunfo - Estrela

Workshop Strategy 5 (Alt. 8)

This alternative strategy is a slight addition to strategy Expansion 2b by adding one extra waterway section - the one from Itaituba to Cachoeira Rasteira on the Tapajós - Teles Pires waterway-system. By doing so, it is a strategy exactly in between Expansion 2b and Alt. 7, which also develops the mentioned section on the Tapajós - Teles Pires but develops yet another system: the Araguaia, on the section from Marabá to Conceição. All waterways are developed without Top Quality (i.e: double locks and dredging at certain sections in order to increase reliability and larger convoys). This leads to the combination of rivers sections and quality level that is presented in Table 5.3.7.

Tabela 5.3.7 - Rivers and Sections improved in the Alternative 8 (Workshop alt. 5)

Rivers	Sections
▪ Amazonas and Solimões	– Santarém - Manaus - Coari – Santarém - Almeirim – Almeirim - Santana – Almeirim - Rio Tocantins
▪ Madeira	– Itacoatiara - Porto Velho
▪ Tapajós and Teles Pires	– Santarém – Itaituba – Itaituba - Cachoeira Rasteira
▪ Tocantins	– Vila do Conde - Marabá – Marabá - Miracema
▪ São Francisco	– Petrolina – Ibotirama – Ibotirama – Pirapora
▪ Paraguai	– Foz rio Apa – Corumbá/Ladário – Corumbá/Ladário - Cáceres
▪ Paraná and Tietê	– Três Lagoas - Pereira Barreto – São Simão - Pereira Barreto – Pereira Barreto - Anhembi
▪ Hidrovia do Sul	– Rio Grande - Porto Alegre Porto Alegre - Triunfo – Triunfo - Cachoeira do Sul – Triunfo - Estrela

5.3.7 Strategies Overview, Including Workshop Strategies

After the inclusion of the five alternative strategies from de workshop, the Table 5.3.8 was elaborated to give an overview of all the development strategies, including the rivers in each strategy and the level of service to be offered.

Table 5.3.8 – Overview of Strategies, Including Workshop Strategies

		Maintenance+	Expansion		Top Quality	Workshop 1	Workshop 2	Workshop 3	Workshop 4	Workshop 5
River-systems	**River-sections**	**1**	**2a**	**2b**	**3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**	**Alt. 8**
Amazon e Solimões	Santarém - Manaus - Coari	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5
	Santarém – Almeirim	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5
	Almeirim – Santana	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5
	Almeirim - Rio Tocantins	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5
Madeira	Itacoatiara - Porto Velho	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5	4x5
Tapajós e Teles Pires	Santarém – Itaituba	2x2	2x2	2x2	3x2	2x2	2x2	2x2	2x2	2x2
	Itaituba - Cachoeira Rasteira	-	2x2 (SL)	-	3x2 (DL)	2x2 (SL)	-	2x2 (SL)	2x2 (SL)	2x2 (SL)
Tocantins	Vila do Conde - Marabá	2x2	2x2	2x2	3x2(DL)	2x2	2x2	2x2	2x2	2x2
	Marabá – Miracema	-	-	2x2 (SL)	3x2 (DL)	2x2 (SL)	2x2 (SL)	2x2 (SL)	2x2 (SL)	2x2 (SL)
Araguaia	Marabá – Conceição	-	2x2 (SL)	-	2x2 (DL)	2x2 (SL)	-	2x2 (SL)	2x2 (SL)	-
	Conceição - São Felix	-	2x2	-	2x2	2x2	-	-	-	-
	São Felix – Aruaña	-	2x2	-	2x2	2x2	-	-	-	-

		Maintenance+	Expansion		Top Quality	Workshop 1	Workshop 2	Workshop 3	Workshop 4	Workshop 5
River-systems	**River-sections**	**1**	**2a**	**2b**	**3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**	**Alt. 8**
Parnaíba	Teresina – Uruçui	-	2x2 (SL)	-	2x2 (DL)	2x2 (SL)	-	-	-	-
	Uruçui - Santa Filomena	-	2x2 (SL)	-	2x2 (DL)	2x2 (SL)	-	-	-	-
	Uruçui – Balsas	-	2x2 (SL)	-	2x2 (DL)	2x2 (SL)	-	-	-	-
São Francisco	Petrolina – Ibotirama	2x2	2x2	2x2	2x4	2x2	2x2	2x2	2x2	2x2
	Ibotirama – Pirapora	-	2x2	2x2	2x4	2x2	-	-	2x2	2x2
Paraguay	Foz rio Apa – Corumbá	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4	4x4
	Corumbá – Cáceres	-	-	3x2	3x2	3x2	-	-	3x2	3x2
Paraná e Tietê	Três Lagoas - Pereira Barreto	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)
	São Simão - Pereira Barreto	2x2	2x2	2x2	2x2	2x2	2x2	2x2	2x2	2x2
	Pereira Barreto - Anhembi	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)	2x2 (SL+)
	Anhembi – Salto	-	2x2 (SL)	-	2x2 (DL)	2x2 (SL)	-	-	-	-
Hidrovia do Sul	Rio Grande - Porto Alegre	SP	SP	SP	SP	SP	SP	SP	SP	SP
	Porto Alegre - Triunfo	SP	SP	SP	SP	SP	SP	SP	SP	SP
	Triunfo - Cachoeira do Sul	SP	SP	SP	SP (SL+)	SP	SP	SP	SP	SP
	Triunfo - Estrela	SP	SP	SP	SP (SL+)	SP	SP	SP	SP	SP

Notes:

5) SP: self-propelled barges.
6) (SL): implementation of one lock in every dam planned.
7) (SL+): implementation of one extra lock in every dam with a lock.
8) (DL): implementation of two locks in every dam planned.

CONVENÇÕES CARTOGRÁFICAS

- Capital Estadual
- Limite político adm.
- Hidrovia
- Massa d'água
- Seaport
- IWT terminal
- Baseline
- Rivers Maintenance +
- Rivers Top Quality
- Rivers with less IWT potential

REFERÊNCIAS

Fontes:
- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010
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ESCALA GRÁFICA
0 120 240 480 km

SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL SAD69

LOCALIZAÇÃO DA FOLHA

MINISTÉRIO DOS TRANSPORTES

ARCADIS logos

PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

RIVERS WITH LESS IWT POTENTIAL

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
ARCADIS logos	1:17.000.000	- BRASIL -	2013

5.4 PHYSICAL MEASURES PER WATERWAY SYSTEM

In the following pages a brief description of the relevant physical aspects of the selected sections of the waterways is presented. The necessary interventions in the waterways sections, including the estimated size of the required locks, and the estimated investments are also presented in the following tables.

As mentioned in Chapter 4, section 4.3.3 (Cost/Benefit), it was assumed at this stage of the work that investments in waterways will be held in six years, starting in 2015.

Schematic maps of the waterways systems with the existing and planned terminals and dams are presented in Annex G.

5.4.1 Measures in the Amazon, Negro and Solimões Waterway System

Amazon Waterway system is fully navigable in all the sections selected. The main identified navigation constraints are described below:

- Section 01: Coari - Manaus

The constraints identified in this section are related to the moving sand bars, and that doesn´t impact on navigation conditions for inland waterway transport, considering the convoys defined in this study.

- Section 02: Manaus - Santarém

No constraints were identified that hinder the inland navigation.

- Section 03: Santarém - Almeirim

No constraints were identified that hinder the inland navigation.

- Section 04: Almeirim – Santana

No constraints were identified that hinder the inland navigation.

- Section 05: Almeirim - Tocantins mouth

This section is an important connection between Amazon River and Belém / Vila do Conde. It consists in a series of narrow natural channels among many islands, mainly in the South of Marajó Island, with a lack of an efficient signaling. In order to overcome the constraints in this section, safety improvements are necessary, by means of enlarging riversides, making dredging and implementing the signaling along all the section.

Table 5.4.1 – The Main Constraints and Estimated Investments in the Amazon Waterway System

RIVERS	AMAZON									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Coari - Manaus (Solimões / Negro rivers)	During dry season there are some restrictive stretches for large ships due to the presence of moving sandbars and some rocks in the margins	Signaling		-		-	50.000.000		-	50.000.000
Manaus - Santarém (Amazonas river)	Attention required because of the heavy traffic of vessels in some ports	-		-	4x5 (55m x 268m x 4,0m) [1]	-	-	4x5 (55m x 268m x 4,0m) [1]	-	-
Santarém - Almeirim (Amazonas river)	Attention required because of the heavy traffic of vessels in some ports	-	4x5 (55m x 244m) [2]	-		-	-		-	-
Almeirim - Santana (Amazonas river)	Attention required because of the heavy traffic of vessels in some ports	-		-		-	-		-	-
Almeirim - foz do rio Tocantins (Amazonas / Canal de Breves rivers)	Narrowing sections, lack of signaling	Readjustment of routes / Signaling		-		-	250.000.000		-	250.000.000
Total							300.000.000			300.000.000

Notes:
1) Barges: 60 m long and 11 m wide; push boat with a length of 28 m
2) Without considering the push boats

5.4.2 Measures in the Madeira Waterway System

The main constraints identified in the Madeira River are related to margin erosions, aggradation and river islands along the river, being more critical in the dry season, particularly in the upstream sections. Rapids and rock outcrops are also observed in the river during the low water level period, especially upstream of Manicoré, the section between Humaitá and Porto Velho being the most critical.

Table 5.4.2 – The Main Cconstraints and Estimated Investments in Madeira Waterway System

RIVERS	MADEIRA									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
	River bank erosion, sedimentation, river islands, which are critical during ebb season on the upstream river sections	River banks strenghtening / Dredging		-		-	800.000.000		-	800.000.000
Itacoatiara - Porto Velho (Madeira river)	During the ebb season, upstream to Manicoré, rapids occur and rocks appear. The most critical section is between Humaitá e Porto Velho	Rock demolition	4x5 (55m x 260m) [2]	-	4x5 (55m x 268m x 2,5m) [1]	-	1.000.000.000	4x5 (55m x 268m x 2,5m) [1]	-	1.000.000.000
		Signaling		-		-	200.000.000		-	200.000.000
Subtotal							2.000.000.000			2.000.000.000
Total							2.000.000.000			2.000.000.000

Notes:
1) Barges: 60 m long and 11 m wide; push boat with a length of 28 m
2) Without considering the push boats

5.4.3 Measures in the Tapajós Waterway System

This Waterway System consists of Tapajós and Teles Pires waterways and its description is presented below, divided into two main sections:

- Section 01: Santarém - Itaituba

The main constraints in this section are related to aggradation, rock outcrops and low depths along the entire section. In order to overcome those, civil works are required, like regularization of the river bed, dredging and rock demolition, and also signaling.

- Section 02: Itaituba - Cachoeira Rasteira

According to PDE-2021 three Hydroelectric Power Plants (HPP) are planned to be constructed in this section: São Luís do Tapajós (in 2018), Jatobá (in 2019) and Chacorão (beyond 2021). There is no information about the construction of locks in these HPPs, although inland navigation in this section depends on their construction.

Even with the construction of these HPP, sections with many natural bottlenecks to navigation, were identified. The first one consists of a sequence of rock outcrops and rapids, 20km long (14 m width), upstream of the future São Luís do Tapajós dam. In addition, between the end of the Jatobá reservoir and the future Chacorão dam, there are many rocks outcrops and sand banks. There is also a section of 150km long (10m width), from the end of the Chacorão reservoir until Cachoeira Rasteira. All these sections require civil works, like regularization of the river bed, dredging, rock demolition and signaling.

Table 5.4.3 – The Main Constraints and Estimated Investments in Tapajós – Teles Pires Waterway System

RIVERS	TAPAJÓS - TELES PIRES									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Santarém - Itaituba (Tapajós river)	Rocks and sedimentation	River bank strenghtening / Rock demolition / Dredging / Signaling	Dimensions not identified	-	2x2 (22m x 138m x 2,5m) [2]	-	80.000.000	3x2 (22m x 200m x 2,5m) [1]	-	100.000.000
Subtotal							**80.000.000**			**100.000.000**
Itaituba - Cachoeira Rasteira (Tapajós and Teles Pires rivers)	Section with rapids and rocks, 20 km long and height difference of 14 m, downstream of the future UHE São Luis do Tapajós	Channel / Barragem com eclusa / Rock demolition / Signaling	n/a	-	2x2 (22m x 138m x 2,5m) [2]	-	500.000.000	3x2 (22m x 200m x 2,5m) [1]	-	900.000.000
	Construction of the UHE São Luís do Tapajós, without locks	Construction of a lock system		-		24m x 150m x 3,5m	650.000.000		DL (24m x 210m x 3,5m) [3]	1.555.200.000
	Construction of the UHE Jatobá, without locks	Construction of a lock system		-		24m x 150m x 3,5m	300.000.000		DL (24m x 210m x 3,5m) [3]	691.200.000
	Section with several rocks between the end of the UHE Jatobá reservoir and the dam UHE Chacorão	Rock demolition / Dredging / Signaling		-		-	560.000.000		-	1.000.000.000
	Construction of the UHE Chacorão, without locks	Construction of a lock system		-		24m x 150m x 3,5m	450.000.000		DL (24m x 210m x 3,5m) [3]	1.339.200.000
	Height difference of about 10 m. Distance of 150 km from the UHE Chacorão reservoir end and the beggining of the Cachoeira Rasteira rapid	Rock demolition / Dredging / Signaling		-		-	500.000.000		-	650.000.000
	Access to Cachoera Rasteira terminal	Construction of a road		-		-	461.000.000		-	461.000.000
Subtotal							**3.421.000.000**			**6.596.600.000**
Total							**3.501.000.000**			**6.696.600.000**

Notes:

1) Barges: 60 m long and 11 m wide; push boat with a length of 20 m

2) Barges: 60 m long and 11 m wide; push boat with a length of 18 m

3) Double lock

5.4.4 Measures in the Tocantins Waterway System

This waterway system was divided into two axis: Tocantins and Araguaia waterways.

The Tocantins axis was divided into two main sections, which are described below.

- Section 01: Vila do Conde - Marabá

In this section there is an extensive rock outcrop known as “Pedral de São Lourenço”, at the end of the Tucuruí reservoir, 42 km long. To make this section navigable, civil works such as the construction of a canal and rock demolition are required.

Moreover, there are sand banks, river islands, rock outcrops and low depths areas between the Tauri and Marabá cities, along 52 km. This section requires civil works like regularization of the river bed, dredging, rock demolition and signaling.

- Section 02:- Marabá - Miracema

In this section it is important to mention the hydraulic works planned (Hydroelectrics) and the civil works required for improving the navigation.

Currently, there is the HPP Estreito, constructed without locks, and the constructions of three more HPPs: Marabá, Serra Quebrada and Tupiratins are planned, without any locks.

Thus, for the viability of navigation in this section the implementation of locks is necessary not only in the HPP Estreito but also in the planned hydroelectrics. The only hydroelectric planned to be built until 2021, according to the PDE-2021, is the HPP Marabá.

Moreover, even with all the HPPs implemented, sections in free flow will still be observed, with constraints like sand banks, river islands, rock outcrops and low depths, in the areas described below:

- Between the end of the reservoir of HPP Marabá, near the city of São Sebastião do Tocantins, and the dam of UHE Serra Quebrada, near the city of Imperatriz, 40 km long;
- Between the end of the reservoir of UHE Serra Quebrada, near the city of Porto Franco, and the dam of HPP Estreito, near the city of Estreito, 32 km long;
- Between the end of the reservoir of HPP Estreito and the reservoir of UHE Tupiratins, 71 km long.

These sections require regularization of the river bed, dredging, rock demolition and signaling.

Table 5.4.4 – The Main Constraints and Estimated Investments in the Tocantins Waterway System

RIVERS	TOCANTINS									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Vila do Conde - Marabá (Tocantins river)	UHE Tucuruí, with locks	-	n/a	33m x 210m	2x2 (22m x 138m x 2,5m) [1]	-	-	3x2 (22m x 200m x 2,5m) [2]		-
	Long Rock outcrops (Pedral do Lourenço) at the end of the UHE Tucuruí reservoir, with 42 km long	Rock demolition		-		-	660.000.000		-	990.000.000
	Sandbar, river islands, rocks, low water depth between the city of Itupiranga and Marabá, with 52 km long	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	180.000.000		-	200.000.000
Subtotal							**840.000.000**			**1.190.000.000**
Marabá - Miracema do Tocantins (Tocantins river)	Construction of UHE Marabá, without locks	Construction of a lock system	n/a	-	2x2 (22m x 138m x 2,5m) [1]	24m x 150m x 3,5m	350.000.000	3x2 (22m x 200m x 2,5m) [2]	DL (24m x 210m x 3,5m) [3]	810.000.000
	Sand bars, illhas fluviais, rocks and low water depth between the end of the UHE Marabá reservoir (next to São Sebastião do Tocantins city) and the UHE Serra Quebrada (next to Imperatriz city), with 40 km	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	700.000.000		-	800.000.000
	Construction of UHE Serra Quebrada, without locks	Construction of a lock system		-		24m x 150m x 3,5m	400.000.000		DL (24m x 210m x 3,5m) [3]	738.000.000
	Sand bars, river islands, rocks and low water depth between the end of the UHE Serra Quebrada reservoir (next to Porto Franco city) and the UHE Estreito (próximo à cidade de Estreito) dam, with about 32 km long	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	200.000.000		-	250.000.000
	UHE Estreito, without locks	Construction of a lock system		-		24m x 150m x 3,5m	640.000.000		DL (24m x 210m x 3,5m) [3]	1.296.000.000
	Sand bars, river islands, rocks and low water depth between the end of the UHE Estreito reservoir and the UHE Tupiratins dam, with about 71 km long	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	450.000.000		-	500.000.000
	Construction of UHE Tupiratins, without locks	Construction of a lock system		-		24m x 150m x 3,5m	200.000.000		DL (24m x 210m x 3,5m) [3]	450.000.000
Subtotal							**2.940.000.000**			**4.844.000.000**
Total							**3.780.000.000**			**6.034.000.000**

Notes:
1) Barges: 60 m long and 11 m wide; push boat with a length of 18 m
2) Barges: 60 m long and 11 m wide; push boat with a length of 20 m
3) Double lock

The Araguaia axis comprises the Araguaia River and part of the Tocantins River and was divided in three main axis:

- Section 01: Marabá - Conceição do Araguaia

The first 50 km downstream of this section is in Tocantins river but the main part is in Araguaia river.

Two HPPs (Santa Isabel and Araguanã) are planned in this section and that will allow navigation in some segments in this section. In addition, the Marabá HPP reservoir will also flood part of this section. However, these three dams are not planned to be built with locks and only Marabá HPP is planned to be constructed until 2021 (according to PDE 2021).

Moreover, even with the constructions of those HPPs, sections in free flow will still be observed, with constraints like sand banks, river islands, rock outcrops and low depths, in the areas described below:

- Between the end of the reservoir of HPP Marabá, near Araguatins, and Santa Isabel dam, 30 km long;
- Between the end of the reservoir of HPP Santa Isabel, near Xambioá, and Araguanã dam, 30 km long;
- Between the end of the reservoir of HPP Araguanã and the city of Conceição do Araguaia, 210 km long.

These sections require works as regularization of the river bed, dredging, rock demolition and signaling.

- Section 02: Conceição do Araguaia - São Félix do Araguaia

There are several rock outcrops, sandbanks, river islands, meandering passages and low depths areas in the entire section, about 485km long and 40m width. This section requires civil works like river bank strengthening, dredging, rock demolition and signaling.

- Section 03: São Felix do Araguaia - Aruanã

There are several rock outcrops, sandbanks, river islands, meandering passages and low depths areas in the entire section of about 500 km long and 60 m head. This section requires civil works as river bank strengthening, dredging, rock demolition and signaling.

Table 5.4.5 – The Main Constraints and Estimated Investments in the Araguaia Waterway System

RIVERS	ARAGUAIA									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Marabá - Conceição do Araguaia (Tocantins and Araguaia rivers)	Construction of UHE Marabá, no rio Tocantins, without locks	Construction of a lock system	n/a	-	2x2 (22m x 138m x 2,5m) [1]	24m x 150m x 3,5m	350.000.000	2x2 (22m x 138m x 2,5m) [1]	DL (24m x 210m x 3,5m) [2]	810.000.000 *
	Sand bars, river islands, rocks and low water depths, between the end of the UHE Marabá reservoir (next to Araguatins) and the UHE Santa Isabel dam, with about 32 km long	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	200.000.000		-	200.000.000
	Construction of UHE Santa Isabel, without locks	Construction of a lock system		-		24m x 150m x 3,5m	410.000.000		DL (24m x 150m x 3,5m) [2]	738.000.000
	Sand bars, river islands, rocks and low water depth between the end of the UHE Santa Isabel (next to Xambioá) and the UHE Araguanã dam, with about 30 km long	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	200.000.000		-	200.000.000
	Construction of UHE Araguanã, without locks	Construction of a lock system		-		24m x 150m x 3,5m	220.000.000		DL (24m x 150m x 3,5m) [2]	396.000.000
	Sand bars, river islands, rocks and low water depth between the end of the UHE Araguanã reservoir and the Conceição do Araguaia municipality, with about 210 km long	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	1.800.000.000		-	1.800.000.000
Subtotal							**3.180.000.000**			**3.334.000.000**
Conceição do Araguaia - São Félix do Araguaia (Araguaia river)	Several rock outcrops, Sand bars, river islands, sinuosity sections and low water depth along 485 km and height difference of 40 m. ***	River bank strenghtening / Dredging / Rock demolition / Signalings	n/a	-	2x2 (22m x 138m x 2,5m) [1]	-	4.000.000.000	2x2 (22m x 138m x 2,5m) [1]	-	4.000.000.000
Subtotal							**4.000.000.000**			**4.000.000.000**
São Félix do Araguaia - Aruanã (Araguaia rivers)	Several rock outcrops, sand bars, river islands, river bank erosion, sinuosity sections, narrowings and low water depth along 500 km and height difference of 60m. ***	River bank strenghtening / Dredging / Rock demolition / Signalings	n/a	-	2x2 (22m x 138m x 2,5m) [1]	-	4.000.000.000	2x2 (22m x 138m x 2,5m) [1]	-	4.000.000.000
Subtotal							**4.000.000.000**			**4.000.000.000**
Total							**11.180.000.000**			**11.334.000.000**

* Lock dimension linked to the Tocantins waterway System

Notes:
1) Barges: 60 m long and 11 m wide; push boat with a length of 18 m
2) Double lock

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5.4.5 Measures in the Parnaíba Waterway System

This Waterway System comprises of two rivers: the Balsas and the Parnaíba rivers, which were divided in the sections described below.

- Section 01: Teresina - Uruçuí

In this section of the river the following constraints are observed such as: aggradation, sand banks, river islands and low depths between Teresina and HPP Castelhano, along 95 km, and rock outcrops which hinder inland navigation. This section requires civil works like river bank strengthening, dredging, rock demolition and signaling.

The construction of HPPs Castelhano, Estreito and Cachoeira are not planned until 2021, according to the PDE 2021. There are also no plans for the construction of locks in these HPPs, necessary to allow the inland navigation in this section. The unfinished lock in the HPP Boa Esperança is considered obsolete and a new one with suitable specifications for the convoy size planned for the waterway is required. There are several sections with low depths between the end of reservoir and the dams immediately upstream, along approximately 60 km. These sections in free flow require works to stabilize the riverbed, dredging, rock demolition and signaling.

- Section 02: Uruçuí - Santa Filomena

In this section of the Parnaíba river, the constructions of the HPPs Uruçuí and Canto do Rio, both crucial for navigation, are not planned until 2021, and HPP Ribeiro Gonçalves is planned to be constructed by 2018, according to the PDE 2021. The constructions of locks for these HPPs are not foreseen, but locks are curcial to allow inland navigation in this section.

There are several sections with low depths between the end of reservoirs and the dams immediately upstream, along approximately 30 km. These sections in free flow require civil works like river bank strengthening, dredging, rock demolition and signaling.

- Section 03: Uruçuí - Balsas

In this section of the Balsas river, the construction of HPP Taboa is not planned until 2021. There are several sections with low depths between the end of the reservoir of the Uruçuí HPP and the dam of the Taboa HPP, along about 20 km, and these sections, in free flow, require civil works like river bank strengthening, dredging, rock demolition and signaling.

Table 5.4.6 – The Main Constraints and Estimated Investments in the Parnaíba Waterway System

RIVERS	PARNAÍBA									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Teresina - Uruçuí (Parnaíba river)	Sedimentation restrictions (Sand bars, river islands), rocks and low water depth between Teresina and UHE Castelhano, along 95 km, with 19 m of height difference	River bank strenghtening / Dredging / Rock demolition / Signalings	n/a	-	2x2 (22m x 138m x 2,5m) [1]	-	860.000.000	2x2 (22m x 138m x 2,5m) [1]	-	860.000.000
	Construction of UHE Castelhano, without locks	Construction of a lock system		-		24m x 150m x 3,5m	200.000.000		DL (24m x 150m x 3,5m) [2]	360.000.000
	Construction of UHE Estreito, without locks	Construction of a lock system		-		24m x 150m x 3,5m	300.000.000		DL (24m x 150m x 3,5m) [2]	540.000.000
	Construction of UHE Cachoeira, without locks	Construction of a lock system		-		24m x 150m x 3,5m	200.000.000		DL (24m x 150m x 3,5m) [2]	360.000.000
	UHE Boa Esperança without locks (the lock structure has not been finished)	Construction of a new lock system		12m x 50m (construction in standby)		24m x 150m x 3,5m	520.000.000		DL (24m x 150m x 3,5m) [2]	936.000.000
	Low water depth between the end of the reservoirs and the upstream dams, along 60 km	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	900.000.000		-	900.000.000
Subtotal							**2.980.000.000**			**3.956.000.000**
Uruçuí - Santa Filomena (Parnaíba river)	Construction of UHE Uruçuí, without locks	Construction of a lock system	n/a	-	2x2 (22m x 138m x 2,5m) [1]	24m x 150m x 3,5m	400.000.000	2x2 (22m x 138m x 2,5m) [1]	DL (24m x 150m x 3,5m) [2]	720.000.000
	Construction of UHE Ribeiro Gonçalves, without locks	Construction of a lock system		-		24m x 150m x 3,5m	600.000.000		DL (24m x 150m x 3,5m) [2]	1.080.000.000
	Construction of UHE Canto do Rio, without locks	Construction of a lock system		-		24m x 150m x 3,5m	400.000.000		DL (24m x 150m x 3,5m) [2]	720.000.000
	Low water depth between the end of the reservoirs and the upstream dams, along 30 km	River bank strenghtening / Dredging / Rock demolition / Signalings		-		-	450.000.000		-	450.000.000
Subtotal							**1.850.000.000**			**2.970.000.000**
Total (Parnaíba)							**4.830.000.000**			**6.926.000.000**
Uruçuí - Balsas (das Balsas river)	Construction of UHE Taboa, without locks	Construction of a lock system	n/a	-	2x2 (22m x 138m x 2,5m) [1]	24m x 150m x 3,5m	600.000.000	2x2 (22m x 138m x 2,5m) [1]	DL (24m x 150m x 3,5m) [2]	1.080.000.000
	Low water depth between the end of the UHE Uruçuí reservoir and the UHE Taboa, along 20 km	River bank strenghtening/ Dredging / Rock demolition / Signalings		-		-	300.000.000		-	300.000.000
Subtotal							**900.000.000**			**1.380.000.000**
Total (Parnaíba+Balsas)							**5.730.000.000**			**8.306.000.000**

Notes:
1) Barges: 60 m long and 11 m wide; push boat with a length of 18 m
2) Double lock

5.4.6 Measures in the São Francisco Waterways System

The main constraints identified in the three main sections of the São Francisco river are presented below:

- Section 01: Petrolina - Ibotirama

In the first segment, about 40 km between Petrolina and Sobradinho HPPs, the river flows over granite and gneiss amid rock crowns that hinder navigation. Therefore civil works for accurate rock demolition are necessary. Auxiliary constructions are also necessary to Sobradinho HPP lock, to support the convoys split. At the end of Sobradinho HPP reservoir, near the city of Pilão Arcado, over 80 km up to Xique-Xique, variations in water levels, due to the natural depletion of the reservoir, are also observed. Furthermore, between Xique-Xique and Ibotirama, over about 200 km, the river flows under free-flow and aggradation caused by erosion of margins are identified. In the area called Meleiro, there is a quartz rock outcrop of 500 m long that hinders the navigation when the water levels decreases. Civil works are needed like dredging and margin recovery and also the demolition of the rock outcrops of Meleiro to enable the inland navigation along the entire section.

- Section 02: Ibotirama - Bom Jesus da Lapa

There are sand banks, river islands, some winding sections and low water depths between Ibotirama and Bom Jesus da Lapa along about 140 km, requiring dredging and river bank strengthening.

- Section 03: Bom Jesus da Lapa - Pirapora

In this section, five formations of limestone, of about 100,000 m^3, were identified. The amount of sedimentation is hard to assess due to the fact that the passage is not used for many years, but, based on the downstream areas, it was possible to estimate an amount of about 1.2 million m^3 of silt. Sand banks, river islands, low depths, erosion of margins, winding sections between Bom Jesus da Lapa and Pirapora, along about 590 km. Civil works are needed such as river bank strengthening, dredging, rock demolition, signaling and margin recovery.

Table 5.4.7 – The Main Constraints and Estimated Investments in the São Francisco Waterway System

RIVERS	SÃO FRANCISCO									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Petrolina - Ibotirama (São Francisco river)	Section downstream from the UHE Sobradinho of 40 km long, with granite bottom, which restricts the navigation of convoys with a draught of 2,0 m	Rock demolition of the Channel	2x4 (38m x 100m)[2]	-	2x2 (16m x 118m x 1,8m)[1]	-	24.000.000	2x4 (32m x 118m x 1,8m)[1]	-	24.000.000
	The convoys passing through the Sobradinho Lock need to be splitted and a mooring point is required	Construction of additional structures		17m x 120m		17m x 120m x 2,5m	15.000.000		17m x120m x 2,5m	15.000.000
	Sand bars, river islands, low water depths between Pilão Arcado and Ibotirama along 305 km	Dredging / Signalings		-		-	5.500.000		-	8.000.000
	River bank erosion, sinuosity sections, narrowing between Xique-Xique and Ibotirama, along 200 km	River bank strenghtening		-		-	64.000.000		-	80.000.000
	Meleiro rock formation, with 40.000 m³ of quartzo	Rock demolition		-		-	24.000.000		-	24.000.000
Subtotal							**132.500.000**			**151.000.000**
Ibotirama - Bom Jesus da Lapa (São Francisco river)	Sand bars, river insslands, low water depth between Ibotirama and Bom Jesus da lapa, along 140 km	Dredging / Signali	n/a	-	2x2 (16m x 118m x 1,8m) 1	-	5.500.000	2x4 (32m x 118m x 1,8m)[1]	-	8.000.000
	River bank erosion, sinuosity sections, narrowings between Ibotirama and Bom Jesus da Lapa, along 140 km	River bank strenghtening		-		-	30.000.000		-	40.000.000
Subtotal							**35.500.000**			**48.000.000**
Bom Jesus da Lapa - Pirapora (São Francisco river)	Sand bars, river islands, low water depth between Bom Jesus da Lapa and Pirapora, along 590 km	Dredging / Signali	n/a	-	2x2 (16m x 118m x 1,8m) 1	-	14.000.000	2x4 (32m x 118m x 1,8m)[1]	-	17.000.000
	River bank erosion, sinuosity sections and narrowings between Bom Jesus da Lapa and Pirapora, along 590 km	River bank strenghtening		-		-	50.000.000		-	70.000.000
	Limestone formation between Bom Jesus da Lapa and Pirapora, with a volume of approximately 100.000m³	Rock demolition		-		-	30.000.000		-	30.000.000
Subtotal							**94.000.000**			**117.000.000**
Total							**262.000.000**			**316.000.000**

Notes:

1) Barges: 50 m long and 8 m wide; push boat with a length of 18 m

2) Without considering the push boats

5.4.7 Measures in the Paraguay Waterway System

This Waterway System comprises the Paraguay River, which was divided into two sections:

- Section 01: Mouth of Apa River - Corumbá

In this section the Paraguay River is very windy, especially in Volta do Rebojo, with small radius bend, requiring channel improvements.

Two bridges (BR 262 and railway) have narrow spans, and the split of some convoys is necessary.

- Section 02: Corumbá - Cáceres

This section is sinuous, with aggradation and low depths, especially between Porto Morrinhos and Cáceres, along 140 km, during the dry season. Civil works are required like channeling, dredging, river banks strengthening and protection works.

Table 5.4.8 – The Main Constraints and Estimated Investments in the Paraguay Water System

RIVERS	PARAGUAY									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Foz rio Apa - Corumbá (Paraguay river)	Small radius bend (Volta do Rebojo)	Channel improvements	4x4 (44m x 240 m) [3]	-	4x4 (44m x 268m x 2,5m) [1]	-	50.000.000	4x4 (44m x 268m x 2,5m) [1]	-	50.000.000
Foz rio Apa - Corumbá (Paraguay river)	Bridges (BR-262 e railway) with narrow spans, splitting is required	Span enlargement and heightening of bridges	4x4 (44m x 240 m) [3]	-	4x4 (44m x 268m x 2,5m) [1]	-	200.000.000	4x4 (44m x 268m x 2,5m) [1]	-	200.000.000
Subtotal							**250.000.000**			**250.000.000**
Corumbá - Cáceres (Paraguay river)	Narrow sections, with high sinuosity index, sedimentation and low depths, mainly between Morrinhos and Cáceres (140 km), during dry season	Channeling / Dredging / Rock demolition / River bank strenghtening	n/a	-	3x2 (22m x 198m x 2,5 m) [2]	-	2.048.000.000	3x2 (22m x 198m x 2,5 m) [2]	-	2.048.000.000
Subtotal							**2.048.000.000**			**2.048.000.000**
Total							**2.298.000.000**			**2.298.000.000**

Notes:
1) Barges: 60 m long and 11 m wide; push boat with a length of 28 m
2) Barges: 60 m long and 11 m wide; push boat with a length of 18 m
3) Without considering the push boats

5.4.8 Measures in the Paraná Waterway System

This Waterway System consists of the Paraná and Tietê rivers, which were divided into four main sections. The main constraints identified in each section are presented below:

- Section 01: São Simão - Pereira Barreto

In this section no constraints were identified that hinder inland navigation.

- Section 02: Três Lagoas -Pereira Barreto

Inland navigation is possible due to the lakes formed by the dams of Três Irmãos and Jupiá. Três Irmãos HPP has a small lock (12 mx 142 m) and the construction of a bigger lock is already required.

- Section 03-Pereira Barreto to Anhembi

This section has good navigation conditions near the dam of Nova Avanhandava due to the lake formed by the Três Irmãos dam. There is a section of about 5 km long, downstream UHE Nova Avanhandava, with basaltic rocks which restricts navigation for vessels with more than 2.5 m draft; therefore demolition works are required in this area.

From this point there is a group of four dams (Nova Avanhandava HPP, Promissão HPP, Ibitinga HPP and Bariri HPP) each with a small lock (12m x 142m). The construction of a bigger lock, parallel to the existing ones, is already required. In adition, a bridge in the SP-191 in Santa Maria da Serra lead to the split of the convoys; therefore improvements are required.

- Section 04 - Anhembi to Salto

In this section there is the UHE Barra Bonita dam with a small lock (12m x 142m) and the construction of a bigger lock, parallel to the existing one, is already required.

A bridge in the SP-147, in Anhembi, leads to the split of the convoys; therefore improvements in the bridge are required. In Tietê and Porto Feliz four bridges and a footbridge hinder the passage of commercial convoys and the reconstruction of the bridges is necessary.

There are problems of aggradation, rock outcrops and high windings from the end of HPP Barra Bonita reservoir to Salto, 250 km long (50 m height). The construction of four dams with locks (Anhembi, Laranjal, Tietê and Porto Feliz) and 2.7 million m^3 of dredging and rock demolition are required.

Table 5.4.9 – The Main Constraints and Estimated Investments in the Paraná Water System

RIVERS	PARANÁ									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
São Simão - Pereira Barreto (Paraná and Tietê rivers)	-	-	2x2 (22m x 120m) [2]		2x2 (22m x 138m x 2,5m)	-	-	2x2 (22m x 138m x 2,5m)	-	-
Subtotal							**0**			**0**
Três Lagoas - Pereira Barreto (Paraná and Tietê rivers)	UHE Três Irmãos with a small lock	Improvement of the existing lock and construction of a new parallel lock	2x2 (22m x 120m) [2]	12m x 142m	2x2 (22m x 138m x 2,5m)	24m x 144m x 3,5m	900.000.000	2x2 (22m x 138m x 2,5m)	(24m x 144m x 3,5m)	900.000.000
Subtotal							**900.000.000**			**900.000.000**
Pereira Barreto - Anhembi (Tietê river)	Downstream to the UHE Nova Avanhandava, there is a 5 km section composed with basaltic rocks that restrict the navigation of convoys with draughts higher than 2,5 m	Rock demolition of the Channel	2x2 (22m x 120m) [2]	-	2x2 (22m x 138m x 2,5m) [1]	-	360.000.000	2x2 (22m x 138m x 2,5m) [1]	-	360.000.000
	UHE Nova Avanhandava with a small lock	Improvement of the existing lock and construction of a new parallel lock		12m x 142m		24m x 144m x 3,5m	840.000.000		24m x 144m x 3,5m	840.000.000
	UHE Promissão with a small lock	Improvement of the existing lock and construction of a new parallel lock		12m x 142m		24m x 144m x 3,5m	370.000.000		24m x 144m x 3,5m	370.000.000
	UHE Ibitinga with a small lock	Improvement of the existing lock and construction of a new parallel lock		12m x 142m		24m x 144m x 3,5m	330.000.000		24m x 144m x 3,5m	330.000.000
	UHE Bariri with a small lock	Improvement of the existing lock and construction of a new parallel lock		12m x 142m		24m x 144m x 3,5m	330.000.000		24m x 144m x 3,5m	330.000.000
	UHE Barra Bonita with a small lock	Improvement of the existing lock and construction of a new parallel lock		12m x 142m		24m x 144m x 3,5m	330.000.000		24m x 144m x 3,5m	330.000.000
	The span of the SP-191 is small, only Tietê convoy (2x1) can pass	Widening of the span and heightening of the bridge		-		-	20.000.000		-	20.000.000
Subtotal							**2.580.000.000**			**2.580.000.000**
Anhembi - Salto (Tietê river)	The span of the SP-147 is small, only Tietê convoy can pass	Widening of the span and heightening of the bridge	n/a	-	2x2 (22m x 138m x 2,5m) [1]	-	20.000.000	2x2 (22m x 138m x 2,5m) [1]	-	20.000.000
	Sedimentation restrictions, rocks, narrowings, high sinuosities at the end of the UHE Barra Bonita reservoir up to Salto, with a height difference of 50 m, and 250 km long	Construction of 4 dams with locks (Anhembi, Laranjal, Tietê and Porto Feliz) e 2.700.000m³ of Dredging works + Rock demolition		-		24m x 144m x 3,5m	3.500.000.000		DL (24m x 144m x 3,5m) [3]	4.140.000.000
	4 Bridges and 1 footbridge that restricts the navigation of commercial convoys in Tietê and Porto Feliz	Bridge reconstruction		-		-	90.000.000		-	90.000.000
Subtotal							**3.610.000.000**			**4.250.000.000**
Total							**7.090.000.000**			**7.730.000.000**

Notes:

1) Barges: 60 m long and 11 m wide; push boat with a length of 18 m

2) Without considering the push boats

3) Double lock

5.4.9 Measures in the Hidrovia do Sul System

This Waterway System consists of the Jacuí and Taquari rivers and the Lagoa dos Patos, which were divided into four main sections. The main constraints identified in each section are presented below:

- Section 01: Rio Grande - Porto Alegre

In the Lagoa dos Patos no constraints were identified that hinder inland navigation, with self-propelled barges.

- Section 02: Porto Alegre - Triunfo

In the Jacuí River aggradation was identified, leading to the formation of some sand banks and river islands, and that requires constant dredging. There are rock outcrops in some sections requiring rock demolition.

- Section 03: Triunfo - Cachoeira do Sul

In this section, the Jacuí River also has aggradation, leading to the formation of some sand banks, margin erosion and river islands. Rock outcrops in some areas, along about 170 km, are also observed.

In addition, the dams at Anel de Don Marco and Amarópolis have a small lock (17m x 120m), suitable for the self-propelled barges, but civil works are required like river bank strengthening, dredging and rock demolition, and also signaling.

Margins contentions and the improvement of the channel in the downstream areas of Anel de Don Marco and Cachoeira are required. In both sections excavations have already been made, but they do not provide the suitable condition for inland navigation.

- Section 04: Triunfo - Estrela

This section, which comprises the Taquari River, has low depths, rock outcrops and sand banks downstream of the Bom Retiro dam, which already has a lock, therefore dredging and rock demolition are required.

Table 5.4.10 – The Main Constraints and Estimated Investments in the Hidrovia do Sul Waterway System

RIVERS	SUL									
SECTION	RESTRICTION	MEASURE	EXISTING		REQUIRED MINIMUM QUALITY LEVEL			REALISTIC MAXIMUM QUALITY LEVEL		
			CONVOY	DIMENSIONS OF LOCKS	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)	CONVOY	DIMENSIONS OF LOCKS	INVESTMENTS (R$)
Rio Grande - Porto Alegre (Lagoa dos Patos)	-	-	self-propelled barges	-	self-propelled barges (16m x 110m x 2,5m)	-	0	self-propelled barges (16m x 110m x 2,5m)	-	-
Subtotal							**0**			**0**
Porto Alegre - Triunfo (Jacuí river)	Localized sedimentation areas (Sand bars e river islands) and rocks - Maintenance is required	Rock demolition / Dredging	self-propelled barges	-	self-propelled barges (16m x 110m x 2,5m)	-	80.000.000	self-propelled barges (16m x 110m x 2,5m)	-	80.000.000
Subtotal							**80.000.000**			**80.000.000**
Triunfo - Cachoeira do Sul (Jacuí river)	Localized sedimentation areas (Sand bars e river islands), rocks e river bank erosion, along 170 km	River bank strenghtening / Dredging / Rock demolition / Signaling	n/a	-	self-propelled barges (16m x 110m x 2,5m)	-	680.000.000	self-propelled barges (16m x 110m x 2,5m)	-	680.000.000
	Amarópolis dam with a small lock	Construction of a new lock parallel to the existing (maximum quality level)		17m x 120m		-	0		17m x 120m x 3,5m	90.000.000
	Anel de Dom Marco dam with a small lock	Construction of a new lock parallel to the existing (maximum quality level)		17m x 120m		-	0		17m x 120m x 3,5m	95.000.000
Subtotal							**680.000.000**			**865.000.000**
Total (Lagoa dos Patos + Jacuí)							**760.000.000**			**945.000.000**
Triunfo - Estrela (Taquari river)	Low water depth, rock outcrops and sand bars, located downstream of the Bom Retiro dam	Rock demolition / Dredging	self-propelled barges	-	self-propelled barges (16m x 110m x 2,5m)	-	500.000.000	self-propelled barges (16m x 110m x 2,5m)	-	500.000.000
	Bom Retiro dam with a small lock	Construction of a new lock parallel to the existing (maximum quality level)		17m x 120m		-	0		17m x 120m x 3,5m	95.000.000
Subtotal							**500.000.000**			**595.000.000**
Total (Lagoa dos Patos + Jacuí+Taquari)							**1.260.000.000**			**1.540.000.000**

6 COST-BENEFIT ANALYSIS

After the elaboration of the main development strategies (Maintenance+, Expansion A and B, Top Quality) it was conducted a cost-benefit analysis (CBA) of these strategies. A Cost-Benefit Analysis (CBA) estimates and totals up the equivalent discounted money value of the benefits and costs to the community of measures to establish whether they are worthwhile.

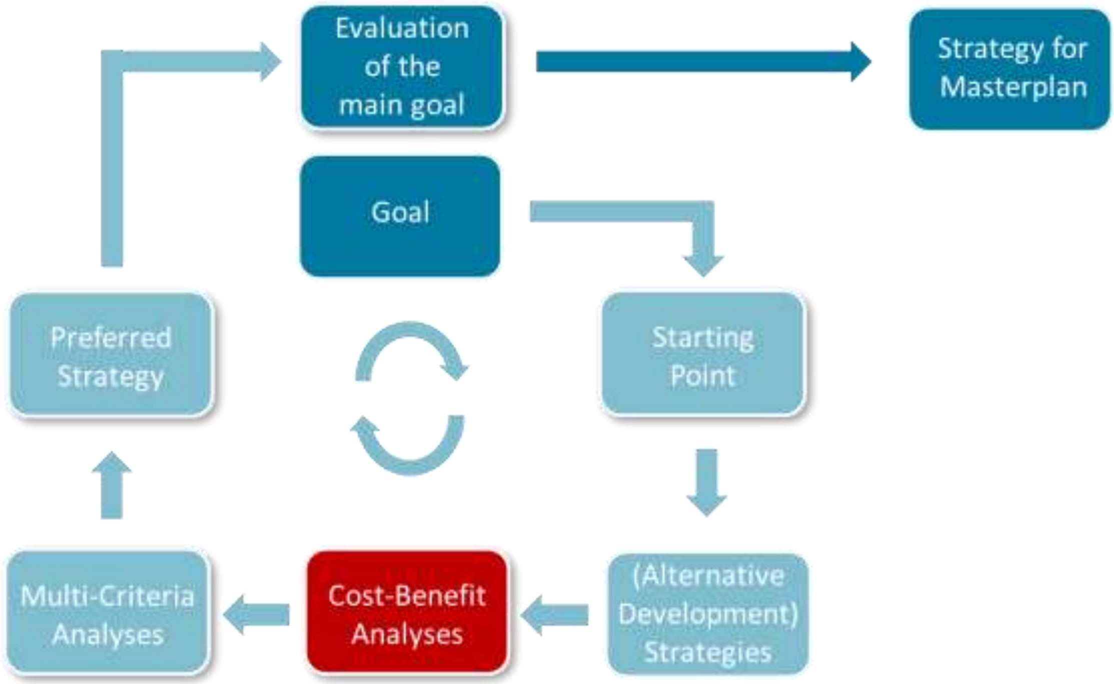


Figure 6.1 – Process Steps – Cost-Benefit Analysis

6.1 METHODOLOGY OF COST-BENEFIT ANALYSIS

The total expected cost of the CBA for the four main development strategies were compared with the total expected benefits, thus determining whether the benefits compensate or are higher than the costs, and what is the margin.

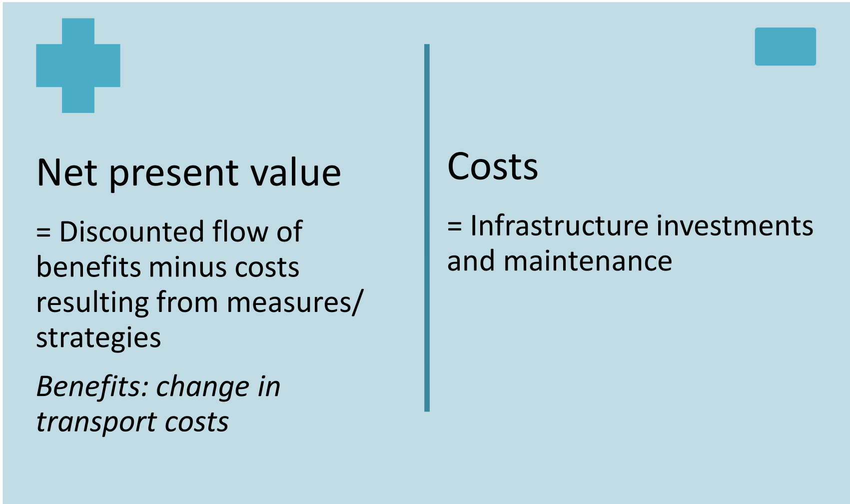


Figure 6.1.1 – Costs-Benefits Balance

The Net present value of the strategies consists of the discounted flow of benefits minus costs. The benefits of this CBA consist of the change in transport costs for all transport modes and routes, resulting from the measures/strategies. The costs consist of:

- Public investment costs for inland waterways infrastructure, superstructure and facilities (hardware), including connecting road infrastructure;
- Maintenance and operating costs.

In this study costs and benefits are tax-inclusive.

The following work steps were carried out:

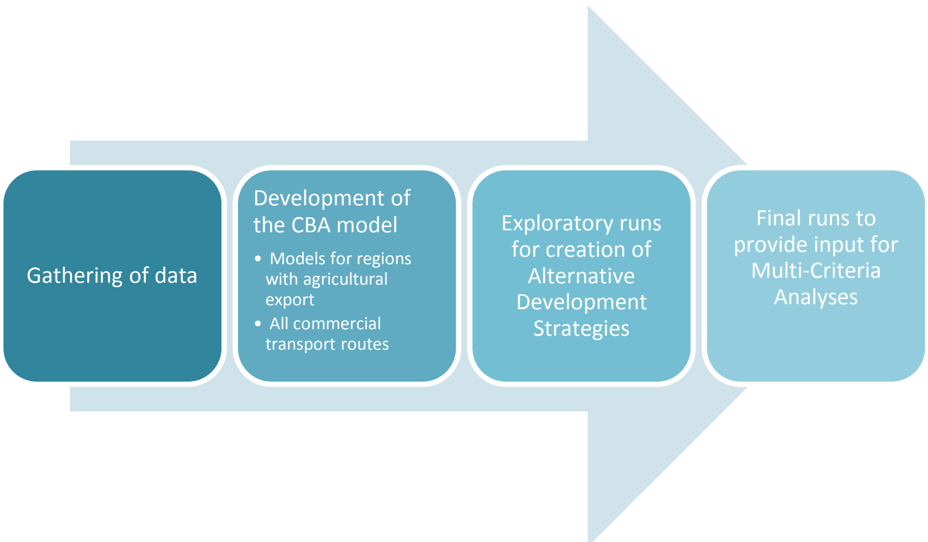


Figure 6.1.2 – Work Steps of Cost-Benefit Analysis

6.1.1 Gathering of Data

Key data that were gathered in order to perform the cost-benefit analysis:

- Forecasts have been made up till the year 2031 for those commodities deemed relevant for inland waterways transport in Brazil, present or future:
  - Soy, soymeal,
  - Sugarcane, sugar and ethanol,
  - Corn,
  - Wood and pulp,
  - Ore and steel,
  - Fertilizers,
  - Containers and RoRo.
- Transport costs. The transport costs of rail were taken from the PNLT2012. The transport costs of road and waterway were taken from the cost model of the University of São Paulo.
- Investment and maintenance costs of the measures as described in Chapter 4.
- Distances in km for transport routes via waterway, road and rail, taken from Google maps and/or transport operating companies.

6.1.2 Transport Forecasts

In the Assessment and Diagnosis Report (Step C) the potential future flows of cargo and passengers on inland waterways in Brazil were analyzed. Potential stands for what is achievable under certain conditions:

- The waterway should at least have a basic navigability. This means in most cases that a convoy of 2x2 barges is able to use the waterway. For a number of waterways this is not the case in the current situation. From this it follows that in the baseline situation (year 2031 without additional measures) the forecasted transport flows will not be realized if no navigability improvements will be made in these waterways.
- Commodities have to be suited for inland waterways. We have chosen the commodities that are transported by IWT in the current situation (mainly soy, corn and ores) and have added a number of flows that may be transported by IWT according to information from expert interviews and other sources (e.g. the transport of ethanol on the Paraná-Tietê River; in the current situation this transport flow does not exist. In the forecast years a relative large flow is expected.)
- The location of the production areas in view of the prospect waterway is important. The distance between the production area and the waterway by road should be less than 500 to 600 km. Also an inland waterway port or terminal should be present. At the moment this condition is not met on every waterway involved.

Forecast Procedures

For cargo flows, production, imports and exports have been the basis for the transport forecasts on specific waterways. It is worth adding that the biggest markets for the THI are dominated by large companies related to producing or transporting commodities over long distances for exportation and importation. For this reason, the loads considered in this Plan are those for exportation. This has been done as follows:

1. Analyze the current transport flows over water.
2. Determine the economic and logistic developments between 2011 and the forecast years (2015, 2023 and 2031) and derive future potential transport flows.
3. Check current and future transport flows with PNLT-data.
4. Determine transport costs per route and mode (water, rail and road) from origin (micro region) to destination (mainly sea ports) for each relevant commodity.
5. Determine the 'top 3' least cost routes and associated IWT cargo flows in the baseline situation.
6. Determine the 'top 3' least cost routes and associated IWT cargo flows, following the measures taken in the IWT strategies.

The data for source-destinations relations have been cross checked with applicable PNLT 2011 data. There was a sufficient match. The full forecasting methodology and the procedures for the use of PNLT data are further explained in the Assessment and Diagnosis Report, Appendix V and VI.

The forecasts for passenger transport are estimated as a linear function of the expected increase of the population and economy in the relevant states. We assume that the number of river crossing highways will remain very limited.

6.1.3 Development of Cost-Benefit Model

It is assumed that waterways investments will be executed in 6 years' time, starting in 2015. Hence benefits derived from these investments (transport costs savings etc.) will start from 2021 onwards until 2045. No additional cost for dam construction is involved as the construction of the locks in Hydroelectric Power Plants will happen at the same time as the construction of the Dams.[9];

In the CBA models a distinction was made between agricultural commodities (especially soy, corn and sugar cane) and all other commodities.

All possible commercial transport routes, including waterway, road and rail, from each micro-region to the nearest port are defined in the models with distances (km).

[9] It is observed that there may be some conflict between the first and second assumption, as the phasing of the HPP investment scheme may differ from the the preferred IWT investment scheme. In the Masterplan we will elaborate this issue in more detail.

For the agricultural commodities with many transport routes and modalities available, transport cost models have been developed in Excel sheet, based on a LOGIT function to forecast marked shares of specific routes and transport modalities. For other commodities with a limited range of transport option basic transport calculations were made.

The model selects the cheapest 3 modal routes. These can be combinations of waterway, rail and road. These cheapest 3 routes are used to calculate the transport benefits as a result of measures per source-destination relation (production region to export port). These benefits are then totalled over the relevant waterways. The result is an overview of all costs and benefits per waterway.

By using a systematic trial and error approach many options were explored. Variations were made in:

- The waterways to invest in (ranging from no waterways to all waterways);
- The quality levels of the waterways (ranging from minimum required to realistic maximum).

The exploratory model runs were used to search for the highest amount of transport tons per year for 'reasonable' investment costs. In other words, the models are used to explore the best value for money.

The output of the CBA models is:

- Transport costs in Δ Reais/ton and Δ Reais/tonkm;
- Δ investment costs (Reais);
- Δ maintenance and operation costs (Reais);
- Efficiency feasibility in Net present value per strategy, per waterway.

In Annex C the setup of the CBA-model is described in more detail.

6.2 RESULTS OF THE COST-BENEFIT ANALYSIS

In the cost-benefit analysis, the results of the transport forecasts for each strategy have been combined with transport cost analysis in order to establish a major type of benefit: transport cost savings. The net present value of transport cost savings have been compared with the investments, operation and maintenance costs. All together this forms a building block for the overall evaluation of the strategies by means of the multi-criteria analysis, presented in Chapter 7 of this report.

In this chapter we first focus on the results of the transport forecasts for the baseline situation and the main strategies (6.2.1). Next we discuss the results in terms of costs and benefits and net present value (6.2.2). More detailed information on these matters relating to the cost-benefit analysis can be found in annex C.

6.2.1 Forecast Results for Cargo Flows

A distinction has been made between three different kinds of transport flows, explained below:

- Group 1 The organic growth of currently existing transport flows (excluding the agricultural products);
- Group 2 Commodities dependent on specific investments or projects;
- Group 3 (Agricultural) commodities in competition with other transport modes / transport chains.

6.2.1.1 The Organic Growth of Currently Existing Transport Flows

For the currently flows in the waterways (2011), with exception to the agricultural products, it is expected an organic growing, according with the autonomous economic development, which can be seen in Table 6.2.1. The main products of this group are: chemical products (including oil) on the Amazon and Hidrovia do Sul, iron ore on the Paraguay River and building materials on the Madeira River. On the Sao Francisco a small amount of cottonseed is transported. The competition with other transport modes is limited because of the nature of the respective commodities and the origin-destination relation.

Table 6.2.1 - Expected Transport Volumes 2031 for Existing Flows (Excluding Agricultural) in tons * 1000

	Development Strategies				
River/Waterway	**Baseline**	**Maint.+**	**Expansion 2A**	**Expansion 2B**	**Top Quality**
Amazon	11.466	11.466	11.466	11.466	11.466
Madeira	-	2.177	2.177	2.177	2.177
Sao Francisco	61	61	61	61	61
Paraguay	14.883	14.883	14.883	14.883	14.883
Hidrovia do Sul	1.618	3.885	3.885	3.885	3.885
Total	**28.028**	**32.472**	**32.472**	**32.472**	**32.472**

The autonomous growth in the baseline is less than in the development strategies. This is a result of overdue maintenance of the Madeira River, eventually resulting in no transport in 2031. For the Hidrovia do Sul only a part of the transport flows will be affected, on the Jacuí and Taquari, mainly consisting of chemical products, oil, coal and wood. In 2031 two million tons are expected to shift to other modes.

6.2.1.2 Commodities Dependent on Specific Investments or Projects

The second group of products is closely connected to the development of the waterway transport, and it is not expected a high competition of the waterways with other modes of transport. This group contains investments in plants or logistical systems that consider the use of waterways. The most important examples are the ALPA steel plant in Marabá, the Eldorado pulp plant in Três Lagoas and the Transpetro ethanol multimodal system (mainly in São Paulo state). The main expected load flow is expected to happen on Tocantins River, between Marabá and Vila do Conde, where Steel products are exported, while coal is imported. The other flows consist of ethanol (on the Paraná-Tietê WS) and pulp (on the Paraná-Tietê WS and on the Hidrovia do Sul). A limited amount of container transport is also included between Porto Alegre and Rio Grande. The competition with other transport modes for these commodities is also limited because of the location of the plants on the waterway (steel, pulp) or the logistical system commitment is specified as to include waterways (ethanol network). The forecasted volumes of load are huge, but depend on specific private investment decisions. The Table 6.2.2 presents the expected load volumes for 2031 from investments in plants and systems.

The main difference between the baseline and the development strategies, as for the amount of cargo, is connected to the expectation for the Tocantins WS. As no investments will take place in the waterway for improving navigability in the Baseline, no investment in the steel plant in Marabá is expected. Hence the flow between Marabá and Vila do Conde will not be considered in 2031.

Table 6.2.2 - Expected Transport Volumes 2031 from Investments in Plants and Systems (in tons * 1.000)

	Development Strategies				
River/Waterway	**Baseline**	**Maint.+**	**Expansion 2A**	**Expansion 2B**	**Top Quality**
Tocantins	-	32.517	32.517	32.517	32.517
Paraná-Tietê	15.988	15.988	15.988	15.988	15.988
Hidrovia do Sul	2.199	2.969	2.969	2.969	2.969
Total	**18.187**	**51.474**	**51.474**	**51.474**	**51.474**

6.2.1.3 (Agricultural) Commodities in Competition with other Transport Modes / Transport Chains

The last group of loads consists of the most relevant agricultural products, like: soy, soymeal, corn (all for export) and fertilizers (import). For a number of big producing areas (Mato Grosso, Goiás, Matopiba region) several alternative transport modes, routes and export ports maritime exist. In the model elaborated per micro region a calculation has been made of the least cost routes between producing (micro) region and export maritime ports, in order to establish the modal shares and hence the subsequent IWT tonnage. The results are given in table 6.2.3. In the baseline the amount of agricultural products will be about 11 million tons, mainly on the Paraná Tiete WS and the Lagoa dos Patos (Sul). On Madeira River no transport can take place according to Group 1 situation.

Table 6.2.3 - Agricultural Products per Strategy 2031 (in tons * 1.000)

	Development Strategies				
River/Waterway	**Baseline**	**Maint.+**	**Expansion 2A**	**Expansion 2B**	**Top Quality**
Madeira	0	3.095	2.771	2.805	2.442
Tapajós	0	0	9.737	0	9.358
Araguaía	0	0	7.253	0	6.086
Tocantins	0	0	0	8.436	6.844
Parnaíba	0	0	8.891	0	5.876
Sao Francisco	0	2.838	487	2.598	487
Paraná-Tietê	7.091	7.091	6.284	4.824	6.284
Paraguay	1.307	1.307	1.121	5.896	4.389
Hidrovia do Sul*	2.479	2.513	2.513	2.513	2.513
Total	**10.877**	**16.844**	**39.057**	**27.073**	**44.279**

* The rivers in Rio Grande do Sul are not part of the transport modeling. Almost all imports and exports use the port of Rio Grande, hence no competing transport routes exist.

6.2.1.4 Totals Cargo Flows Forecast

Table 6.2.4 states the total exports and imports for the relevant agricultural products (soy, soymeal, corn and fertilizers) for the regions included in the calculations. In Expand strategy 2A 39 million tons of a possible total of 67.5 million tons (58%) is transported by inland waterways. In Top Quality, this is even 44 million tons (65%).

Table 6.2.4 - Total Exports per Region for Agricultural Products in 2031 (in tons * 1000)

	Matopiba	Mato Grosso	Goiás (+DF)	Total
Soy	12.361	17.610	4.071	34.042
Soy meal	2.253	6.961	6.961	16.175
Corn	760	8.624	1.200	10.584
Fertilizers	2.003	3.290	1.420	6.713
Total	**17.377**	**36.485**	**13.652**	**67.514**

In Table 6.2.5 is presented a summary of the IWT forecasts per type of flow (group 1, 2 and 3), and for the baseline situation (2031).

Table 6.2.5 Overview of Total Flows per Strategy in 2031 (in tons * 1000)

Transport flow	Baseline	Maint.+	Expansion 2A	Expansion 2B	Top Quality
Organic growth	28.028	32.472	32.472	32.472	32.472
Specific Projects	18.187	51.474	51.474	51.474	51.474
Agriculture Products	10.877	16.844	39.057	27.073	44.279
Total	**57.092**	**100.790**	**123.003**	**111.019**	**128.225**

In the baseline (2031), with very modest maintenance costs (only for the Paraná – Tietê maintenance is foreseen), total transport volume will be about 57 million tons. Halve of this amount is from organic growth on the Amazon and Paraguay River. The projects on the Paraná – Tietê WS (ethanol and wood/pulp) will add another 18 million tons. Although substantial larger than the current situation, the forecasted IWT cargo flows are still far off the target of 110 million tons.

About the results from the development strategies, the expected cargo flow nearly doubles compared to the baseline situation, reaching over 100 million tons. Expand strategy (2B) just reaches the goal, amounting to nearly 111 million tons. Expand strategy (2A) and Top Quality (3) succeed in surpassing the main goal of 110 million tons in 2031.

6.2.2 Benefit/Cost Ratios of Strategies

The costs in the CBA consist of the investment and maintenance costs. These have been calculated for all measures, differing per waterway and strategy (see Chapter 5 and Annex B for more details).

Based on the transport forecasts and the analysis of transport costs per mode and route, the sum of changes in transport costs between the baseline situation and the IWT strategies have been established for all relevant commodities and origin-destination combinations. More detail can be found in Annex C.

Finally the net present value of costs and benefits has been calculated for each strategy. In Table 6.2.6 an overview is presented of the present value of costs and benefits as well as the benefit/cost ratio. The values are derived from comparing strategies Maintenance, Expansion 2A, Expansion 2B and Top Quality, with the baseline situation.

Table 6.2.6 - Discounted Cost and Benefits per Strategy

	Transport benefits	Costs	B/C ratio	Volume
	R$ * million	R$* million	#	Million ton
Baseline	0	0	-	57
Maintenance+	9.480	3.569	2.66	101
Expansion 2A	17.390	28.276	0.62	123
Expansion 2B	12.390	11.553	1.07	111
Top Quality	19.486	41.101	0.47	128

The Maintenance+ strategy and the Expansion 2B both show B/C ratios > 1, hence being efficient strategies. The other strategies (Expansion 2A and TQ) result in less positive B/C ratios, however with a (far) higher IWT volume compared to the main goal.

It is worth noting that the cost-benefit analysis, in general, include the calculation of the most important quantifiable benefits, but in this work to cost-benefit analysis did not incorporate social and environmental aspects as emissions, noise generation and safety (called externalities). Thus some benefits may be underestimated so, since the multi-criteria analysis was chosen as the central decision-making tool in the analysis of development strategies, the results were introduced into the ACB AMC.

Yet the results show that the CBA investments in waterways have a relatively high B/C. Projects in Europe, it is found B/C rates of about 0.6 for projects related to IWT.

The discount rate in Brazil is higher than in Europe (the U.S.). This means that investments in the early years of the project involve large values and benefits in recent years have lower weight. As the sensitivity analysis, presented in Chapter 10 depict that the results would be better if discount rates were lower

6.2.2.1 *Strategies Feasibility and Need for a MCA*

While the CBA shows the feasibility of waterway development, it only considers economics aspects. Although a key aspect (and decisive because if it is not economically feasible the development of IWT probably will not occur), recommended public policies should not be solely based on benefits from the investment, but also on a broader set of objectives.

The transport cost savings are the economic benefits of the strategies, as expressed in the CBA. In addition to these transport cost savings (relating to existing flows) other types of benefits are relevant for evaluating the IWT strategies, like:

- Enabling regional development (e.g. the steel plant in Marabá);
- Environmental benefits (reducing emissions of greenhouse gases);
- Transport safety benefits;
- Natural and social habitat impacts.

This larger set of objectives includes institutional considerations, as well as ensuring social and environmental sustainability. In order to account for the different dimensions of the implied decision of waterway development, the results of the Cost-Benefit Analysis are complemented with a Multi-Criteria Analysis (MCA). Both analytical tools combined yield solid results that assisted for the decision making process.

7 MULTI-CRITERIA ANALYSIS

Following the Cost-Benefit Analysis, a Multi Criteria Analysis (MCA) was conducted, as illustrated in Figure 7.1. The MCA allowed the evaluation of the strategies, incorporating institutional cohesion and environmental, social sustainability, as well as the economical results from the CBA. This chapter describes the methodology, the results and the conclusions of the MCA, which provided the basis for selecting the Preferred Strategy.

Figure 7.1 – Process Steps – Perform Multi-Criteria Analysis

7.1 METHODOLOGY OF MULTI-CRITERIA ANALYSIS

7.1.1 Introduction

Governments have the responsability of planning for the long term and beyond a strictly financial aspect. Waterway transport clearly promotes net environmental benefits compared to other modes of transport. That is why the methodology chosen to support the decision over the best strategy for IWT was the Multi-Criteria Analysis (MCA) and not solely the Cost-Benefit Analysis. International experiences show that the MCA is a very appropriate analytical framework for this kind of complex decision-making process, since explicit recognition is given to the fact that a variety of both monetary and non-monetary objectives may influence policy decisions, as discussed by Janssen (2001)[10].

In the MCA framework, desirable objectives are specified and corresponding criteria are identified. The actual measurements of the criteria are often based on the quantitative

[10] Janssen, R. (2001): **On the Use of Multi Criteria Analysis in Environmental Impact Assessment in The Netherlands**. Journal of Multi-criteria Decision Analysis, Vol. 10, No. 2, pp. 101-109.

analysis (through scoring, ranking and the use of comparable units) of a wide range of qualitative impact categories. Different environmental and social indicators may be developed side by side with economic costs and benefits.

It must be noted that the MCA analysis does not make the decision nor selects the best alternative. Each alternative set of waterway developments results in different km of navigable waterways, different investment costs, different transport costs, different environmental disturbances, etc. And exactly due to this diversity, the methodology does not generate the "best" PHE strategy, but rather provides the elements and analytics necessary in order to support the decision making process.

7.1.2 Hierarchical Structure

The MCA methodology is based on a hierarchical structure where alternatives that address the posed question are compared and ranked according to a structure of dimensions, objectives and criteria. The structure of the MCA is the following:

- A well-defined goal towards which the compared alternatives will be judged to head;
- Balanced dimensions in order to homogeneously represent their relative importance and hold relevant differences among them;
- A clear set of objectives that balances the choice of alternatives and enables each dimension's broad reach to be addressed;
- Defined criteria based on the underlying objectives that measure them unequivocally and uniquely (as to prevent double counting), without representing a political comparison;
- Lastly, scores that are clearly measurable and distinguish the alternatives.

The MCA addresses the multi-objectives involved in choosing from one alternative set of waterway to develop to another set.

The alternatives not only reflect the inclusion or exclusion of a waterway on the development of IWT strategy, but also compare multi-modal strategies that include the waterways. It must be noted that the PHE is not deciding whether trains or IWT is better, the main assumption of the Cost-Benefit Analysis and also of the MCA is that the agricultural commodities that are produced in Brazil and exported will continue to be so - independently of the choice for transport. The CBA did consider multi-modal alternatives without waterways with the purpose of calculating monetary costs and benefits from different transport alternatives. By doing so, the analysis shows the competitiveness of the waterway on the transport system as a whole, a criterion utilized in the MCA.

Moreover, the Diagnose Report constructed a rich and powerful database upon the precise analysis of each waterway's 10 km stretch, where the physical, environmental and social aspects were classified. This database allows not only for the thorough analysis of each waterway, but also compare which combination of waterways yields more environmental disturbances, for instance.

The MCA, thus, compares the possible development strategies by addressing the question of which combination of waterways will yield the best National plan considering the balance between the four dimensions (economical sustainability, institutional cohesion and environmental and social sustainability).

Following the decision pathway, the comparison between the distinct sets of possible waterway developments will allow for a complete set of alternatives to deliver a solid planning for the sector, including multi-modal comparisons. From a public policy's point of view, the balance between the four dimensions means promoting a transport system that will yield net benefits for society.

The figure bellow shows the hierarchical structure with the segregation of the four dimensions into their objectives and onto the criteria that measures them.

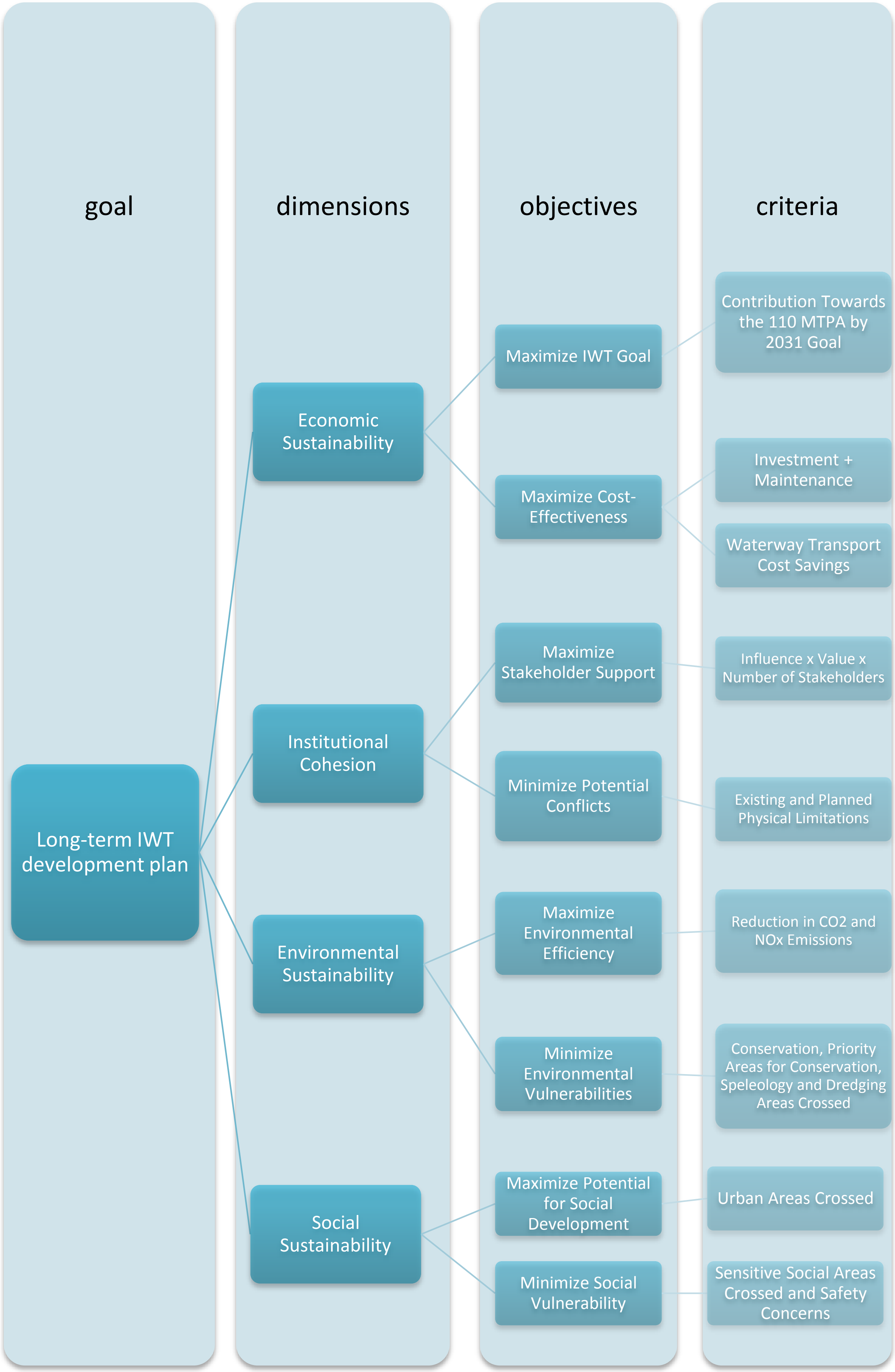


Figura 7.1.1 - Hierarchical structure of objectives and criteria

7.1.3 Alternatives

The compared waterway routes are combinations of several waterways; each set aggregating different development necessities. The waterways that build up each set of alternatives are composed of road-water-road-port, road-water-port and road-water-rail-port modes that are spread over different regions and cover different distances, as explained in details in Chapter 5.

7.1.4 Dimensions, Objectives and Criteria Description

The scores are allocated to each of the criteria across all alternatives being compared. This allocation is done with the purpose of comparing the alternatives and not judging one individual waterway out of this context. Some scores are absolute values of a specific waterway, and thus do not present variation if interpreted out of the context. Other criteria, however, are valid for comparisons in the specific context for which they are built[11].

An example can be the crossing of protected areas, a criterion of environmental vulnerability: one protected area that a waterway crosses in one of its 10 km section might be a hundred times larger in size than the sum of two other protected areas that another waterway crosses in one of its 10 km sections. For the MCA score, the waterway that crosses two protected areas will turn out to be comparably worse. A broad-range comparison of the sort undertaken demands this kind of approximation, whereas a closer look (that necessarily oversees the bigger picture) at the exemplified case might conclude that the larger protected area is more vulnerable.

The MCA method can also be viewed as the construction of an aggregated index for the different alternatives, and this index will only be able to support decision with accurate and well-connected inputs. The reasoning behind the dimensions and the assumptions and methods behind the criteria, are further listed and explained in this chapter.

The databases utilized to construct the scores are those from:

- The Diagnose Report, in which physical, social, environmental and navigability aspects were thoroughly mapped for each of the studied waterways;
- The Stakeholder Consultation, in which preferences and influences over waterways have been assessed over a broad range of stakeholders;
- The Cost-Benefit Analysis, in which transport cost calculations were performed for each waterway sectionsection considering agricultural commodities that need to reach a seaport; and

[11] After defining the scores for each of the criteria, they are standardized in order to enable numerical comparisons. Each score has a specific preference structure, which is standardized between 0 and 1 respecting the characteristics of each criterion and the objective it measures. There are six different types of preference structures: i) binary criterion, where the effect is either zero or one; ii) almost binary, where the value for "zero" may be any real value, iii) linear structure, where there is growth defined by an analogous expression; iv) preference levels ("step-change"); v) linear structure with an indifference area; and finally vi) Gaussian preference (with distinct coefficients).

- The Investment Necessary, in which the necessary investment costs were calculated for all waterway sections under 'Expansion' and 'Top Quality'.

Economic Dimension

The economic dimension of waterway transport means the sector as a key player in a multi-modal and competitive setting. It reflects the possibilities that waterway navigability will be made possible because it allows for savings in transport costs that offset the required investments and will thus lower costs and increase competitiveness. IWT needs to be a choice for private development and for private interests that are aiming at delivering their produces to seaport at a lower fare with less transport hassles.

The main concern of this dimension is having IWT play a key role in the transport matrix with the "waterways with potential" developed; the one that will bring the major economic benefits. At the same time, the public sector must aim at a far-reaching transport system that can tend to many regions. Therefore, the need to pursue the goal of 110 MTPA by 2031 is complementary to the purely cost-benefit perspective. The promising set of waterways needs to maximize public investment and at the same time they must enhance private sector competitiveness.

To synthetize the economic dimension, these two objectives are laid out: i) the maximization of the IWT goal that will lift the sector into the transport matrix and ii) the maximization of cost-effectiveness that will enable waterways to be privately and publicly developed, enhancing competitive positions and minimizing costs.

Table 7.1.1 – Goals and Criteria regarding the Economic Sustainability

ECONOMIC SUSTAINABILITY	
Objective / Criteria	**Maximization of Internal Water Transport Goal**
Criteria	**Contribution Towards the 110 MTPA by 2031 Goal**
Rationale	The closer to the transport goal, the more a strategy contributes to the promotion of IWT as a key-player in the multi-modal transport sector
Score	This criterion only captures the tonnage transported in the following commodities: corn, soy, soy meal and fertilizer. The total tonnage that waterways will be transporting by 2031 will be higher than the indicated percentages calculated for this criterion. The reason for only accounting for the agricultural commodities is that they are the main drivers of economic feasibility. Therefore, the score calculates the total tonnage transported by each strategy by 2031 and divides that by the goal of 110 MTPA
Unit	Percentage points
Cost/Benefit	Benefit (the higher the score is, the better the strategy is)

Table 7.1.2 – Goals and Criteria regarding the Cost–Benefit ratio

ECONOMIC SUSTAINABILITY		
Objective / Criteria	**Maximization of Cost-Effectiveness**	
Criteria	**Investment + Maintenance**	**Waterway Transport Cost Savings**
Rationale	The rationale is that investments should be as low as possible and should yield maximal returns. Not necessarily the public sector will be the sole responsible for the investments needed. Public-private partnerships are an option for waterway development. Just as well, private transport operators can assume responsibility over some maintenance costs. Therefore, the rationale is to account for all investments and maintenance costs needed independently of who will pay for it. This is the "cost" of the cost-benefit analysis	The rationale is that the addition of waterways in the transport matrix would lower transport costs. The cheaper the transport costs are, the more competitive a production region gets. The benefits of developing waterway transport are, thus, the differences in costs from the modal choices with and without the waterways. These differences are assessed for each specific route option considering the agricultural commodities that are produced and their expected growth until the year 2031
Score	This criterion gathers all investment needed to render the waterway sections on each strategy navigable by the means of dredging, rock-blasting, sinuosity-correction, lock building and so on. The investments are spread out over time according to the same assumptions made for the Cost-Benefit Analysis. Please refer to that section for further details.	This criterion reflects the difference of all transport costs for the agricultural producer of soy, soy meal and corn and the importer of fertilizer from each of the 127 micro-regions analyzed to seaport when there is a waterway available instead of the regular road and/or rail alternative. The model utilized to calculate the cost difference is the Cost-Benefit Analysis. The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option). In sum, it represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs. The tonnage considered is the one forecasted for the year 2031
Unit	Net present value of the total investment and maintenance costs in R$ divided by the tons carried, yielding a R$ of NPV / ton figure. Discount rate of 6.25%, same as for the cost-benefit analysis	Net present value of the total transport cost per ton with waterways minus the same transport costs without waterways in R$ divided by the tons carried, yielding a R$ of NPV / ton figure. Discount rate of 6.25%, same as for the cost-benefit analysis
Cost/Benefit	Cost (the lower the score is, the better the strategy is)	Benefit (the higher the score is, the better the strategy is)

The two criteria for the maximization of cost-effectiveness are complementary in the following way: their difference yields the net economic benefits of investing in waterway navigation. Since the figures are all calculated in a per ton basis, the comparisons are direct and show the expected gain for each ton under each strategy. Whereas the "per ton" figures are optimal as MCA criteria, the corresponding totals are presented along with the description of the strategies.

Since the combination of benefits minus costs yields the net economic effect, it is important to state that the weight allocated to each of these criteria must be 50% in order to yield the cost-benefit result. Although this cannot be changed due to the logic applied, the weight between the dimensions (Economic, Institutional, Environmental and Social) and also between the objectives (Maximize IWT Goal and Maximize Cost Effectiveness) still represent the relative importance of the criteria and the objectives.

The transport cost calculation models the transport flows from the micro-regions that produce the larger agricultural commodities to seaport. Each micro-region distributes its cargo via a LOGIT model over the three cheapest routes for transporting their produce to a port. In the first setting there is no waterway option, so they allocate their routes over the three cheapest multi-modal routes including road and/or rail combinations. In the second setting the waterways are included, rendering possible for them to be amongst the three cheapest routes, including waterways. This method allows for the calculation of the difference in transport cots over a multi-modal setting, capturing the competitiveness of the IWT sector for this set of commodities.

One consideration that must be done on the presented choice of criteria is that some of the waterways with current commercial navigation logicaly have priority for expansion over 'greenfield' waterway development. Since the investment costs for currently non-navigable commercial waterways already captures this different situations, and being such costs higher, it would be double counting if another criteria was set to capture this effect.

It's important to note that the figures for the cost-benefit analysis on the MCA are not exactly the same as on the CBA. The differences occur due to the fact that on the MCA the waterways that do not accrue benefits in terms of transport savings costs for the agricultural commodities considered did not have their investment and maintenance costs considered, which is the case for the Amazon and Solimões and for the Hidrovia do Sul.

Institutional Cohesion

This dimension reflects the necessity for the government to provide a strategic answer to waterway development that is consistent with the multi-purposes presented and is able to be implemented. The rationale is that even if the promising set of waterways become navigable due to public investments, IWT will not become a key player on the national transport matrix if it fails to become reliable due to physical impediments or due to stakeholder resistance. The objectives that describe this dimension capture the main aspects that affect the reliability of internal waterway navigation - maximizing institutional support and minimizing potential conflicts from both current and expected physical limitations (namely dams).

Table 7.1.3 – Goals and Criteria regarding the Institutional cohesion

INSTITUTIONAL COHESION	
Objective / Criteria	**Maximization of Stakeholder Support**
Criteria	**Influence x Value x Number of Stakeholders**
Rationale	The PHE's resulting waterway development is set to influence entire regions, a broad set of private companies, communities and governments at all levels. Thus, it is not only desirable but also necessary to have ample stakeholder support. The different waterway sets being compared imply distinct support from stakeholders, including those that already have a stake in waterway navigation such as waterway transport companies. The rationale of the criterion is to identify the relative priorities to be given to each strategy by the stakeholders by means of perceiving the most powerful stakeholders and those more interested in the success of each waterway development
Score	The score is calculated utilizing the resulting information from the interview of 58 stakeholders from three main categories: i) industries (agribusiness, mining, fuels, potential users and industrial sector organizations); ii) public organizations (national and regional coverage: transport, national and regional coverage: others); and iii) logistic companies (specializing in waterway transport, port operation, logistics / potential investor, shipyards and organizations in the logistics area). The interviews captured these aspects: the region (or waterway system) they were influenced by or did influence; the value they gave to the waterway (in reference to the interests of a stakeholder in the IWT sector) and the influence they exerted on the waterway (in reference to how powerful a stakeholder is in the IWT sector)
Unit	The unit of measure is the addition of the influence times the value given by each stakeholder across the waterways that it influences or is influenced by. The influence score reflects the influence of the interviewee in the definition / implementation of measures related to the improvement of the inland waterway transportation; whereas the value score reflects the importance given by the interviewee to the inland waterway transportation. Note that experts consulted were ignored from the value x influence analysis
Cost/Benefit	Benefit (the higher the score is, the better the strategy is)

Table 7.1.4– Goals and Criteria regarding the Reduction of Potential Conflicts

	INSTITUTIONAL COHESION	
Objective / Criteria	**Minimization of Potential Conflicts**	
Criteria	**Number of Existing Physical Limitations (dams and bridges)**	**Number of Dams Planned**
Rationale	When a waterway section has either a dam without a lock (or with a lock that limits navigation) or bridges with a limiting height/width, independently of the monetary investment needed to surpass these limitations, third parties will undoubtedly get involved. For instance, a bridge that needs to be raised may be on a federal highway that is under private concession. That will demand negotiations with ANTT and the concessionaire, besides causing traffic nuisance (albeit temporarily). The same holds true for a waterway that has a dam without locks: the company managing the dam will need to get involved, property appraisal must be done in order to acquire the needed land for lock-building, relocation assistance to owners, tenants, businesses, and farm operations will have to be provided, etc. These exemplified procedures are potentially demanding on time and negotiation between external parties, thus being potentially time and effort consuming, even presenting some risks to the reliability of that waterway stretch	Certain waterway sections have natural physical limitations due to rapids and too much energy potential. Exactly due to this potential, the building of dams in a requirement for navigability that is matched with the requirement for hydroelectricity generation. Although there are cost-saving opportunities for both the transport and the energy sector, they can only be rendered via straight coordination. Should a hydro-power dam block lock building, navigation will be impeded. Moreover, the implementation of hydro-dams consumes at least four years to be implemented but possibly even longer. Until that time is elapsed, no navigation is possible, and thus the implementation of terminals and the building of barge fleets will not happen. The most serious reason is that nearly all of the currently proposed dam projects do not consider the implementation of locks. Therefore, coordination is necessary whenever a waterway might receive a hydro-power dam, demanding time and negotiation between all the institutions involved
Score	Addition of the number of dams and bridges that are either limiting or impeding navigation, independently of the physical severity of this limitation, on each of the routes' 10 km sections (from the Diagnose Report, grades 3, 4 and 5)	The measurement of this criterion is the addition of all proposed dam projects on the routes, counted at each of its 10 km sections (from the Diagnose Report)
Unit	The measurement of this criterion is done with reference to the following attribute classification, as presented on the Diagnose Report: Absence of physical obstacles: grade 1; Presence of non-limiting dam with lock or non-limiting bridge: grade 2; Presence of limiting dam with lock or limiting bridge: grade 3; More than one limiting bridge: grade 4; Presence of dam without lock: grade 5	Number of dams planned by route with reference to the following attribute classification, as presented on the Diagnose Report: Dam planned with lock: grade 1; Dam planned without lock: grade 3
Cost/Benefit	Cost (the lower the score is, the better the strategy is)	Cost (the lower the score is, the better the strategy is)

The criteria listed under the second of the objectives represent potential conflicts that can be compared across the different alternative waterway routes. Most definitely, the possibility of having a dam built for hydropower generation without a lock on a certain route leads it to be unreliable. The criteria, however, does not break down the large set of recommendations that are waterway-wide applicable on a route-to-route basis. An example is the recommendation to broaden the choices of courses to form new water transport crewmembers - that applies to all waterway developments and helps insuring reliability for IWT as a whole and thus is not considered on the MCA.

Moreover, the criteria do not account for the investment amount that is needed in order to implement the modifications to the dams or bridges, and as such do not represent double counting with the investment criterion. Just the same, since the implementation of the expected 'missing' locks is a major investment already considered in the investment criterion, under institutional cohesion it will not be considered in order to avoid double counting.

Environmental Sustainability

Waterways are the preferred transport mode under an environmental sustainability dimension. Not only the environmental disturbances are smaller because a waterway's course is already set by nature, but also transport efficiency is much higher. The emissions of CO_2, for instance, are five times smaller per tonkm than road haulage. Therefore the implementation of waterways can almost certainly render net environmental benefits when the whole transport matrix is considered.

Nonetheless, when a waterway route crosses a conservation area, it is possible that it provokes local environmental disturbances such as accidents, air pollution and noise, even of low intensity and impact. There is also the possibility of opening access to illegal activities such as deforestation and animal trafficking. It should be noted that while highways and railroads are a clear vector for environmental disturbances and illegal activities (especially in the northern region of the country), waterways are not expected to be so[12].

The objectives of the environmental sustainability dimension, thus, have to address these two features: the gains from the inclusion of internal water transport in the multi-modal transport sector and also the local impacts caused by the implementation and operation of waterways, including dredging and the crossing of environmentally sensitive areas.

[12] Of the many studies that corroborate the conclusion that roads are a vector for deforestation and environmental degradation, we suggest the four following references: i) Nepstad, D., G. Carvalho, A.C. Barros, A. Alencar, J.P. Capobianco, J. Bishop, P. Moutinho, P. Lefebvre, and U. Lopes da Silva, Jr. 2001. **Road paving, fire regime feedbacks, and the future of Amazon forests.** Forest Ecology and Management 5524: 1-13. ii) Soares-Filho, B., R. Silvestrini. D. Nepstad, P. Brando, H. Rodrigues, A. Alencar, M. Coe, C. Locks, L. Lima, L. Hissa, and C. Stickler. 2012. **Forest fragmentation, climate change and understory fire regimes on the Amazonian landscapes of the Xingu headwaters.** Landscape Ecology. doi: 10.1007/s10980-012-9723-6. iii) Gonçalo F., Gareth J. R., Philip C. S., Richard O. B., Stuart L. P, and Thomas E. L. 2003. **Rates of species loss from Amazonian forest fragments.** Proceedings of the National Academy of Sciences of the United States of America (PNAS), November 25, 2003 vol. 100 no. 24 14069-14073. iv) Dourojeanni M. J. 2006. **Estudio de caso sobre la carretera Interoceánica en la amazonía sur del Perú.** Banco Inter-americano de Desenvolvimento (BID), Corporación Andina de Fomento (CAF) e Fondo Financiero para el Desarrollo de la Cuenca del Plata (Fonplata), para a Iniciativa de Integración de la Infraestructura de Sudamérica (IIRSA).

Table 7.1.5 – Goals and Criteria regarding the Environmental Sustainability

ENVIRONMENTAL SUSTAINABILITY		
Objective / Criteria	**Maximization of Environmental Efficiency**	
Criteria	**Reduction in CO_2 Emissions**	**Reduction in NO_x Emissions**
Rationale	Atmospheric emissions of CO_2 and NO_x are evidences of environmental disturbances at global and local levels, thus the route that emits the smallest amount of air pollution is comparably better	
Score	Since the development of waterways will reduce emissions when compared in a per/km basis with road and rail transport, this criteria are calculated in a multi-modal fashion, considering the whole route taken from the production region to seaport including pre-haulage by road and final haulage either by road or rail. The final figures show the difference in emissions that water transport allows when compared to other multi-modal combinations of road and/or rail	
Unit	The assumption for the calculations is the transport of all agricultural commodities from farm to seaport via waterway in 2031 shown in TTPA (thousand tons per year)	
Cost/Benefit	Benefit (the higher the score is, the better the strategy is)	

Table 7.1.6 – Goals and Criteria regarding the Reduction of Environmental Vulnerabilities

ENVIRONMENTAL SUSTAINABILITY				
Objective / Criteria	**Minimization of Environmental Vulnerabilities**			
Criteria	**Average Conservation Areas Crossed by 100 km**	**Average Priority Areas for Conservation Crossed by 100 km**	**Average Speleology Areas Crossed by 100 km**	**Average Dredging Needed by 100 km**
Main Rationale	Once the objective aims at measuring local impact potential, a relative criterion was reached by adding the number of times a waterway crosses environmentally vulnerable areas, then averaging them per 100 km sections. The relative criterion allows for comparisons between different strategies that have longer and shorter routes included, once the rationale is that the agricultural production of corn, soy and soy meal will be hauled from farm to seaport through a route that will certainly include pre-haulage by road and thereafter a combination of waterway/road/rail either way.			
Specific Rationale	Protected areas are under pressure from an array of human impacts, and the crisscrossing of a large-scale economic activity through such areas evokes caution	Priority areas for conservation could become parks and other protected areas as long as they are maintained viable ecosystem corridors	Natural cavities may hide signs from past civilizations and thus should be treated as vulnerable to activities that may offer harm	Dredging provokes environmental disturbances such as high turbidity, possible release of chemicals from bottom sediments and other modifications that affect a waterway's ecosystem
Score	The score assigned is the average number of protected areas crossed at each of the 100 km sections on each of the waterways that make up a strategy option, with the differentiation between protection-only counting as 1 and sustainable use counting as 0,5	The score assigned is the average number of all priority areas crossed at each of the 100 km sections on each of the waterways that make up a strategy option, with the differentiation between 'extremely high' and 'very high' priority areas counting as 1 and 'high' and 'insufficiently known' priority counting as 0,5	The score assigned is the average number of areas that either have a speleology site or have the potential of having a speleology site crossed at each of the 100 km sections on each of the waterways that make up a strategy option	The score assigned is the average number of areas that require dredging crossed at each of the 100 km sections on each of the waterways that make up a strategy option, following the depth criteria 3, 4 and 5. The depth criterion is multiplied by its respective number of 100 km sections in order to differentiate the amount of dredging needed
Unit	Average number of conservation units crossed by the route on each of its 100 km sections	Average number of priority areas for conservation crossed by the route on each of its 100 km sections	Average number of speleology areas crossed by the route on each of its 100 km sections	The attribute classification is: above 4m: 1; between 3 and 4m: 2; between 2 and 3m: 3; between 1 and 2m: 4; lower than 1m: 5. The higher the indicator, more dredging will need to be done
Cost/Benefit	Cost (the lower the score is, the better the strategy is)			

It is important to observe that the purpose of this MCA is to compare waterway sets with other waterway sets and not explicitly across modes of transports. Such an analysis would render interesting results in terms of understanding the differences in environmental impacts from road and rail options.

The economic dimension has a criterion for the investments needed in order to render a waterway navigable. Whilst this criterion captures the need for dredging and the correction of other natural physical impediments to navigation just as the criteria under the environmental dimension, the way they are assessed prevents double counting and is done is such a way that both are well represented: dredging a long section with sand is cheap, and thus under the investment criterion will not comparatively impact the waterway, whereas under the environmental disturbance criterion the length is considered. The measurement is especially valid for the proposed comparison between the combinations of the waterways routes.

Another consideration is on the measure of sinuosity of the waterways. It was not considered as a criterion for, due to expert judgment, it is not considered to be a significant impediment to navigability on the waterway routes that make up the four alternative strategies. Therefore, no major disturbances are expected from sinuous waterways. The sections of water that could have sinuosity as a major setback were already discarded from the possible waterway route composition due to feasibility issues (basically shorter upstream sections).

Social Sustainability

Two social objectives must be sought after when developing waterways: maximizing the potential of the infrastructure development in fostering regional development and minimizing social vulnerabilities. The criteria to address these objectives, though, are not at all easy to distinguish and calculate. Social vulnerability is more straightforward than potential social development, because it can safely be assumed that any large-scale economic activity that crisscrosses sensitive social areas is prone to causing disturbance. Social resistance, then, can be expected - even though the potential disturbances caused by waterways may be rather small compared to the implementation of railway lines and even highways. The exact route of man-made transport lines, however, can deviate an indigenous area - whilst waterway routes are set a *priori* and can seldom be changed.

For the specific dataset analyzed, the objective of maximizing the potential for social development is measure by the total number of urban areas that the strategies crossed. As of adding new modal connections as a way of fostering economic development, only indirect effects can be perceived at this planning stage. Since the future is a social practice, waterway connections (or the possibility to be connected) to cities that do not have easy or cheap access from other modes will certainly produce a multiplicity of effects - a few that can be intentional and many others that are not.

Table 7.1.7 – Goals and Criteria regarding the Social Sustainability

SOCIAL SUSTAINABILITY	
Objective / Criteria	**Maximize Potential for Social Development**
Criteria	**Number of Urban Areas Crossed**
Rationale	Many regions across the country do not have good access to market for their production, the market being either regional centers of distribution or international markets for high value-added goods. While the feasibility of waterways is based on their capacity to tender for large-scale agricultural production of corn and soy, the long range and long term planning of waterway connections can foster regional economic development. Just the same, the establishment of waterways will allow for an increase in passenger transport, mirroring the importance of this sector in the Amazon region where smaller boats navigate waterways and other channels and smaller waterways with local cargo and passengers
Score	The potential for regional economic development can be captured by the number of urban areas crossed by each of the waterways that make up the strategies. Although this is only a proxy for social development, it becomes clear that the more urban areas a strategy crosses, the more opportunities to use the waterway will be developed. The crossing of a waterway network in urban areas present the possibility for the development of passenger transport integration and commerce
Unit	Number of urban areas crossed by the route
Cost/Benefit	Benefit (the higher the score is, the better the strategy is)

Table 7.1.8 – Goals and Criteria regarding the Reduction of Social Vulnerabilities

Objective / Criteria	Minimization of Social Vulnerability	
Criteria	**Number of Indigenous, Quilombola and INCRA Communities Crossed**	**Safety Concerns**
Rationale	When a waterway route crosses a sensitive social area, it is possible that it provokes disturbances such as changes in the traditional relationship with the waterway, disturbance of fish patterns and their reproduction strategies, possible accidents, air pollution and noise	Waterways are considered very safe, especially when compared to road transport. The criterion for the safety concern is the number of km/ton under road transport implied by each strategy, once waterway transport also needs pre-haulage by road from the production area to the terminal
Score	The score assigned for this criterion is the average of all socially sensitive areas crossed at each 100 km sections, with the differentiation between Indigenous communities counting as 1 and Quilombola and INCRA communities areas counting as 0,5	The different set of waterway routes imply a different set of distances covered by trucks to deliver the agricultural produces from farm to waterway terminals, which can be then used as a proxy for the possible safety hazards once road transport implies more safety concerns than waterways
Unit	Average number of Indigenous, Quilombola and INCRA communities crossed by the route on each of its 100 km sections	Number of kilometers by road implied by each strategy divided by the tons carried, rendering a km by road / ton figure
Cost/Benefit	Cost (the lower the score is, the better the strategy is)	Cost (the lower the score is, the better the strategy is)

For the security concerns, one of the greatest setbacks of water transport occurs while transferring cargo to and from the barges. Although that number would have made a good proxy for safety concerns, transshipments occur more or less on the same amount of times for all possible strategies, rendering a bad comparison. Also under the safety criterion, it would have been an optimal indicator to have the average number of accidents by road, water and rail in order to compare the multi-modal combinations. Such indicators, however, are not available from trusted sources.

7.1.5 Weight Allocation

In order to obtain the desired comparability between the four dimensions that are relevant for the waterway development decision-making process, it becomes necessary to assign weights intra and inter dimensions, objectives and criteria. The definition of weights gives thus the relative importance of each of the dimensions, objectives and criteria. Assigning a bigger weight to one dimension represents a larger relative importance towards the others. The assignment of weights involves prioritizing one aspect over the other. Therefore, it constitutes a political decision.

When using the MCA methodology for supporting the choice of a set of waterways to be developed, it is suggested that the weights consider the preferences of all stakeholders involved, although the government is the sole responsible for the final assignment. In order to allocate the weights, a workshop with the Ministry was conducted in order to systematize the decision making process so as not to make it a "black box".

When the several waterway sets are presented and all the dimensions and objectives are listed and explained, homogeneity between the positive and negative features of each of them arise, making tradeoffs emerge naturally.

7.2 RESULTS OF THE MULTI-CRITERIA ANALYSIS

7.2.1 Introduction

The following section presents the results of MCA with the comparison of the strategies. It ranks them in the hierarchically structured definition for the four dimensions considered: economic, environmental and social sustainability and institutional cohesion.

Firstly, it contextualizes the role of the MCA in the process of selecting the preferred strategy. Secondly, the MCA results are shown and briefly described. Thirdly, conclusions are drawn from the analysis, whereas sensitivity analysis are listed on Annex E.

Since the MCA method can also be viewed as the construction on an aggregated index for the different alternatives, the weight allocation yields the relative structure by which the index is calculated. Given the assumptions and methods behind each of the criteria, explained in the methodology section, the workshop with the Ministry of Transport assigned the following weights over the dimensions, objectives and criteria.

Table 7.2.1 - MCA Weighting

Dimensions		Objectives		Criteria	
Description	Weight	Description	Weight	Description	Weight
Economic Sustainability	0.40	Maximize Internal Water Transport Goal	0.20	Contribution Towards the 110 MTPA by 2031 Goal	1.00
		Maximize Cost-Effectiveness	0.80	Investment + Maintenance (R$ of NPV / ton)	0.50
				Waterway Transport Cost Savings (R$ of NPV / ton)	0.50
Institutional Cohesion	0.20	Maximize Stakeholder Support	0.30	Influence x Value x Number of Stakeholders	1.00
		Minimize Potential Conflicts	0.70	Number of Existing Physical Limitations (dams and bridges)	0.50
				Number of Dams Planned	0.50
Environmental Sustainability	0.20	Maximize Environmental Efficiency	0.50	Reduction in CO2 Emissions (multimodal, TTPA in 2031)	0.50
				Reduction in NOx Emissions (multimodal, TTPA in 2031)	0.50
		Minimize Environmental Vulnerabilities	0.50	Average Conservation Areas Crossed by 100 km	0.30
				Average Priority Areas for Conservation Crossed by 100 km	0.20
				Average Speleology Areas Crossed by 100 km	0.20
				Average Dredging Needed by 100 km	0.30
Social Sustainability	0.20	Maximize Potential for Social Development	0.40	Number of Urban Areas Crossed	1.00
		Minimize Social Vulnerabilities	0.60	Average Sensitive Social Areas Crossed by 100 km	0.60
				Safety Concerns (km by road / ton)	0.40

7.2.2 Effects Table

The Table 7.2.2 below presents the shows the data obtained and processed from the following databases: Diagnose Report; Stakeholder Consultation; Cost-Benefit Analysis; and Investment Necessary to render the waterways navigable.

An overall glance at the effects table shows that there is a great balance of scores for each strategy. Each strategy has very strong scores for some criteria combined with smaller scores for others. No specific strategy stands out as a clear favorite over another, and that is inherently why the MCA methodology was chosen - in order to deal with a complex situation in which many aspects need to be considered. Under such situation, the defining factor for ranking of the strategies is the weight assessment, which conveys the preferences over the dimensions and objectives considered.

Table 7.2.2 - MCA Effects Table

Dimension	Objectives	Criteria	Maintenance+	Expansion		Top Quality	Workshop 1	Workshop 2	Workshop 3	Workshop 4	Workshop 5
			1	2a	2b	3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Economic Sustainability	Maximize Internal Water Transport Goal	Contribution Towards the 110 MTPA by 2031 Goal	9%	54%	27%	71%	68%	18%	34%	43%	37%
	Maximize Cost-Effectiveness	Investment + Maintenance (R$ of NPV / ton)	331	531	404	578	479	501	424	384	382
		Waterway Transport Cost Savings (R$ of NPV / ton)	73	402	399	538	448	354	377	392	412
Institutional Cohesion	Maximize Stakeholder Support	Influence x Value x Number of Stakeholders	33	51	38	56	56	36	42	45	41
	Minimize Potential Conflicts	Number of Existing Physical Limitations (dams and bridges)	8	19	9	20	20	9	9	9	9
		Number of Dams Planned	1	23	6	26	26	4	12	14	11
Environmental Sustainability	Maximize Environmental Efficiency	Reduction in CO2 Emissions (multimodal, TTPA in 2031)	173	676	379	792	846	385	308	313	307
		Reduction in NOx Emissions (multimodal, TTPA in 2031)	11	83	41	83	85	27	30	44	41
	Minimize Environmental Vulnerabilities	Average Conservation Areas Crossed by 100 km	2.03	2.53	2.04	2.43	2.43	1.87	2.19	2.29	2.29
		Average Priority Areas for Conservation Crossed by 100 km	10.88	10.69	10.56	10.25	10.25	11.09	11.05	10.61	10.15
		Average Speleology Areas Crossed by 100 km	0.87	1.47	2.09	1.70	1.70	1.21	1.33	2.07	1.99
		Average Dredging Needed by 100 km	11.16	22.40	17.65	23.74	23.74	13.16	17.54	20.75	19.60
Social Sustainability	Maximize Potential for Social Development	Number of Urban Areas Crossed	111	199	144	217	217	126	140	158	148
	Minimize Social Vulnerabilities	Average Sensitive Social Areas Crossed by 100 km	4.16	5.54	4.26	5.30	5.30	4.35	5.56	5.31	4.91
		Safety Concerns (km by road / ton)	153	82	111	76	79	125	106	101	100

The very first criterion under the economic dimension portrays the contribution of each strategy towards the goal of having 110 MTPA by 2031 transported via waterways. By showing this contribution as a percentage, it allows for a quick glance over which strategy carries more cargo and, indirectly, which has the greatest amount of navigable waterways. The order of the strategies in terms of the expansion of internal waterway transport is: 1st - Top Quality; 2nd -

Alt. 4; 3rd - Expand 2a; 4th - Alt. 7; 5th - Alt. 8; 6th - Alt. 6; 7th - Expand 2b; 8 th - Alt. 5; and lastly 9th - Maintenance+.

In line with the conclusion of the Cost-Benefit Analysis, some of the strategies do not accrue enough benefits to overcome the required investment and maintenance costs and produce net benefits. Assessing the cost-effectiveness of waterways on the basis of its capacity to tender for large-scale agricultural production of corn and soy that is exported is clearly a reduction of reality, for it does not consider other commodities such as iron ore and pulp that could also benefit from waterways over time.

The cost-benefit output shows the three cheapest ways to haul agricultural commodities from their production areas to ports, already accounting for the expected growth of this produce over the years until 2045. For that it utilized a set of data (agricultural commodities, rail and road availability) and assumptions (the route from the productive region to a port, discount rate, logit parameter etc.), showing the share of goods that each of the three best routes is allotted - mounting to the total transport costs[13].

Nonetheless, the fact that some strategies yield positive returns only with the transport costs savings for agricultural commodities is already a strong indicator that there is much to gain from internal waterway development. The strategy that yields the highest positive return is by far Alt. 8. It requires an investment in physical measures to render the waterway sections navigable plus its maintenance over the years of R$ 382 per ton on a NPV (net present value) basis. These costs are offset by the R$ 412 per ton (also NPV) savings in transport costs by using the waterway instead of the current transportation mode. This means that Alt. 8 has a net positive benefit of R$ 30 per ton in NPV.

The second highest ranking strategy in terms of cost-effectivenes is Alt. 7, which yields a net benefit of R$ 8 per ton in NPV. The remaining strategies yield negative returns, but it is noteworthy that, as explained in Chapter 6 (cost benefit analysis) this Plan chose to present conservative numbers for the growth of cargo volume in the waterways, considering only large volumes of commodities that meet the external market. The results would probably be better if the estimation also have considered other types of cargo, such as containers, fertilizer and wood.

Whereas Expansion 2b nearly yields a positive return (with a net loss of R$ 5 per ton in NPV), the fourth highest ranking strategy is Alt. 4 with a net loss of R$ 30 per ton in NPV.

The Top Quality strategy and Alt. 6 have similar net losses of, respectively, R$ 41 and R$ 47 per ton in NPV[14]. Although Top Quality requires high-capital investments due to double locks and

[13] Since these possible routes are multi-modal, meaning they consider waterway options against - and combined with - rail and road routes, the CBA output indicates the competitiveness of the waterways against these other modes of transport.

[14] As explained in the MCA methodology chapter, the net present value was calculated with a discount rate of 6.25%, the same as for the cost-benefit analysis. It is important to compare NPV figures on the MCA in order to consider the timing embedded in each strategy, just as well as to have a figure that conveys the possible net benefit in current monetary terms. Moreover, these figures do not account for investments and maintenance costs for the river sections that do not accrue benefit in terms of the agricultural commodities modeled.

extra dredging to ensure reliability, the higher capacity of cargo flows yield a per/ton figure of R$ 578. Although undoubtedly desirable, these costs are not matched by the benefits of transport cost reduction of R$ 538 per ton in NPV.

Both of the above mentioned strategies are much better in economic terms than Expansion 2a and Alt. 5, which yield net losses of, respectively, R$ 129 and R$ 147 per ton in NPV. It is interesting to note that both of these strategies develop very little over what is already navigable and still have economic losses. This means that, since the criterion is on a per/ton basis, there is much to gain from a certain level of development for the waterways.

Although it yields a loss in the cost-effetivenes criteria, the Top Quality strategy can transport all agricultural commodities considered from farm to seaport and thus contribute in 71% towards the goal of transporting 110 MTPA by 2031 via waterways. Alt. 8 is the most cost-effective, but on the other hand contributes with a more modest 37% to this goal. Strategy Alt. 7, also cost-effective but at a much lower level, develops one more waterway-system than Alt. 8 and contributes with 43% to the goal.

On the institutional cohesion dimension, the strategies that develop the greater amount of waterway systems gathers the strongest support from stakeholders once, basically, everyone will be benefited. The opposite is true for the objective of minimizing potential conflict, once the strategies that develop the lesser amount of waterways turn out to be comparatively better for they embed a smaller number of interactions with third parties.

In developing either Top Quality or Alt. 4, much stakeholder support will be gathered because all waterways are involved. On the other hand, there are 20 existing physical limitations to surpass and each of them would require negotiations with affected parties that would need to be successful in order to implement the strategy. On the same token, there are 26 planned dams that would need to consider waterway navigation, meaning the necessity for a very efficient coordination with the energy sector. Maintenance+ is the only strategy with one single dam planned on its path.

It is interesting to compare strategies Expand 2a and Alt. 7 in the institutional dimension, for they both increase waterway transport by similar figures but develop different waterway systems in order to achieve that. Whereas Expand 2a needs to surpass 19 existing physical limitations (dams and bridges) and negotiate another 23 planned dams in the years to come, Alt. 7 faces 9 existing limitations and 14 dams to surpass.

Under the environmental dimension, the maximization of environmental efficiency confirms the common wisdom that indeed internal waterway transport is a net reducer of pollutant emissions. The strategies that deliver more waterways are thus better off at avoiding pollution because they save emissions from otherwise more polluting options, namely road transport. It is interesting to note that some waterway sections, however, yield a negative reduction in CO_2 emissions (i.e they need extra road haulage in order to reach waterway terminals, thus increase pollution). This is particularly the case for the Madeira River, although its net emissions are highly compensated by the savings on all the other waterways. As becomes clear from the Effects Table, all strategies are considerable net pollutant savers.

As for the relative criteria that measure the objective of minimizing environmental vulnerabilities, it becomes interesting to see the performance of Top Quality and Alt. 4. These two strategies that develop all waterways, on average cross less vulnerable areas (conservation areas, priority areas for conservation and speleology areas) than strategies that develop a smaller amount of waterway systems. This happens because the addition of one or another waterway section under the other strategies, compared to their size, crosses more sensitive areas. Expand 2a, for instance, develops the Araguaia up to Aruaña, thus crossing the Bananal Island which is the largest fluvial island in the world, a Ramsar and Biosphere Reserve site.

The criteria for the crossing of priority conservation areas present a surprisingly small variability between strategies, meaning that most of them, on average, cross 10 such areas per 100 km. The strategy that crosses the most does so 11.09 times per 100 km (Alt. 5) and the one that crosses the least does so 10.15 times (Alt. 8). There are two particular waterway sections (from Marabá to Miracema, on the Tocantins River and from Ibotirama to Pirapora, on the São Francisco River) that cross 30 and 70 speleology areas, respectively. Therefore, the strategies Expand 2b and Alt. 7, which have both of these sections developed, are comparably worst under this criterion.

The social dimension reveals that the potential for social development increases as more waterway sections are developed. It follows the rationale that the more urban areas a strategy crosses, the more it opens possible access to market, being either regional centers of distribution or international markets for high value-added goods. The long range and long term planning of waterway connections can foster regional economic development and passenger transport, mirroring the importance of this sector in the Amazon region where smaller boats navigate waterways and other channels and smaller waterways. Therefore, Top Quality and Alt. 4 score the highest in this criterion.

On the other hand, the objective of minimizing potential conflict shows a different picture. Since the strategies that develop the most waterways are also the ones that increase waterway navigability the most, on average they are comparatively better than some strategies that develop some sections with many socially vulnerable areas crossed. That is especially the case of Alt. 6, which includes the Tapajós and Teles Pires Rivers and the section from Marabá to Conceição on the Araguaia River. These two sections cross 131 and 65 socially vulnerable areas, respectively. On the other hand, however, Alt. 6 is a strategy that has an average safety concern once it requires a 106 km per ton by road transport and not 153 as Maintenance+, the highest safety-concern strategy.

7.3 MCA RANKING

The MCA results are presented in the graph below, where the ranking of all strategies is performed under the weighting set at the mentioned workshop. It is important to note that the MCA methodology does not select the promising PHE strategy, but rather provides the elements and analytics necessary in order to support the decision over which strategy to choose.

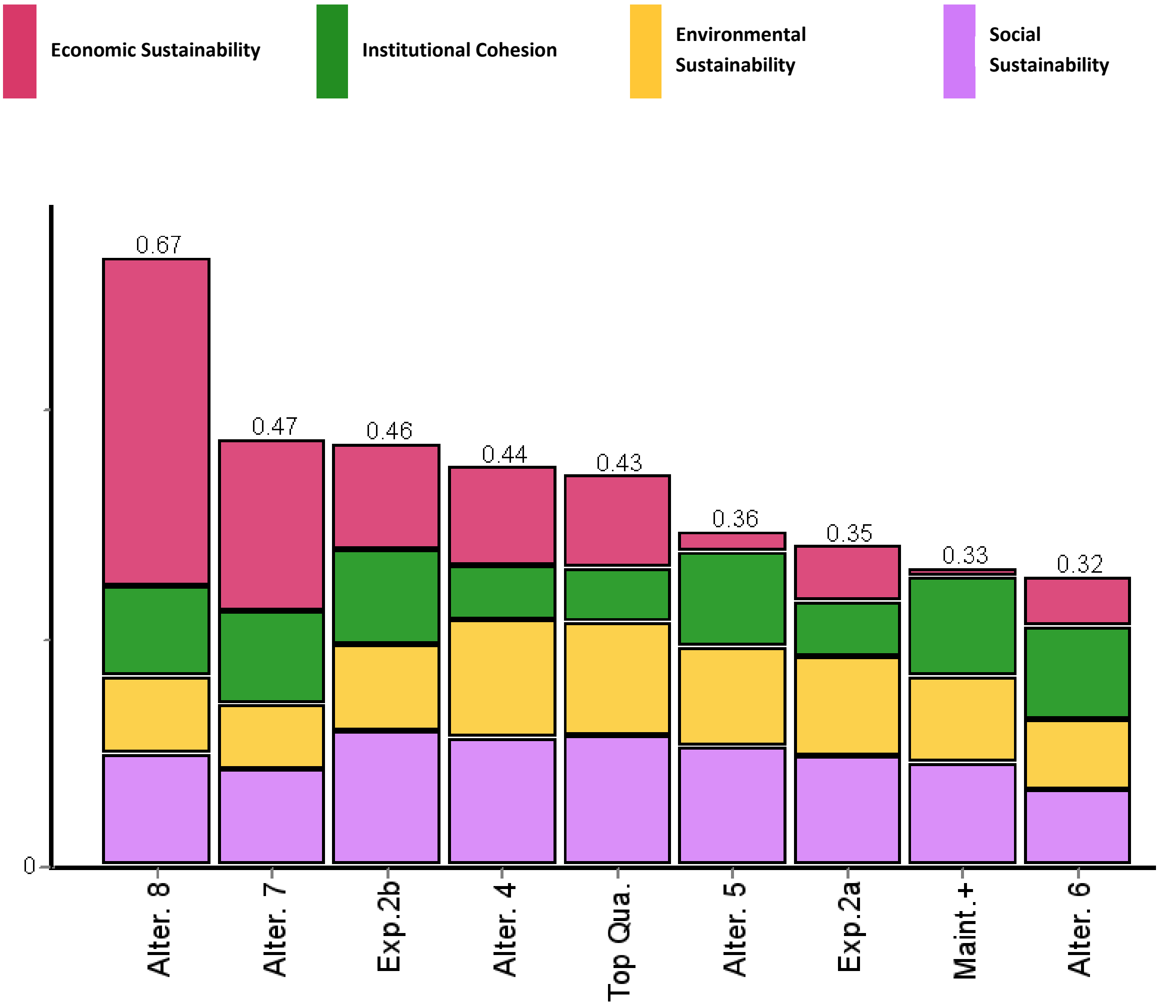


Figure 7.3.1 - MCA Results

The highest-ranking strategy is Alt. 8, especially for its well-performing score under the economic dimension. Moreover, it is also a high-scoring strategy under the institutional dimension, but not the highest. Under the environmental and social sustainability dimensions the strategy also scores well, but never the highest. Overall, it ranked first because it provides a clear balance between the dimensions involved in the decision-making process.

The second highest-ranking strategy is Alt. 7, which builds upon the same sections as Alt. 8 with the addition of the section from Marabá to Conceição on the Araguaia waterway. This strategy is faced with relatively more difficulties under the environmental and social dimensions than the previous one, presenting the lowest and second-lowest scores, respectively. Under the institutional and economic dimensions, however, Alt. 7 presents an interesting combination of high-ranks that leads it to be the overall second-highest.

The third highest-ranking strategy is Expand 2b, which is the building strategy for Alt. 8 since it develops all sections from Alt. 8 but the one on the Tapajós - Teles Pires from Itaituba to Cachoeira Rasteira. Although the strategy brings a negative net economic value (albeit a small one of - R$ 5 per ton of NPV), strategy Expand 2b has by far the highest score for social sustainability and also a good one for the environment dimension. Institutionally, it is one of the highest-ranking strategies.

Not coincidently, the top three strategies are the ones with the most solid economic results, good institutional results and a good balance between environmental and social results. It is interesting to note that the high score of Alt. 7 for the economic dimension is nearly offset by the greater balance of the environmental and social dimensions of the two strategies that develop all waterways (Top Quality and Alt. 4). These two are high-scoring strategies under the environmental and social dimensions, but not so in the economic and institutional ones. Therefore, small changes to the scores should produce some shuffling of the results for third position.

Expansion 2a, which develops all waterways with the exception of some sections of the Tocantins (Marabá to Miracema), the São Francisco (Ibotirama to Pirapora) and the Paraguay (Corumbá/Ladário to Cáceres), scores very similarly to Alt. 5. In fact, it is a strategy with a good score for the environmental dimension and a modest score for the social dimension. Its institutional score, however, is the lowest, just as its economic score is one of the lowest. The combination renders the strategy as one of the least preferable.

Maintenance+ stands out as the second lowest-ranking strategy, besides having the highest-score for the institutional dimension. This apparent discrepancy occurs because this is the strategy that does the smallest development possible besides the overdue maintenance on the already navigable waterway sections. Exactly due to this reason, it is the easiest of the strategies under the institutional cohesion once it does not deviate stakeholder support from the groups that already support IWT and requires the smallest interactions with third parties.

Strategy Alt. 6 presents the lowest score of all nine strategies once it only scores well under the institutional dimension but not for the other three dimensions. It is in fact the lowest-scoring strategy under the social dimension. Its economic score is slightly better than Alt. 5 and Maintenance+ but still results in negative net benefits.

The graph below portrays the rankings per dimension exclusively, where the differences emerge with ease over the best strategies for each of the considered domains of the decision-making process.

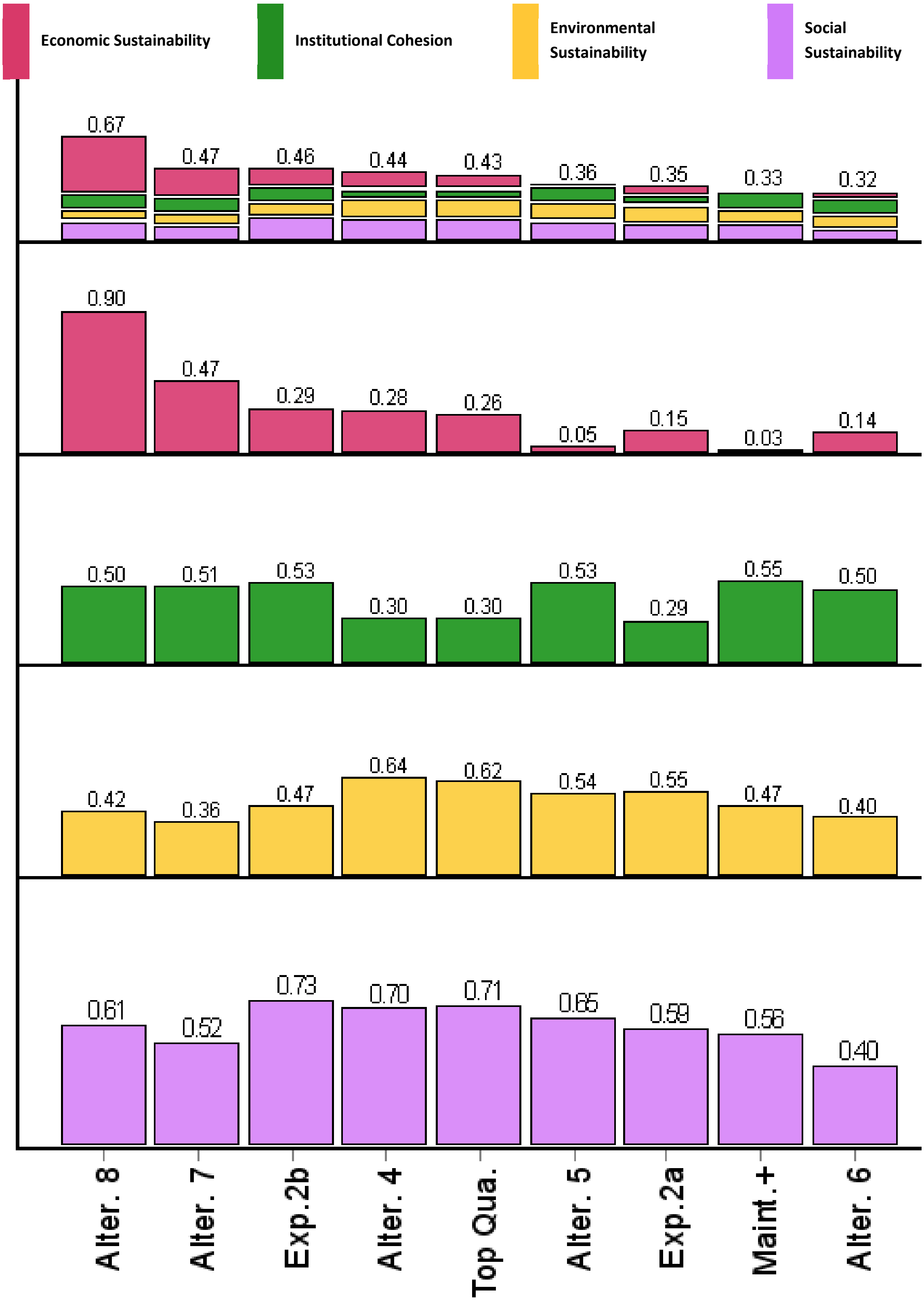


Figure 7.3.2 - MCA Results for Each Dimension

If the economic dimension were exclusively considered, the ranking order would be the same for the top five strategies. Only Expand 2a and Alt. 6 would change positions and become better ranked than Alt. 5 and Maintenance+, which would be respectively second-to-last and last.

Should the institutional dimension be the only one considered, the ranking order would change with Maintenance+ becoming the highest-ranking strategy. Besides this significant inversion of ranking positions, from second-to-last to first, Expand 2b would still rank second, besides Alt. 5. Alt. 7 would become 4th and Alt. 8 would be tied in fifth with Alt. 6. The institutional cohesion ranking perfectly reflects the sequence of waterway developments across the strategies, as each strategy sequences the other in adding one or more section development at a time:

- From Maintenance+, Alt. 5 adds the section from Marabá to Miracema on the Tocantins;
- Expand 2b adds to Alt. 5 the sections from Ibotirama to Pirapora on the São Francisco and from Corumbá to Cáceres on the Paraguay;
- Alt. 8 adds the Tapajós and Teles Pires (from Itaituba to Cachoeira Rasteira) to Expand 2b;
- Lastly, Alt. 7 adds to Alt. 8 the section from Marabá to Conceição on the Araguaia.

Not surprisingly, the three alternatives that develop the most waterway sections are the least favorable under the institutional dimension, even when one of its objectives is the maximization of stakeholder support. Perhaps the criterion chosen to measure the stakeholder support is biased due to the fact that the interviewees favored the waterways that are already navigable whilst not foreseeing the benefits they could derive from the ones yet to be developed. Due to this chance, a robustness check is performed for this score so as to set it with uncertainty, as presented on the Annex E.

The environmental dimension ranking shows that Top Quality and Alt. 4 are by far the highest-scoring strategies. They are followed by Expand 2a in third, which is the one that develops the most waterways after the top two. The strategy Alt. 5 would rank as 4th and would be followed by Maintenance+ and Expand 2b as 5th and 6th. This shuffling of the ranking suggests that the most extensive waterway developments benefit the environment more than a smaller selection of waterways. This holds true mainly due to the emission reductions of CO2 and NOX, which are multi-modal criteria. The highest-ranking strategy, Alt. 8, would fall to third-to-last. This implies that the optimal selection of strategies under the allocated weights will miss out on some of the possible environmental benefits that IWT can provide.

Ranking the nine strategies under the exclusive realm of social sustainability yields yet another re-shuffling of the strategies, with Expand 2b as the highest-ranking, followed by Top Quality and Alt. 4 in 2nd and 3rd. Alt. 5 would be the 4th highest, followed by Alt. 8 in 5th. The ranking reflects the two objectives that capture the dimension, namely the potential for social development and the minimization of vulnerabilities. The strategies that develop the most waterways are quite clearly crossing more urban areas and, concomitantly, are diluting the effects of crossing social vulnerable areas.

The weighting structure utilized reveals that there is a preference for the economic dimension over the other three dimensions. The rationale is that, although all dimensions need to be addressed, the economic effectiveness is a trigger without which no development occurs.

The weighting set has a 40% preference for the economic dimension over the remaining three, which equally share the other 60%. The graph below portrays four different perspectives to ponder over the influence of each of the main dimensions by scoring them with a 50% preference over the remaining three, which in turn equally share the other 50% (16.67% each).

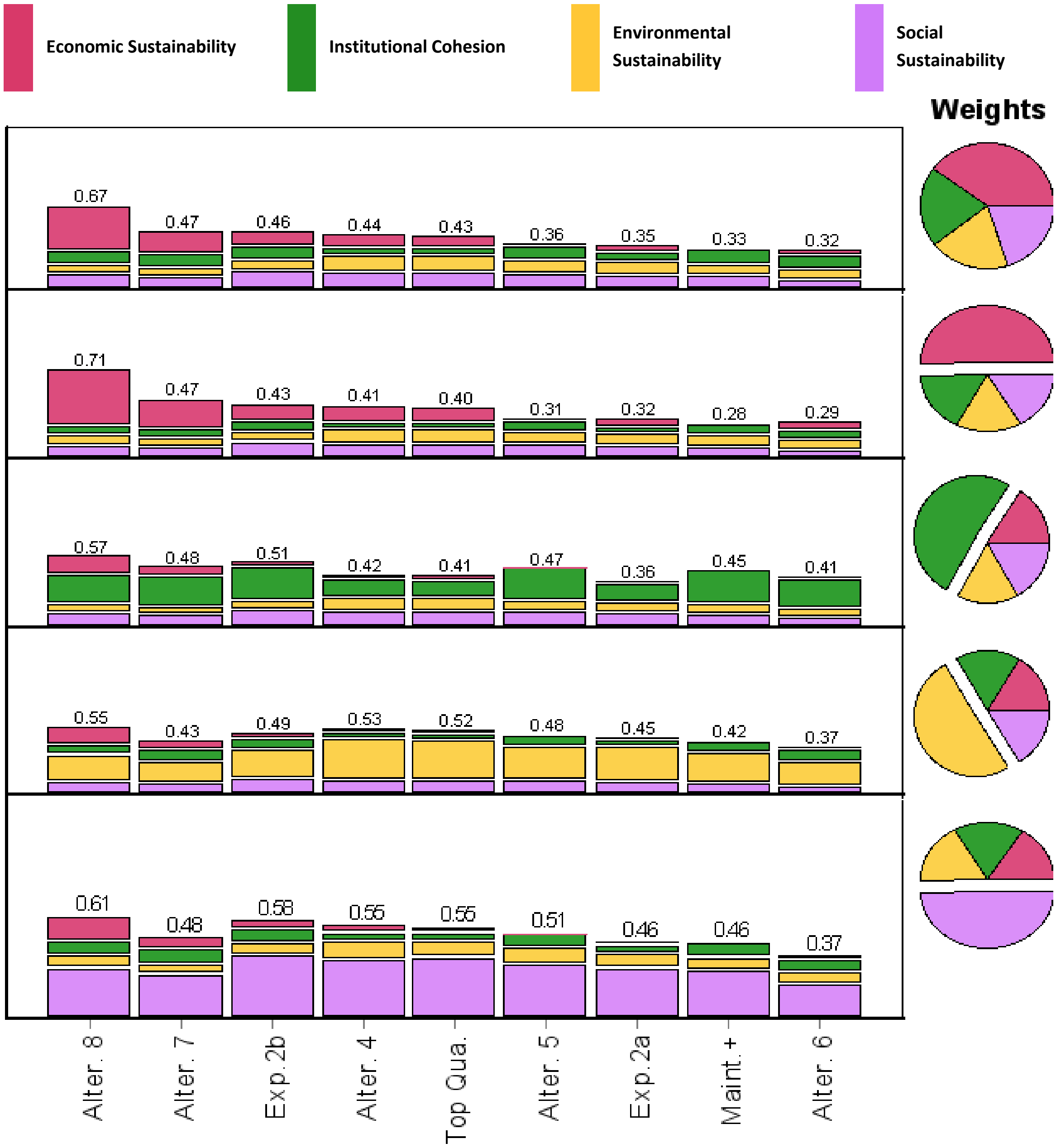


Figure 7.3.3 - MCA Results under Different Weight Perspectives

Quite clearly, assigning the economic dimension not with 40% of the preference, but rather with 50%, only enhances the differences between the strategies without changing the rankings. All the top five strategies would remain the same.

Should the institutional dimension receive 50% of the preference, the top three strategies would not change. It is interesting to note that Maintenance+ would surpass Alt. 4 and Top Quality.

If the highest preference were assigned for the environmental dimension, the highest-ranking strategy would still be Alt. 8. The second and third ordered strategies, however, would change from Alt. 7 and Expand 2b to Top Quality and Alt. 4, respectively.

Lastly, should the social dimension receive the highest share of the weight (50%), again Alt. 8 would be the highest-ranking strategy, followed by Expand 2b in second. Alt. 7 would lose its second place for Alt. 4, Top Quality and also Alt. 5.

7.4 CONCLUSIONS OF THE MULTI-CRITERIA ANALASIS

The analysis of the criteria that compare waterways to other multi-modal transport options assure the benefits of IWT. All strategies represent annual savings in transportation costs of agricultural products (see results of the strategies in Annex D). The various combinations of waterway systems and sections always result in a net reduction of pollutant emissions from CO2 and NOx. On the social dimension, IWT potentially generates regional development and reduces safety concerns when compared to other modal transport combinations.

Additionally, the perspective of shifting the weighting structure in favor of one dimension over the others shows that, consistently, strategies with many waterway developments are higher ranked than Maintenance+. The Top Quality strategy turns out to be a consistent high-ranked strategy when the economic aspect is not assigned with the heaviest of the weights. Actually, when more weight is given to the environmental and social dimensions, the more the "do all waterways" strategies stand out (Alt. 4 and Top Quality). On the opposite line, the more the weight is shifted towards the economic perspective, the more Alt. 8, Alt. 7 and Expand 2b stand out.

Independently of the weighting preference, consistently Alt. 8 outranks the others. As the sensitivity analysis performed also corroborates (see Annex E), it can be concluded that Alt. 8 is indeed a strong strategy for the development of the internal waterway transport system in Brazil under the time horizon of 2031.

It must be noted that the current MCA exercise did not account for a "learning curve" as it compared strategies that did not arrive at the same levels of development. Recapitulating, the objective was to portray waterway development potential without having a restricting factor, such as a budget constrain or even a non-negotiable goal for an amount of tonnage to be transported. Rather, the MCA was built on the most diverse set of strategies possible in order to illustrate all development possibilities and highlight, under a hierarchical structure, the many tradeoffs involved.

8 STRATEGY TO IMPROVE AND EXPAND THE NAVIGABLE INLAND WATERWAY NETWORK

The ranking and conclusions of the Multi-Criteria analysis provided sufficient grounds to select thepreferred strategy. Its contribution to achieving the objective will be evaluated in the next step of the process (see Figure 8.1). This chapter describes the selection process and the preferred strategy.

Figure 8.1 – Process Step – Select and Define Preferred Strategy

8.1 SELECTION OF PREFERRED STRATEGY

8.1.1 Selection Process

The selection of the preferred strategy by MT was done in three steps:

1. The preliminary results for the Baseline, Maintenance+, Expand A and B and Top Quality were presented and discussed. This preliminary ranking showed three equaly high scoring strategies. With the 'best' building blocks of these strategies the technical teams of the MT and ARCADIS combined routes and measures to develop additional alternatives (the Workshop Strategies).

2. The technical team of ARCADIS processed the Workshop Strategies and fine-tuned the all the strategies in the CBA and the MCA (optimalisation). The results were discussed. The MT selected a preliminary preferred strategy.

3. During a final meeting with MT final improvements were made to the preliminary preferred strategy to form a new Workshop Strategy. Again the CBA and MCA were

run and updated. This preferred strategy was approved for further elaboration in the Masterplan.

8.1.2 Performance Considerations of Preferred Strategy

The results from the MCA show that IWT is an overall solid and must-do to increase transport systems in Brazil. This conclusion arises from two complementary facts: the one strategy that stands out on the upper side is Alt. 8, which contains an increment of waterways to the already navigable ones. On the other hand, Maintenance+ scores lower than any other combination of waterways besides Alt. 6. This combination of results shows that there is much to gain from the development of waterways in some particular combinations.

The consistent high-ranking of Alt. 8 shows that it is the strategy that best combines the developments of waterways. That can be said, because the alternatives Maintenance+, Alt. 5, Expand 2b, Alt. 8 and Alt. 7, respectively, are perfect sequences of the addition of waterway sections. It is worth adding that Maintenance+ and Alt. 5 rank are lower than the others doesn´t mean that they don't aggregate enough benefits from the waterways. Expand 2b, Alt. 8 and Alt. 7 add more waterways, but Alt. 8 is the combination that extracts the best possible results out of the many waterway-sections that could be combined.

The first and foremost difficulty is proving its worth by cutting transport costs above its implementation and maintenance costs. The economic trigger can set the momentum for further development, and the highest-ranking strategy, Alt. 8, does "pull the trigger".

Alt. 8 should have a capacity to transport 36.3 MTPA of agricultural commodities by 2031 about 9 thousand km of navigable waterways that span 8 waterway-systems and 20 waterway sections. It also crosses 148 urban areas for which the waterways might become a new lifeline for development.

Given the above reasoning, the conclusion that clearly arises from the hierarchical comparison of the strategies under the multi-criteria methodology is that any of the three top ranking strategies (Alt. 8, Alt. 7 or Expand 2b) are consistent with a choice for the preferred strategy. Alt. 8 is the one that sits in between Expand 2b and Alt. 7 in terms of the waterways to be developed, proving it is the best combination possible. Because it consistently ranks the highest, it is technically recommended as the preferred strategy.

This Strategy (Alt. 8) was confirmed by the MT staff as the development strategy to be presented in the Masterplan/Strategic Plan.

8.2 DESCRIPTION OF PREFERRED STRATEGY

Alternative Development Strategy 8 from the MCA was chosen as the preferred strategy for investments. This strategy was the highest-ranking strategy in the Multi-Criteria Analysis. With the investments in waterways the strategy aims at expanding the waterway network in the best combination from an economic perspective. This alternative strategy is a slight addition to strategy Expansion 2b by adding one extra waterway section - from Itaituba to Cachoeira Rasteira on the Tapajós - Teles Pires River-system. All waterways are developed without Top

Quality (no double locks and no dredging in some parts). This strategy contains the following waterways:

1. Currently used waterways with major cargo flows maintained properly on a basic level of navigability, currently used 2x2, 2x3 or 4x5 barge convoys. Already planned improvements (PAC) executed.

    a. Amazon e Solimões (Santarém - Manaus – Coari) (Santarém – Almeirim) (Almeirim – Santana) (Almeirim - Rio Tocantins)
    b. Madeira (Itacoatiara - Porto Velho)
    c. Tapajós e Teles Pires (Santarém – Itaituba)
    d. Tocantins (Vila do Conde – Marabá)
    e. São Francisco (Petrolina – Ibotirama) (Ibotirama – Pirapora)
    f. Paraguay (Foz rio Apa – Corumbá)
    g. Paraná – Tietê (Três Lagoas - Pereira Barreto) (São Simão –Anhembi)
    h. Hidrovia do Sul (Rio Grande - Estrela)

2. In addition to the waterways already used, basic navigability (2x2 barge convoy size) is guaranteed for a further set of waterways, in a longer timeframe (to be defined in the Masterplan phase):

    a. Tapajós (Itaituba – Cachoeira Rasteira)
    b. Tocantins (Marabá – Miracema)
    c. Paraguay (Corumbá – Cáceres)
    d. São Francisco (Ibotirama – Bom Jesus da Lapa)

In the short term, the opening of a new waterway system (the Tapajós and Teles Pires) will be combined with the extension of the Tocantins to Miracema, the extension of the São Francisco to Pirapora and the extension of the Paraguay to Cáceres. Therefore, there is an optimal combination of new developments and extensions that will contribute to making IWT a key player in the national transport matrix.

In general the transport flows related to investments tend to be large. The risk is that investment decisions could be postponed or lead to other locations. In this respect it is very important to have a reliable investment planning for waterways tuned with company investment plans. Note that once the system is functioning, the competition from other modes or transport chains will be limited, because the high investments in plants and systems make changing costly. This too makes coordination of investments in waterways from the government and from the private sector in plants a necessity.

CONVENÇÕES CARTOGRÁFICAS

- Capital Estadual
- Limite político adm.
- Hidrovia
- Massa d'água
- Seaport
- IWT terminal
- Rivers Preferred strategy

REFERÊNCIAS

Fontes:
- Base Cartografica Integrada do Brasil ao Milionéssimo - IBGE, 2010
- ANA, 2010
- PNTL, 2010

ESCALA GRÁFICA
0 120 240 480 km
SISTEMA DE COORDENADAS GEOGRÁFICAS, DATUM HORIZONTAL: SAD69

LOCALIZAÇÃO DA FOLHA

MINISTÉRIO DOS TRANSPORTES

ARCADIS logos

PLANO HIDROVIÁRIO ESTRATÉGICO - PHE

IWT RIVERS PREFERRED STRATEGY

EXECUTADO POR:	ESCALA:	FOLHA:	DATA:
ARCADIS logos	1:17.000.000	- BRASIL -	2013

In Table 8.2.1 a summary is presented of the transport flows per inland waterway and type of cargo. A more detailed view of the composition of these flows has been discussed in chapter 10.

Table 8.2.1 - Overview of Commodities per Inland Waterway in Preferred Strategy (in tons * 1.000 tons)

Transport flow	Growth of existing flows without modal competition	Additional flows from investments in plants and logistic systems	Additional flows (mainly agricultural) with heavy modal competition	Total
Amazon[15]	11.466			11.466
Madeira	2.177		2.547	4.724
Tapajós			9.694	9.694
Tocantins		32.517	8.559	41.076
Sao Francisco	61		2.598	2.659
Paraná – Tietê[16]		15.988	4.824	20.812
Hidrovia do Sul	3.885	2.969	2.513	9.367
Paraguay River	14.883		5.519	20.402
Total	**32.472**	**51.474**	**36.254**	**120.200**

[15] On the Amazon River some short distance (1 km) transport exists of oil products within the port of Manaus. This is left out of the calculation

[16] Short distance transports of Sand on the Tietê River and agricultural commodities on the Paraná are left out of the calculations.

9 STRATEGY TO IMPROVE THE RELIABILITY OF THE TRANSPORT SYSTEM

9.1 INTRODUCTION

A complementary strategy is presented in order to achieve more reliability to the transport system and, consequently, enable the main goal to be reached.

To increase the quality and reliability of the transport system the following demands must be met (see section 3.2.2):

A. The transport chain for both cargo and passengers must have sufficient capacity and all the elements of the transport system must be reliable and of high quality. In addition, passenger transport must be safe and comfortable. Encouraging IWT should ideally be done using the latest technology, research and innovations of the shipbuilding industry.

B. The institutional framework must be improved in order to ensure the required support to the necessary civil works and to ensure the system operation; the incentives efficiency, as well as encourage environmental sustainability and integration of the system.

These two aspects add up and are complementary to one another but they need to be different approaches as the first one (A) has a more direct relation to the preferred strategy selected on the previous chapter and provides a qualitative and quantitative result. The second aspect (B) carries the challenge to sustain the inland waterway transport mode growth by providing a supportive institutional framework.As the implementation of measures is always highly dependent on political support, the expert team presents a set of recommendations for the Ministry to decide upon and suggests a method to implement them.

9.2 IMPROVEMENT OF THE TRANSPORT CHAIN AND STRATEGY TO MEET FUTURE CARGO POTENTIAL

Road, and to a lesser extent, rail transport can either compete with or be complementary to the inland waterway transport (IWT) for the commodities under consideration. The basic advantage of IWT is the low cost per ton.km as well as the fact that the basic river infrastructure is in many situations already available. The problem is that this basic river infrastructure does not guarantee navigation up to the required standards.

To determine how to improve the transport system, several elements of this system are covered, which elements are the basis for an efficient and effective transport system.

The selected strategy for waterway development defines the rivers that are presently being navigated and will have their conditions upgraded as well as the rivers that in the future will be navigable for cargo transport purposes. Integration is the key success factor in logistic improvement. The simultaneous development of the transport system elements (equipment as well as infrastructure) will have to be a coordinated effort to prevent under- or over-capacity in the chain. This coordination will result in an effective and efficient transport system.

9.2.1 Connectivity for pre and end haulage

Connectivity for pre and end haulage is the road or rail connectivity from production areas to ports and inland terminals. A terminal needs a good accessibility by water. But the terminal itself is not always the destination (for import) or origin (for export) of cargo flows. As for export, the production area is mostly more landwards. In order to get the cargo at the right time at the terminal, good connectivity with its catchment area is needed to optimize logistics and so minimize transport costs. For the day to day operation these inland connections need a certain basic maintenance level on which operators can depend on. For their long term investments, like new inland terminals and plants, companies depend on future investments that improve inland connectivity by upgrading existing (rail)roads or building new (rail)roads.

Connectivity between production areas and inland ports will have to be guaranteed. Within the framework of this project upgrading of present road connections will not be considered. New roads to new ports will be indicated in the Masterplan.

9.2.2 Ports and Inland Terminals

In order to transport cargo through inland waterways, ports and inland terminals are needed, located as close to the production areas as possible to minimize costs of pre and end haulage and consequently the overall chain transport cost. In their day to day operation the capacity of ports and terminals needs to be sufficient to handle all the cargo. As stated in the diagnosis report, companies identified business opportunities in the inland waterway market as they foresee that overall capacity will not be sufficient and expansion might be needed. Expansion of current ports and terminals is needed, as well as expansion with new ports and terminals closer to production areas. Besides that, the capacity at seaports is important as the companies select their transport routes. For example, partly due to efficiency problems in the port of Santos, companies tend to shift to northern ports. As a consequence, different routes will be considered which can make use of inland waterway transportation as well other modalities. The expansion of the sea terminals is considered to be beyond the scope of this project.

To keep up with the development of the waterways new terminals will have to be constructed along the upgraded and newly developed waterways. The proposal location of the new terminals has been presented in a more detailed way in Annex F, where is also presented the result of an analysis to identify environmental conditions that may possibly be restrictive to the implementation of new terminals, as well as the expansion of existing ones. It is proposed two new terminals (Cachoeira Rasteira and Miracema do Tocantins), being Cachoeira Rasteira terminal not included in the Study “Macrolocalização de Terminais Hidroviários no Brasil (2013)”, of ANTAQ, which defined priority areas for public port facilities and/or terminal in the horizons of 2015 and 2020.

The amount and required capacity of these new terminals will be determined during the Master Plan phase of the project. The terminals will have to be equipped with state-of-the-art loading and unloading equipment as well as storage facilities to meet the capacity demand of the increased cargo volumes and the environmental requirements for cargo handling activities.

To achieve a rapid increase in terminal numbers and capacity, clearer procedures for the procurement of licenses for terminal construction and operation will have to be discussed.

9.2.3 Fleet

To achieve the main goal of 110 million tons of inland water transport in 2031 sufficient vessels and barges are needed. In general the convoy size varies between 2-by-2 barges and 4-by-5 barges. Since every river has its own characteristics (for example depth, lock sizes), convoys need to be adjusted. On the short term, companies need to rely on the ability of the industry to assure a certain maintenance level of the fleet and the substitution of outdated vessels and barges. The current fleet needs to be enlarged to be able to transport 110 million tons of cargo in 2031. In addition to this enlargement the replacement of the present fleet plays a role in the required new-building capacity of barges and push-boats.

This will require an increase in the number and efficiency of the fleet. Sufficient barges and push-boats will have to be constructed to meet the new demands as well as the demands for replacement of the outdated fleet. The required amount of barges and push-boats will be determined during the Master Plan phase of the project.

Efficiency will be increased by introducing innovations in the following fields:

- Vessel design to develop new markets or to enhance safety. Shallow draft barges and push-boats for restricted water-depth situations, double hull tank vessels for dangerous cargos etc.

- Improvement of environmental performance. The environmental performance of truck transport is rapidly increasing. To stay ahead in sustainable transport terms the IWT sector should invest in e.g. emission reduction and energy savings.

Efficiency can be increased by providing more real-time information on the river conditions. A forecast of the minimal depth during a trip will allow the barge operators to optimally load their vessels and in doing so increase the capacity.

9.2.4 Crew

Since Brazilian waterways are capricious, qualified personnel are needed to navigate these rivers. At first teaching professional shipping needs a modernized education system to go along with new innovations in the ship building industry. Second, sufficient personnel need to be educated to navigate the increasing fleet. And third, this personnel needs to be educated accordingly for navigating the right rivers (since every river has its own specific characteristics) and deployed at the right rivers basins.

Manning and staffing problems may also occur at the terminals, both inland and in sea ports. As well as in the field of logistic service provision. Due attention must be given to sufficient education capacity and recruitment.

The required amount of crew members will be determined during the Master Plan phase of the project.

In view of the highly specialized profession of inland crew members and pilots it is strongly recommended to consider the set-up of a specialized inland navigation education system.

9.3 IMPROVEMENT OF THE INSTITUTIONAL FRAMEWORK

To achieve the main goal the government is a very important player. By structuring a supportive framework for IWT, the government can encourage navigation significantly. The two main fields that need to be better organized can be summarized into:

- Provide an effective waterway management structure
- Implement supportive policies and integrated planning

These fields are highly dependent on political support, so the recommended way to implement this strategy is through the organization of task forces to define upon certain aspects, which are organized under suggested agenda settings, better described below.

9.3.1 Approach

9.3.1.1 Cooperation model

The implementation of the items mentioned in the previous chapters will require changes in public structures and will affect the interests of all parties involved. In view of this fact it is of paramount importance that all parties will be involved in the decision making process about the further development of IWT in Brazil.

The benchmarks for the situation in Europe and the United States showed that successful development of the inland waterways primarily depends on a close cooperation between all parties involved, both public and private, nationally and, where required, internationally.

The conditions required for successful use of the inland waterways can be derived from these benchmarks. In this way the ideal situation for the development of inland waterway transport in Brazil can be sketched. This ideal situation can be characterized as follows:

- Government acts consistently and stimulates the use of inland waterways through financial incentives and legislation;
- Decisions on the improvement of waterways are taken in such a way that the interests of all parties involved are being considered.

The challenge in the development process of the inland waterway transport in Brazil is that the selected strategy will be structured in such a way that the above conditions will be met during the process. The implementation of the Master Plan will be used to improve the integrated government planning, as weel as public-private partnerships, financial incentives and revised legislation.

The resulting cooperation model is based on two pillars:

- A national Task Force IWT Development
- Regional Development Groups

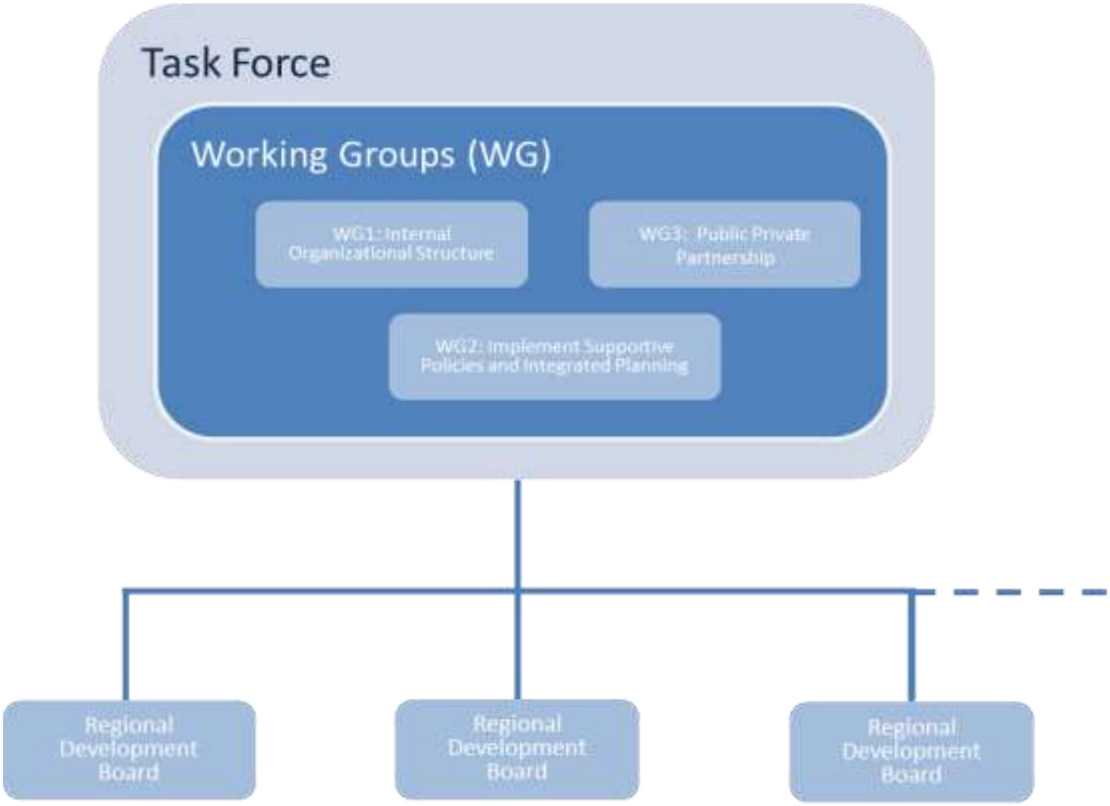


Figure 9.3.1- Cooperation model proposed

9.3.2 Task Force IWT Development

9.3.2.1 Introduction

A Task Force will be established at a national level and it will create the conditions for the implementation of the Strategic Plan as defined by the present plan.

9.3.2.2 Participants

This Task Force will have to represent the relevant stakeholders and as a consequence the following parties and agencies will have to participate:

- CONIT (chaired and represented by the Minister of State for Transport, that have as members the Ministry of "Casa Civil"; Finance; Planning, Budget and Management; Development, Industry, and Trade, Agriculture, Livestock and Supplies; and the Secretary of Port as well as of Civil Aviation, besides some civil society representatives),
- Waterway Administrations,
- SEGES,
- EPL,

- DNIT
- ANTT
- ANTAQ
- Ministry of Energy
- Ministry of Defense (Navy)
- Ministry of Environment
- National Water Agency (ANA)
- Ministry of Foreign Relations
- Cargo owners (trading companies)
- Shipping companies
- Terminal operators

The benefits that each stakeholder can get by participating in the Task Force should be exposed, in order to encourage the effective participation of a large number of stakeholders in the discussions. In addition to coordinated and integrated development of the IWT as greater benefit to all parties, some of the benefits are listed below:

- Balanced public and private investments and, consequently, greater financial efficiency for various stakeholders;
- Reduction in transport costs;
- Growth in the volume of cargo to be transported by waterways;
- Reduction of the necessary investments in infrastructure and optimization of the steps for implementation;
- Reduction of GHG emissions (greenhouse gases) and also, being a natural route, of lower environmental impacts when compared to the impacts created by the construction of roads and railways.

9.3.2.3 Agenda

The Task Force will have the following agenda:

- Approval of Strategic Waterways Plan (Plano Hidroviário Estratégico);
- Approval of the project list;
- Ascertain whether the objectives of the plan are clear to each staff member;
- Selection of waterway systems for various pilot projects;
- Confirmation of the monitoring plan to be adopted;
- Definition of the working groups;
- Plan update.

The approval of the Strategic Plan and Action List / Projects will give the Task Force considerable decision-making power to the development of IWT in Brazil, which proves to be essential to ensure the stakeholder participation in the Task Force.

9.3.2.4 Working Groups

In addition to providing the discussion of the proposed agenda items, the Task Force will be an instrument for achieving the necessary conditions (according to the benchmark) for the successful development of the IWT. This additional agenda will address the following high priority topics:

- Internal organizational structure to support IWT;
- Integrated planning;
- Public-Private Partnerships.

The most effective way to address these items is through the creation of a Working Group for each topic. The Working Groups will be formed by the most important stakeholders to the subject being treated.

The first Working Group will consist of representatives exclusively of the public sector, specifically the institutions that are part of the Ministry of Transport. The second will also only representatives of the public sector, but in many sectors, and the third will involve the private sector. All Working Groups will report to the Task Force.

9.3.2.4.1 WG 1: Internal Organizational Structure to Support IWT

As described on the Assessment and Diagnosis Report (Step C) the current waterway management structure is not effective or efficient. Change of this structure requires political support and its change could be achieved through the approval of the PHE, being incumbent to the Ministry of Transport the definition of a new structure.

Such changes in the structure require the adaptation of the framework in which the waterway management is functioning currently. These changes can vary from options with high impact to ones with less impact: (i) reorganization of the structure itself, (ii) revision of the competence of each institution involved, when needed, (iii) definition of minimum required activities and (iv) definition of indicators. These will only result in the best possible arrangement if provided with political support and assigned with enough budgets to implement the works.

Recommendations of measures and topics to be discussed by the Task Force, which will contribute to the structuring of meetings, were grouped into five main actions, as follows:

A. Balance attention among different modes of transport

B. Improve and clarify the structure organizational of WAs

C. Better arrange the geographic spread of the WAs

D. Establish a standard procedure to be adopted by WAs

E. Develop a rating and information system

The set of relevant measures to each action is presented:

A. Balance attention among different modes of transport

More attention needs to be directed to the THI, and to achieve that, it is recommended a better balance within DNIT structure. It is required a special attention directed to the DAQ, during some years, through, for example, untying the structure of this DNIT department. This change would allow DAQ to have an equivalent position as DNIT department historically geared to roads, in the the MT structure.

B. Improve and clarify the structure organizational of WAs

The current structure that connects Waterways Administrations (WA) to the structure of the Ministry is established through an agreement signed by DNIT / DAQ and CODOMAR, which binds all WAs to CODOMAR in the same contract, and the CODOMAR to DNIT/DAQ. The agreement states that, if there is any problem regarding to the expense report from one of the WAs, the budget next year will not be delivered to no one. This type of agreement has proven ineffective. Furthermore, this structure deviate the decentralized offices of the WAs from the key decision makers.

Thus, it is recommended to review the organizational structure of WAs, in order to inset them at the same strategic discussions, since they hold the best knowledge of the local situation. In this review the WAs would be subordinated directly to the DAQ without the intermediation of CODOMAR.

Also, there is the necessity to establish a clear system of responsibilities for the institutions involved in IWT, referring to: investments, waterway maintenances and superstructure (terminals and jetties); inspection of the fleet and equipment and inland navigation.

C. Better arrange the geographic spread of the WAs

Currently, the AHs have a geographical distribution that differs from the River basin organization, where the basin committees are established. Also, for example, two WAs are responsible for managing part of the Tocantins waterway, resulting in a fragmented responsibility. To facilitate the operation and further integrating the structure of WAs to basin committees this fragmentation should not exist. Therefore, the following recommendations are suggested for discussion.

- Rearrange the geographic division of WAs to accompany the river basin division. This would facilitate the conduct of an integrated planning, since it would create a better connection with the basin committees, responsible for the planning of multiple uses of water resources.

- Consult or include WAs in the discussions about a "international"waterway system, since these discussions are currently concentrated in the Ministry of Foreign.

- Create a supranational commission for the river basins with an international scope, in order to facilitate the coordination of strategies of the governments involved. As an example, the Central Commission for Navigation on the Rhine, or the Danube

Commission, dealing with the freedom of navigation, maintenance standards and safety, etc.

D. Establish a standard procedure to be adopted by WAs

Waterwa Administrations need to clearly and define its: mission, goals, roles, and a set of tasks that must be performed throughout the year, for their proper performance. Their performance shall be assessed through indicators, and for this, it is necessary, for example, minimum maintenance activities, that would help in the planning of interventions, and resources provision (financial, physical and human).

E. Develop a rating and information system

The Brazilian waterway system is incipient in providing reliable information for its users and for planners, as updated electronic charts, water level forecasts and statistics concerning transportation. The Navy is updating the nautical charts, but these are available for a limited number of rivers and for many waterways there is no historical data about traffic. Information relating to the IWT is still scarce and dispersed, which complicates the planning activities and the waterways system reliability, harming their development. Develop a rating system of waterways, connected to a system of information of the river (RIS) is elementar. So, a pilot project aims the development of RIS in Brazil.

9.3.2.4.2 WG 2: Implement Supportive Policies and Integrated Planning

Also as a result of the Assessment and Diagnosis Report (Step C), it was identified that a major bottleneck that hampers the inland waterway transport development is that inland navigation hasn't been consistently part of the agenda in terms of government planning and policies. Inland navigation could be boosted if, not only, more policies would take the theme into account, but also in a more coordinated and integrated manner.

The energetic sector was mentioned as a very important one to work more closely with, in order to align the planning of interventions on rivers.

To create the boundary conditions for supportive policies and integrated planning the following items must be addressed.

A. Integrate water management issues in the development of an long-term inland waterways infrastructure in order to articulate the demands of the different users

The Waterway planning must be connected to: energy sector, irrigation and ports planning, and others related to the multiple uses of water. For example, although currently the ports and waterways are under the direction of individual institutions, these systems need to work closely, because there is no waterway without ports, and vice versa. Likewise, the construction of hydroelectric dams without locks may mean ignoring the potential of the river to the development of IWT. Some options to improve the integration between sectors are:

- Firstly encourage integration at the local level through the implementation of the Regional Development Group, where the major institutions involved in water resources should participate togheter in the watershed planning. In this case, the WAs could represent stakeholders in its area of jurisdiction, ensuring the debate on the several demands for improvement of the IWT, with other representatives of state or local government.

- Coordinate the energy sector plans with the necessary improvements to the development of IWT.
- Discuss with the Ministry of Environment about the need for a clearer procedure for requesting environmental licenses for interventions in the riverbed and nearby.
- Greater coordination in the process of developing strategies and planning with some ministries, such as: Ministries of Justice (and FUNAI), Rural Development (and INCRA), Fishing (to assess the fishermen colonies), Health, of Social Development, Environment, Cities, Culture (and IPHAN), Planning, Agriculture, Industrial Development, Mines and Energy (Oil and Mines), Foreign Affairs (who participate in international negotiations on waterways) , Education, Science and Technology and Defence (Navy), among others.

B. Encourage intermodality to support the use of waterways

There is a need to invest in the improvement and expansion of the highways and railways to facilitate access to the rivers and, thus, speed up the transportation of cargo to its final destination. Not only the waterway transport will be benefited from the increased supply of intermodal connections, but also the other modes.

Some recommendations to encourage intermodality are presented, as following:

- Stimulate the development of poles through geographic concentration of terminals/ports and cargo flows. In Europe, the focus on developing of several ports for bulk cargo were performed well, especially in the case of containers, which is required a significant concentration of volumes of cargo to make viable inland. On a pole more facilities can be offered for a relatively low price, such as waterway-rail intermodal connections. Moreover, trhough the facilities available, companies can be grouped in the surroundings which will further strengthen the pole.
- Combining regional development and deployment of multimodal systems. The WAs are decentralized institutions linked to the federal government level, the but states and municipalities have their own institutions that manage the overall transportation (some institutions have specific aprivate waterways). These insituições should plan interventions and develop policies jointly. A pilot project is proposed to stimulate regional development by promoting intermodality.
- Propose tax incentives to encourage intermodality, which will increase the benefits of the waterway system in terms of cost reduction.
- The strategic planning of the logistics system, which should address the several modes of transport in an integrated way, should be regularly updated in order to provide input for updating the specific strategic plans of different modes of transport in the

coming years. A number of plans related to cargo transportation has been developed, which has resulted in dispersed investments. In this sense, the EPL is currently developing the PNLI ("National Plan of Integrated Logistics") in order to increase the integration of policies and investments in the transportation sector.

C. Stimulate and integrate the transport of passengers

Passenger transport plays an important role in the Amazon region, where the waterway terminals are concentrated. Most of these terminals does not meet some basic requirements, from accessibility (in terms of specific areas for bus and taxi stops, bus lines that connect to the terminal and others) until availability of facilities and services (police station, medical service and other), as pointed out in the ANTAQ study ("characterization of Supply and Demand of river Transport of Passengers in the Amazon"). In this sense, it seems necessary to develop a master plan for the waterway terminals dedicated to the transport of passengers, to guide projects of expansion and improvement, as well as their integration with existing urban infrastructure. It is suggested to prepare the first Master Plans for the busiest terminals.

9.3.2.4.3 WG 3: Public-Private Partnership

It has been identified during the stakeholder interviews that involving the private sector in the planning process could be beneficial for the IWT development. The private sector can contribute, for example, offering courses for crew training, currently concentrated in brasilian Navy.

In addition, public-private partnerships have been considered relevant to the development of transport infrastructure - helping the public sector in the areas in which their performance proved to be limited. For this reason, it is recommending the adoption of a model of public-private partnership that could be first implemented as a pilot project.

Aimed at creating an friendly environment to this partnership, this working group will deal with the following actions, considered of mutual interest to both the public and private stakeholders in IWT:

A. Propose contracts of Design, Construction, Financing and Maintenance (DBFM)

B. Encourage innovation

C. Promote the IWT for new users

The following set of recommendations for each action is presented:

A. Propose contracts of Design, Construction, Financing and Maintenance (DBFM)

The working group will evaluate a new division of responsibilities in which private parts coinvestem in waterway infrastructure.

The system DBFM (Design Build Finance Maintain) can be adopted as a new form of contract between the public and private sectors', transferring to the latter's responsibilities of Design, Construction, Financing and Maintenance (DBFM). A pilot project should be implemented to evaluate this measure.

B. Encourage innovation

Research institutes can work together with the waterway sector to join forces in researchs that aim innovations. Below are a few lines of research that may be more encouraged:

- Technologies to reduce greenhouse gas emissions, and energy savings. Innovative researches in Europe, for example, focus on alternative fuels (LNG, hybrid craft, etc.).
- Facilities of waste collection of vessels (including waste engine oil, sewage, materials containing oil, etc.) in ports and inland terminals, which enable a large improvement in environmental performance. In Europe, this system works for over 10 years and was a joint initiative of the private and public sectors, responsible for financing the same.
- Innovative system for docking station. This system will allow substantial time savings in the coupling process and reducing risks to the crew during the pairing process.
- Design of barges and push boats for specific rivers, with little depth.
- Development of double-hull tanker to increase the safety level of the transport of dangerous cargoes in the Brazilian waterways.
- Design of new barge systems for the transport of for new loads. The Barge Juice, a charging system specially designed for the transport of fruit juices, is being developed in Europe, for example.

C. Promote the IWT for new users

To intensify the promotion of IWT as a sustainable and highly competitive transport, the establishment of an Agency for the Promotion of public transport is recommended. The costs of the promotion agency should be supported by public and private entities together, as both will benefit.

The WG3 will define the purpose, mission and ambition of this agency.

9.3.2.5 Summary

The Task Force characterization for the IWT Development is summarized in the following table.

Tabela 9.3.1 - Task Force for IWT Development

Aim	
Create the conditions for the implementation of the Master Plan for the development of IWT in Brazil.	
Suggested Agenda	
1. Approval of the Master Plan The selected strategy will have to be approved by the stakeholders to guarantee the implementation process. 2. Approval of the project list The strategy has been translated in an action list of actions to be executed. This list will be approved and prioritized. 3. Selection of a limited number of pilot projects The development of the selected strategy gets a kick-start by selecting a number of pilot projects from the action list 4. Monitoring of the implantation and results The pilots projects will be part of a set of first measures to be adopted e should be monitored. The evaluation of the results will be conducted trough the monitoring plan, to be implemented. This evaluation should be discussed within the task force to solve the bottlenecks and increase the performance of the system. 5. Definition of main areas that would need policy revision/development or further planning The main expected result is the enterations of the main interested stakeholders, enabling solutions to be discussed and presented. Working groups will be installed to tackle the (institutional) questions.	
Responsible organization	Ministry of Transport
Participants involved	Public: Representatives from CONIT, Waterway Administrations, SEGES, EPL, DNIT, ANTT, ANTAQ, Ministry of Energy, Ministry of Defense (Navy), Ministry of Environment, National Water Agency (ANA) and Ministry of Foreign Relations Private: Cargo owners, shipping companies, terminal operators, etc. , civil society organization
Timeframe for development	[December/2013] - [December/2018]
Budget*)	To be determined during Master Plan phase

*) The Task Force will be provided with a budget to cover the expenses of studies required for these additional tasks. According to the present study some 20 billion R$ will be spent on IWT improvement. Sufficient budget should be allocated to supporting studies and restructuring.

9.3.3 Regional Development Board

9.3.3.1 Introduction

Once the waterways that will be developed have been selected and approved, the improvement projects can be executed. The primary responsibility for the implementation of a specific development project will be with the Waterway Administration responsible for the specific waterway, which must lead the process in a integrated way, together with all of the relevant regional stakeholders.

In most cases the IWT development requires the coordinated development of a number of different elements in the transport system. Not only dredging works, dams and locks, but the simultaneous development of connecting road infrastructure, terminals and fleet expansion. To guarantee this coordinated development a Development Group will be established for each Waterway.

The Regional Development Groups should assure that all relevant plans and policies that regard its jurisdiction are harmonized, resulting in a consciousness use of public resources and also stimulating IWT initiatives to be implemented.

9.3.3.2 Participants

The major public and private stakeholders on the river basin level will participate in the Group. The River Basin Committees can fulfil an important role in the Development Groups as they integrate the users of water resources in the region, but also for containig other stakeholders interested in enabling a reliable navigation mode.

Convincing the participants of the need to join will be easier than for the Task Force. First of all the higher level representatives in the Task Force will stimulate the participation. The second reason is that for a specific river basin the stakeholders are much closer to their immediate interests. They have common interests and will benefit from working together. Per region it will be discussed whether associations and classes councils might participate as this would be an alternative not to have every individual company to participate.

9.3.3.3 Agenda

The Development Group will assist the Waterway Administration in implementing the measures required by formulating a common goal, confirm and guard the timeframe etc. In this way the integrated government planning process and the public-private partnerships will further be strengthened on the practical way.

Once finalized the planned interventions, a department responsible for the management and maintenance will have to be in operation, which may or may not be the Waterway Administration. During the implementation process of the waterway the WA will have time to raise the management system up to the level required for an efficient operation. The Development Group will be instrument of setting up the specifications for proper management and maintenance and will assist in implementing these specifications. The Development Board will be provided with a budget to cover the expenses of studies required for these tasks. The responsibility for the management and the maintenance will be with the Waterway Administration, but the RDG should provide enough support to overcome obstacles.

9.3.3.4 Summary

Tabela 9.3.2 - Development Group

Aim	
Implement the required measures in the selected waterway together. All members will add their own efforts to the the Waterway Administration while implementing the improvement interventions	
Suggested Agenda	
1. Formulate common goal For the development of a specific waterway a goal will be formulated that guarantees benefits for all stakeholders involved 2. Agree upon projects, planning, budget and responsibilities and, Guarantee a balance in the designs, combining accordingly the public and private investments 3. Design study and execution of the projects Execute the required measures jointly 4. Confirm and monitor time frame The time frame will be set in such a way that a simultaneous development of all elements in the transport system results 5. Determine efficiency and effectiveness indicators to evaluate the waterway management and operation	
Responsible organization	Ministry of Transport
Participants involved	Public and private representatives to be determined specifically for each separate development project
Timeframe for development	[September/2013] - [December/2020]
Budget	To be determined

10 EVALUATION OF MAIN GOAL

10.1 INTRODUCTION

In this chapter the preferred strategy is evaluated in terms of the main goal: in what way does the strategy contribute to achieving this goal? For this purpose also a sensitivity analysis has been carried out. In this analysis the robustness of the preferred strategy is tested by changing driving factors concerning costs, benefits and valuation.

In this chapter the level of contribution of the selected strategy to reach the goal is evaluated, and the goal will be adjusted to the performance of the strategy to be recommended in Strategic Plan. For this, after selecting the preferred strategy, a sensitivity analysis was carried out on this strategy (see process steps in Figure 10.1.1), and in this analysis, the robustness of the chosen strategy was tested, based on factors related to changes in the costs, benefits and evaluation.

Figure 10.1.1 – Process Steps – Evaluation of Main Goal

10.2 PERFORMANCE OF PREFERRED STRATEGY

10.2.1 Transport Volume: the Main Goal

The preferred Strategy will, according to the forecasts, lead to a transport volume of 120 million tons on inland waterways in Brazil in 2031, surpassing the preliminairy set target of 110 million tons.

The *current* modal share of IWT in the main relevant commodities market is approximately 9%, in terms of ton per kilometers (volume and distance). For 2031 the modal share is expected to move towards 40% for these market, more than four times the current share, if the preferred strategy is implemented.

It is important to compare competitive markets in the analysis of the participation of the different modes of transport. The comparison between the THI and goods distribution system in cities, for example, is not very helpful because they serve quite different markets. The THI can hardly compete in the distribution of food on a daily basis to a big city like Sao Paulo or Brasilia.

For this reason the comparison of transport modes should consider the transport performance, which is measured in tonne-km, to prevent some double counting of flows, which would give a false impression of the degree of participation. One problem, however, is the availability of data about transport performance, since most of the volume transported is only measured in tons. When considering only the volume transported, a ton transported over a distance of one kilometer is as important as a ton transported more than 1000 km.

This chapter briefly explains the driving forces behind this growth, which is originating from three commodity segments with their own characteristics:

A. Organic growth of currenly existing IWT flows in which the waterway experiences no competition from other transport modes

B. Additional IWT flows resulting from investments in processing plants and logistic systems, using waterways

C. Current and additional IWT flows with heavy competition from other transport modes and chains

A. Organic growth of existing flows without modal competition

This group of commodities is currently transported on natural waterways like the Amazon, the Paraguay River and Lagoa dos Patos, and will grow autonomonous. Waterway transport is possible without big investments on these particular waterways, since these waterways have no dams, locks or other man-made obstacles. The commodities are oil and chemical products, coal, iron ore manganese and Ro-Ro transport (Semi Reboque Beau). These transport flows exist in the base year and will show a growth that is at least as high as the growth of the GDP.

Important for the growth is the lack of alternatives for transport over water. In the Amazon region currently hardly any alternatives for transport over water exist. The same is vallid for the transport on the Paraguay River and the Lagoa dos Patos.

This explains why, without large investments, transport over water will grow to 32.5 million tons in 2031. The shares of Paraguay River (iron ore and manganese) and Amazon River (chemical oil and Ro-Ro) in this segment are respectively 46 and 35%.

B. Additional flows, resulting from investments in processing plants and logistic systems, using waterways

For a number of production processes inland waterway transport is an excellent alternative for the transport of commodities used in the production process or for the transport of final products. In Europe the iron and steel industry in the famous Ruhr area would not have been possible without the Rhine. The same is vallid for a number of chemical plants, like BASF in Ludwigshafen. Other examples come from the building industry and the animal food industry.

In the forecasts a number of plants and systems have been taken into account that have recently been build or will be built shortly, which will use waterway transport as the main mode of transport. In the forecasts is assumed that in Marabá (PA) a steel plant will function. The Tocantins will be used as the major transport route. In Três Lagoas (MS) a major pulp factory recently started producing. The input (wood) and the output (pulp for export) is expected to use the Paraná and the Tietê. The Paraná and Tietê also will be used to transport ethanol to Anhembi and from there to Paulina. This is part of a bigger system, including pipelines, to transport ethanol to a central point and distribute it from there.

In Rio Grande do Sul a pulp factory is also planned in Guaíba. We assume that the transport of pulp will be done by inland waterways. In Rio Grande do Sul we also expect container transport between Rio Grande and Porto Alegre in 2031.

It is very well possible that other initiatives will follow if the mentioned investments turn out to be successful and the waterway can be used as a reliable mode of transport. The given forecasts only show known investment plans with a high probability of success.

Total inland waterway transport from investment plans amount to 51.5 million tons in 2031. The flows are expected on the Tocantins (Marabá – Vila do Conde) 32.5 million tons, Paraná – Tietê (till Anhembi): 16 million tons and the Hidrovia do Sul: 3 million tons (on Lagoa dos Patos).

The concentration of these flows on a few waterways leads to the conclusion that with relatively limited investments (removal of rocks on the Tocantins River and investment in locks on Tietê River) a large volume of transport can be achieved.

C. Current and additional flows with heavy competition from other transport modes and chains

The third group consists of agricultural commodities (including fertilizers, which are used in agriculture). The main characteristic of these commodities is a large area of production, unlike plants where the production is concentrated, in areas with no natural mode of transport. In Brazil the main producing areas of soy and corn, the two main agricultural commodities for inland waterways[17], have a large range of options for export. Especially Mato Grosso,

[17] Sugarcane is very important for Brazil, but not very attractive for IWT because of the location of the main producing areas (the state of Sao Paulo and the Northeastern states) and the large numbers of plants that produce sugar and/or ethanol. Except for the ethanol system, inland waterways transport little sugarcane, sugar or ethanol. This is not expected to change much.

according to the forecasts, in 2031 still the largest producing and exporting state of Brazil with an export (and import of fertilizers) of 36.5 million tons of agricultural products.

With the CBA model the effects of individual waterways on the transport volumes were calculated. For the PS the main waterways are the Tapajós (9.7 Mt), Tocantins (8.6 Mt), Paraguay River (5.5Mt), Paraná Tietê (4.8 Mt) and other waterways together 7.6 Mt. in total 36.2 Mt will be transported according to the results of the models.

In the following tables a more detailed forecast is provided of the amount of cargo per type and inland waterway.

Table 10.2.1 - Overview of Commodities per Inland Waterway in Preferred Strategy (in tons * 1.000 tons)

Transport flow	Growth of existing flows without modal competition	Additional flows from investments in plants and logistic systems	Additional flows (mainly agricultural) with heavy modal competition	Total (in 1000 ton)
Amazon[18]	11.466			11.466
Madeira	2.177		2.547	4.724
Tapajós			9.694	9.694
Tocantins		32.517	8.559	41.076
Sao Francisco	61		2.598	2.659
Paraná – Tietê[19]		15.988	4.824	20.812
Hidrovia do Sul	3.885	2.969	2.513	9.367
Paraguay River	14.883		5.519	20.402
Total	**32.472**	**51.474**	**36.254**	**120.200**

The Table 10.2.1 presents an overview of the total flows per strategy, showing how well the Preferred Strategy performs, compared with the main strategies.

Table 10.2.2 - Overview of Total Flows per Strategy (in tons * 1000)

Transport flow	Baseline	1 M+	2A EXP	2B EXP	3 TQ	PS
Organic	28.028	32.472	32.472	32.472	32.472	32.472
Projects	18.187	51.474	51.474	51.474	51.474	51.474
Agriculture	10.877	16.844	39.057	27.073	44.279	36.254
Total	**57.092**	**100.790**	**123.003**	**111.019**	**128.225**	**120.200**

[18] On the Amazon River some short distance (1 km) transport exists of oil products within the port of Manaus. This is left out of the calculation

[19] Short distance transports of Sand on the Tietê River and agricultural commodities on the Paraná are left out of the calculations.

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in Amazon WS)

Amazon WS					
Organic		Projects		Agriculture	
Chemical products	4.357				
Oil Products	1.357				
Ro-Ro	5.025				
Others	727				
Total	**11.466**	**Total**	**0**	**Total**	**0**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in Madeira WS)

Madeira WS					
Autonomous		Projects		Agriculture	
Oil products	716			Soy	1.507
Ro-ro	655			Soy meal	365
Cement	403			Corn	504
General Cargo	246			Fertilizers	170
Other	157				
Total	**2.177**	**Total**	**0**	**Total**	**2.547**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in Tapajós WS)

Tapajós WS					
Autonomous		Projects		Agriculture	
				Soy	4.717
				Soy meal	1.864
				Corn	2.240
				Fertilizers	873
Total	**0**	**Total**	**0**	**Total**	**9.694**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in Tocantins WS)

Tocantins WS					
Autonomous		Projects		Agriculture	
		Coal	9.371	Soy	5.909
		Iron ore	1.976	Soy meal	1.130
		Manganese	3.643	Corn	643
		Pig iron	936	Fertilizers	876
		Steel	16.119		
		Others	472		
Total	**0**	**Total**	**32.517**	**Total**	**8.558**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in São Francisco WS)

São Francisco WS					
Autonomous		Projects		Agriculture	
Cottonseed	61			Soy	1618
				Soy meal	621
				Corn	96
				Fertilizers	264
Total	**61**	**Total**	**0**	**Total**	**2.598**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in São Paraná-Tietê WS)

Paraná – Tietê WS					
Autonomous		Projects		Agriculture	
		Wood	1.667	Soy	2.496
		Pulp	5.000	Soy meal	1.151
		Ethanol	8.553	Corn	847
		Oil	500	Fertilizers	331
		Others	268		
Total	**0**	**Total**	**15.988**	**Total**	**4.824**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in Hidrovia do Sul WS)

Hidrovia do Sul WS					
Autonomous		Projects		Agriculture	
Agriculture other	292	Wood	770	Soy	754
Coal	471	Pulp	1.424	Soy meal	696
Chemical	1.078	Container	775	Corn	8
Oil	1.753			Fertilizers	1.055
Industry other	291				
Total	**3.885**	**Total**	**2.969**	**Total**	**2.513**

Table 10.2.3 - Tons per Commodity Type and Inland Waterway in the Preferred Strategy (in Paraguay WS)

Paraguay WS					
Autonomous		Projects		Agriculture	
Iron Ore	14.660			Soy	2.775
Manganese ore	163			Soy meal	1.008
Sugar	60			Corn	1.172
				Fertilizers	564
Total	**14.883**	**Total**	**0**	**Total**	**5.519**

10.2.2 Benefit/Cost Ratio of the preferred strategy

The costs in a CBA consist of the investment and maintenance costs. These have been calculated for the preferred strategy including all relevant measures per inland waterway and are presented in Table 10.2.4.

Table 10.2.4 - Investments and Maintenance Costs per Strategy

	Investments	Maintenance	NPV
	R$* million	R$* million /year	R$* million
Baseline	0	0	
Maintenance+	3.603	187	3.569
Expansion 2A	32.413	1.119	28.276
Expansion 2B	13.460	437	11.553
Top Quality	46.555	1.679	41.101
Preferred Strategy (8)	16.881	543	14.455

Based on the transport forecasts and the analysis of transport costs per mode and route, the sum of changes in transport costs between the baseline situation and the preferred strategy have been established for all relevant commodities and origin-destination combinations. Please refer to Annex C for more details.

Finally, the net present value of costs and benefits has been calculated for the preferred strategy. In table 10.2.5 an overview is presented of the present value of costs and benefits as well as the benefit/cost ratio. The values are derived from comparing the preferred strategy with the baseline situation.

Table 10.2.5 - Discounted Cost and Benefits for the Preferred Strategy

	Transport benefits	Costs	B/C ratio	Volume
	R$ * million	R$* million	#	Million ton
Baseline	0	0	-	57
Preferred strategy	13.536	14.455	0,94	120

The b/c ratio of the preferred strategy is just below break-even (0,94). This may seem somewhat disappointing. However only transport cost savings have been taken into account as benefits in the CBA. Other benefits have been explicitly assessed in the MCA in the process of selecting the preferred strategy. So the b/c score does not tell the whole story. As mentioned before in this report, in an international perspective, the CBA results are considered to be good for IWT investments. In similar projects in Europe, such ratios are around 0,6.

10.3 SENSITIVITY ANALYSES

10.3.1 Introduction

An important part of a cost benefit analysis is testing the stability of the results. In other words would the conclusions concerning the performance of the preferred strategy change if some important assumptions would be changed? In this analysis we will use different discount rates (+ or -/- 2% from the used rate of 6.25%), investments and maintenance costs (+ or -/- 25% of the calculated costs) and lower transport costs per truck. In this study the results of models from the University of Sao Paulo were used. In the used models it is assumed that the costs of road transport will increase compared to the current costs. In the sensitivity analysis a check was made with use of lower variable costs.

10.4 CHANGING THE ANALYSIS DISCOUNT RATE

The discount rate does not influence the cargo flows themselves, only the valuation of costs of benefits.

Table 10.4.1 - Sensitivity Analysis Discount Rate

6,25%	Benefits	Costs	B/C
PS <-> Base	13.536	14.455	0.94
8,25%	Benefits	Costs	B/C
PS – Base	9.250	11.950	0,77
4,25%	Benefits	Costs	B/C
PS – Base	20.284	17.828	1,14

The first line of the table shows the original result, based on a discount rate of 6,25%, as reported in the previous section.

The higher the discount rate, the heavier the costs in the first years will influence the results. Benefits in the future will have less impact. Hence with an interest rate of 8.25% discounted costs and benefits both will be lower, but the impact on benefits is bigger. The B/C ratio will be lower.

If the interest rate is 4.25% the opposite is true. Future costs and benefit have more influence. That is why the b/c ratios are higher than with the base discount rate.

Compared to EU, the discount rates in Brazil are rather high. In the Netherlands 2% is used. For the USA and Great Britain the box below gives more information.

Approach in the United States of America

Three federal agencies in the United States of America, including the Congressional Budget Office, the Government Accountability Office and the Office of Management and Budget have routinely used CBA to evaluate infrastructure and other long-term, large-scale federal investments. The Congressional Budget Office recommends a discount rate around 2% based on its estimate of the federal government's long-term cost of borrowing. Its theoretical foundation is primarily a social rate of time preference.
The Government Accountability Office favors the nominal yield on Treasury debt with a maturity matching the project length, less the forecast rate of inflation and other technical adjustments.
The Office of Management and Budget (OMB) instructs using a discount rate close to the "marginal pre-tax rate of return on an average investment in the private sector in recent years." Both of these policies are theoretically closer to the social opportunity cost of capital approach. The OMB further stipulates the real discount rate based on different horizons. For thirty years and longer 2% is used.

Approach in the United Kingdom

The United Kingdom's approach is largely based on the social time preference, with HM Treasury recommending to use a real social discount rate of 3.5%, which declines over very long time periods.

Conclusion

An interest rate of 6.25% is relatively high compared to countries like the Netherlands, the United Kingdom and the United States. It is highly possible that the discount rate in Brazil will also be lower in the future.

10.4.1 Changing cost Analysis

The sensitivity analysis only influences the costs; benefits remain the same. The higher the costs, the lower the benefit costs ratio. In the cost estimates analysis taxes are included. It is very difficult to estimate the share of taxes in the total costs in Brazil because of differences in state taxes and federal taxes. It is also possible that part of the investments will be exempt from federal taxes, as is the case for the PAC investments. In general total taxes in Brazil exceed 25%.

From the calculations it becomes clear that 25% lower investments will have a very positive effect on the B/C ratios. The opposite holds for higher investment costs.

Table 10.4.2 - Sensitivity Analysis Costs (in R$ * million)

Base	Benefits	Costs	B/C
PS – Base	13.536	14.455	0.94
+25%	Benefits	Costs	B/C
PS – Base	13.536	18.069	0.75
-/-25%	Benefits	Costs	B/C
PS – Base	13.536	10.841	1.25

10.4.2 Changing Road Transport Costs

For the calculation of the transport costs for road transport and waterway transport a dedicated cost model, developed by the University of Sao Paulo, has been used. This model calculates the costs of transport on the basis of fixed and variable costs like wages, fuel costs, depreciation, and insurance. Furthermore, the model takes in account new legislation on road transport, which will make road transport more expensive in the future.

The results of the models for road transport have been compared with realized transport costs on a number of relations (e.g. Sorriso – Santos). The main conclusion is that actual transport costs in 2011 are lower than the calculated transport costs with the models. Two main reasons exist for this difference. In the first place the difference between transport costs and transport tariffs. In a very competitive market it is not unusual that not all costs are incorporated in the tariffs. This seems to be the case in Brazil. Another important factor is the new legislation. This will, as stated above, increase the costs of road transport, especially for long distance transport. As most of the calculations are used for the period 2020 – 2045 it seems appropriate to incorporate this new legislation. In Table 10.4.3 the differences for some important transport relations are given.

Table 10.4.3 - Examples of Transport Costs in R$ per Ton Realized (2011) and Calculated[20]

Origin	Destination	Distance	Actual costs	Calculated (0,16)	Calculated (0,08)
Sorriso	Santos	1.915	206	340	187
Rio Verde	Santos	912	107	179	106
Primavera do Leste	Santos	1.450	160	265	164

The transport costs used in the models are higher than the currenly charged transport costs (2011). The main reason to use the higher transport costs for road is that these already take into account new regulations that will make road transport more expensive. The formula used is Road costs = 33.4 + 0.16*distance. If the variable costs are halved (Road costs = 33.4 + 0.08*distance) the actual costs are far better approximated. In the sensitivity analysis the value of R$ 0.08 per kilometer is used. Note that this influences the modal split. The tons

[20] Source of realized transport costs: Soy transportation guide 2011 (July 2012)

transported by the different mode will, therefore, differ from base calculations. Table 10.4.4 shows the results for the agriculture commodities in 1.000 tons.

Table 10.4.4 - Agricultural Commodities Transported by IWT in the Preferred Strategy (PS) with Different Variable Costs for Road Transport

	PS (0.16)	PS (0.08)
Madeira	2.547	2.515
Tapajós	9.694	12.179
Tocantins	8.559	7.579
Sao Francisco	2.598	0
Paraná-Tietê	4.824	2.203
Paraguay	5.519	4.102
Sul	2.513	2.513
Total	**36.254**	**31.091**

Total transport over water decreases, but some waterways will profit, especially the Tapajós. Other waterways like Paraná-Tietê and Paraguay River show a decline. This pattern can be explained, as the Northern routes (Madeira and Tapajós) have no competition from road transport. Northern rivers benefit, as the routes to the North will be cheaper for inland waterways because the pre haulage by truck is cheaper. In southern direction however, more competition between inland waterways and road transport exists. A part of the cargo shifts from IWT to road transport. The Paraná – Tietê suffers the most from this shift.

Effects on Transport Costs

In table 10.4.5 the transport costs for PS (0.16) and PS (0.08) are presented. The total transport cost will be reduced drastically (about 23%) in the Preferred strategy with lower transport costs for road.

Table 10.4.5 - Total Transport Cost in Preferred Strategy (in R$* million)

Strategy	P.S (0.16)	P.S. (0.08)
Road	46.397	46.517
Water	13.448	9.615
Rail	22.847	7.204
Total	82.692	63.336
Difference		19.356

Effects on B/C Ratio

In order to calculate the B/C ratio it is not sufficient to use the transport costs from Table 10.4.5. The baseline transport costs are also affected by a change in the costs of road transport: road transport in the Baseline also will be cheaper. Overall, the benefit/cost ratio falls from 0,94 to 0.61.

Although in some regions lower transport costs for road transport seems to work out positive for waterway transport (especially in the North), the overall picture is negative. Lower transport costs for road transport makes waterway investments less profitable, as could be expected.

11 MASTERPLAN

The implementation of the Preferred Strategy will, according to the forecasts, lead to a transport volume of 120 million tons on inland waterways in Brazil in 2031, surpassing the preliminary set target of 110 million tons. The main goal from this Strategies report will be adjusted for the higher transport volume of the Preferred Strategy. This adjusted goal of 120 million tons and the 2 subgoals combined with the preferred strategies, will be the basis of the Strategic Masterplan of PHE. This is the last step of the development strategy process (see Figure 11.1).

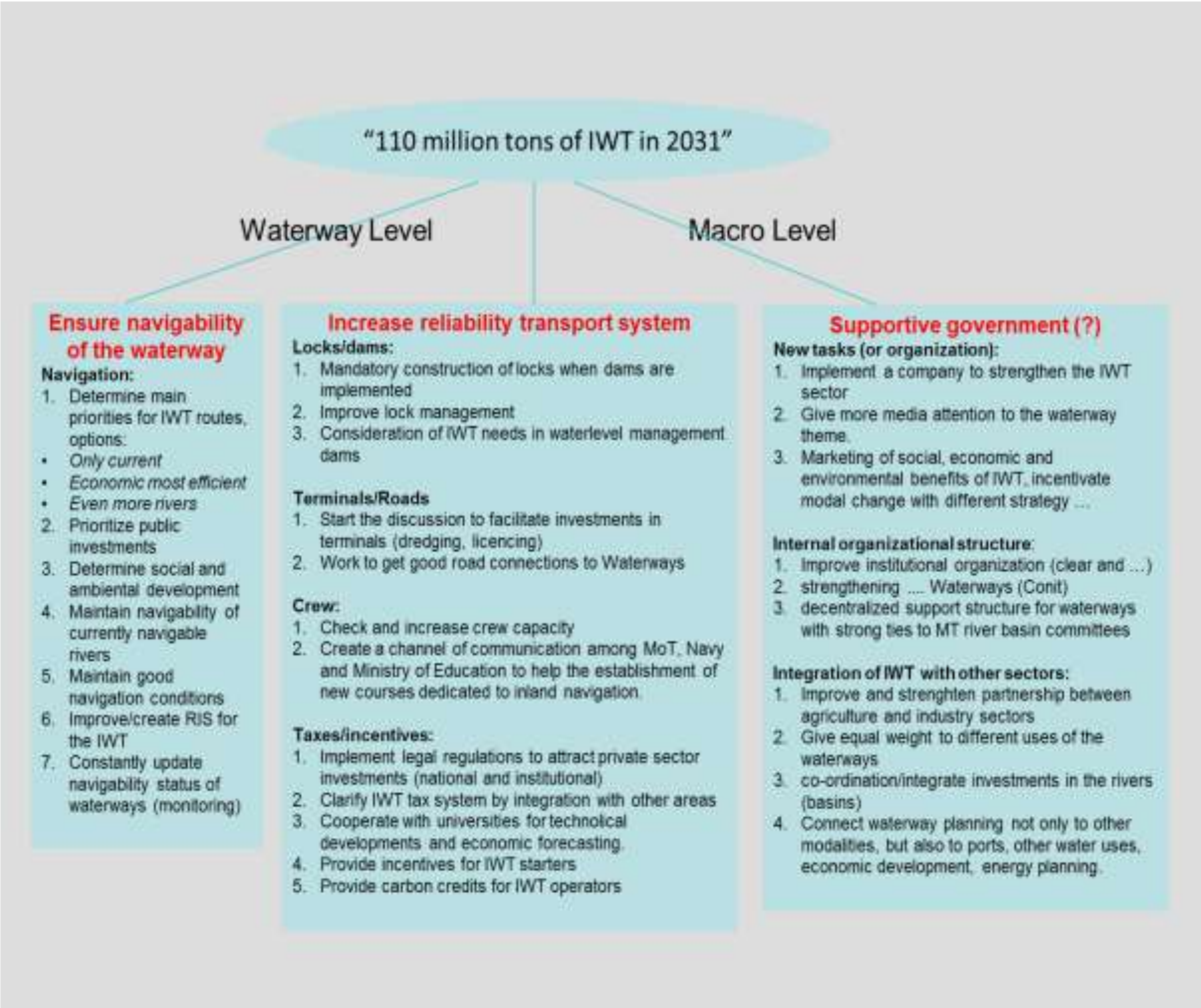
Figure 11.1 – Process Steps – Strategy for the Masterplan

In the next phase of the PHE project the Strategic Masterplan will be developed. The investments and actions will then be elaborated and prioritized, together with the Ministry of Transport. Considerations in the discussion will be the yearly available investment budget of the MT, expected annual development of the cargo flows, political reasons to prioritize and expected time of execution of the investments/actions. The physical and institutional measures will be further detailed.

Since the final strategy is based on a time frame of twenty years until 2031, the selected waterway development must be both feasible within the time frame and desirable from a political perspective. The PHE does not end the sector's planning phase; quite the opposite, it only gets it started. The Masterplan will describe the Preferred Strategy, allowing for further step-wise development, whereas the development of all waterway sections must be an even longer-term goal towards which the sector must head to.

The optimal combination that Alt. 8 presents can be seen only as the first step on a pathway of waterway developments that stakeholders will follow, continually contributing to making IWT an important mode of transport in the national transport matrix. Like one of the many push-boats that will soon traverse the country, each incremental waterway section helps to push the sector ahead.

ANNEX A: RESULTS OF WORKSHOP 1 WITH MT



ANNEX B: GENERAL CRITERIA FOR PHYSICAL WATERWAY INTERVENTIONS

1. Introduction

The definition and estimation of the costs of the physical interventions on the waterways in this study were performed based on: the Diagnosis report of the physical conditions of the waterways (PHE-Product 3); works built and planned to be built of the same type / size of the proposals in this plan; official documents prepared by competent authorities, besides critical analysis of experts Arcadis Logos.

The main interventions needed to upgrade the selected waterways into waterways, with full capacity and reliable operation, were divided into two main groups: **Physical Interventions along the Riverbeds** and **Construction of Lock Systems**.

The analysis of the necessary physical interventions leads to a great divergence between the solutions and costs adopted between the various agencies responsible for Planning, Operation and Management of Inland Waterways, besides Consultants beliefs. These differences are the result of the scarcity of detailed field surveys in each river, besides the little previous experiences in large interventions in the Brazilian waterways. The Cost estimations were made for the rivers and sections considered in the Strategy step, summarized below.

Table 1. Selected Rivers studied in Strategy step

River	Selected Stretch
Amazon	Foz - Coari
Madeira	Itacoatiara - Porto Velho
Tapajos	Santarém - Itaituba
	Itaituba - Cachoeira Rasteira
Tocantins	Vila do Conde - Marabá
	Marabá - Miracema do Tocantins
Araguaia	Maraba-Conceicao
	Conceicao-São Felix
	São Felix-Aruana
Parnaiba	Teresina-Urucui
	Urucui-Santa Filomena
	Urucui-Balsas
Paraguay	Foz rio Apa - Corumbá
	Corumbá - Cáceres
Tietê - Paraná	Três Lagoas - Pereira Barreto
	Pereira Barreto - Pederneiras
	Pederneiras - Salto
South (Jacuí - Taquari)	Rio Grande - Porto Alegre
	Porto Alegre - Triunfo
	Triunfo - Cachoeira do Sul
	Triunfo - Estrela
Sao Franscisco	Petrolina - Ibotirama
	Ibotirama - Pirapora

2. Physical Interventions along the Riverbeds

The rivers consist on dynamic elements and are often subject to imbalances, natural or anthropogenic, that may hinder the navigability conditions of commercial vessels. These bottlenecks can be mitigated or avoided through the appropriate interventions and works.

Among the range of selected rivers in Step Strategy, and previously presented in Table 1, it is highlighted that the selected rivers have two main behaviors from the point of view of the riverbed: **Mobile Riverbed** and **Fixed Riverbed**. The Physical interventions along the riverbeds are basically function of these conditions.

The main features of each condition and the main obstacles that they may represent for commercial navigation are summarized below.

2.1 Mobile Riverbed

The river sections with mobile riverbed have, in general, low slope, high erosion and sedimentations rates, resulting in erosion of the river bank erosion, aggradation and mobile sand bars. These are mainly alluvial rivers with typical characteristics of lowlands regions.

These are the cases of the Amazon, Madeira, Tapajós (Santarém to Itaituba), Parnaíba, Paraguay, Jacuí and sections of Tocantins, Araguaia and San Francisco rivers.

The main physical obstacles for navigation that these rivers provide are related to erosion and sedimentation. Mobile Sandbanks and riverbank erosions are the main restrictive elements, resulting in narrowing and reducing of the depths for the navigation in several sections. These elements usually present significant annual variations, depending on the hydrologic regime and on the land use on the basin and on the river bank, among other factors.

Moreover, the recurring problems about this type of riverbed usually occur on large extensions of the rivers, so the solutions and required interventions should extend for almost the entire of river sections.

Such temporal and geographical imprecisions in identifying the obstacles result in big uncertainties involved in quantifying and estimating the cost of the necessary physical interventions.

2.2 Fixed Riverbed

The river sections with fixed riverbank present as main features: bottom and margins mainly formed by rocks, high slopes and flow speeds. These are typical rivers of upland areas.

The main bottlenecks to navigation are fixed and well located elements such as falls, rapids, rocky outcrops, and narrowings. The river bed material is resistant to the forces of dragging caused by the flow, so the river bed tends to remain fixed.

The river sections with rocky riverbed and margins are generally in the upper regions of the watershed, in places with poor conditions of navigability. This is not the scenario of the selected rivers in the current stage of this study, however, many of the analyzed rivers have mixed features, alternating fixed riverbed conditions with mobile riverbed conditions.

The main rivers studied whose characteristics are the one mentioned above are: sections of Madeira, Tapajós, Tocantins, Araguaia, São Francisco, Parnaíba and Tietê rivers.

2.3 Main interventions proposed

The main technical solutions analyzed consist of those already carried out successfully in domestic and international context, in addition to those presented in the bibliography. Moreover the interventions in the rivers should be considered such that the combination of structures, protections and dredging keep the sediments moving through the river and ensure the draft specifications in the navigation channels.

The main interventions considered in the riverbeds are summarized below:

2.3.1 Dredging

Having as main goals the opening of navigable channels in mobile riverbed sections and their maintenance, the dredging services are focused manly in desilting, widening, clearing, removal, or excavation of bottom material. The predominant sediment to be removed for maintenance dredging consists of sands, which settle more easily, due to their higher specific weight. In dredging of channel opening, the granulometry of the sediments tends to be more diversified.

When aggradation problems are well-located and stable in time, the best alternative action is the realization of dredging, to remove the obstacle.

Well-characterized cases of rivers that require intense activities of dredging for the feasibility of waterways are sections of the rivers: Jacuí (Triunfo - Cachoeira do Sul), Paraguay (Corumbá - Cáceres), São Francisco (Pirapora - Ibotirama), Tapajós (Itaituba – Cachoeira Rasteira), Solimões (Manaus - Coari), Madeira (Humaitá - Porto Velho) as well as extensive sections of the Parnaíba, Tocantins and Araguaia rivers.

Moreover, all the rivers in the study will require maintenance dredging activities, in different levels, to ensure the navigability conditions over time.

Due to the intensity of sediment transportation in many rivers, dredging must be performed constantly, because the river continuously replaces the sand that is removed. Because to the technical and economical impossibility of dredging the whole river all the time, beyond considering the environmental costs involved, dredging activities may not be the best alternative, if analyzed as the only solution.

Stands out even the necessity of intense control over the disposal of the excavated materials resulting from the execution of dredging, which must have specific allocations, in order to not compromise the conditions of the riverbanks.

2.3.2 Rock Demolition

The Rock Demolition activity consists in a specific branching of dredging, focusing on the excavation and removal of rocks, mostly still in consolidated states. Thus, the rock demolition activities aimed at the opening of navigable canals, in the midst of regions with fixed riverbed.

There are basically two methods of demolition of riverbeds: surface and underwater. In the case of works to be performed in surface, it is usually necessary to build cofferdams and diversion works. The works of demolition can be performed with or without explosives. The demolition without explosives is called cold, and using explosives, by fire.

The underwater rock demolition by fire is similar to the surface one; however, it has some difficulties and requires additional cares. In some cases it may be necessary protection against any effects caused by ripples produced during the detonation of the charges. The drilling control cannot be performed properly, since the drilling is not visible, so the implementation of the perforation must be made more carefully. Another kind of problem is the difficulties in the removal of the material, once it is difficult to ascertain whether the material was removed in their entirety. The load necessary in this type of demolition is also greater by the fact that part of the energy is absorbed by the water. Because of these problems, the time required for execution of the works is about 10 times greater than the works by surface (Brighetti & Brandão, 2011).

In the present study it was considered the need for demolition activities in sites already known to require such intervention, highlighting: Pedral de São Lourenço (Tocantins river), downstream of HPP Nova Avanhandava (Tietê river), dowstream of Bom Retiro Dam (Taquari river), Pedral de Meleiro (São Francisco river), the section between Humaitá (AM) and Porto Velho (RO) (Madeira river), among others.

In many of the sections with rocky outcrops, which would require rock demolition for the viability of the waterway, it was proposed a solutions consisting of dams with locks, whose reservoirs creates the necessary conditions of depth, flooding the rocks, falls, rapids and other obstacles, ensuring safety for navigation. The details and costs of these interventions are described in item 3 of this Annex.

2.3.3 River Regularization

The basic idea of river regularization is to narrow some cross sections of the river to raise the water level and thus increase the depths without significant deepening of the bed. Moreover, through this practice the river takes the place of the dredging, moving continuous large percentage of the sediment to downstream, using the own energy of the river.

Moreover, during the drought, the flow of a river may be divided into several branches and form channels where depths may be insufficient for navigation. Thus, it becomes necessary to concentrate the flow in a single well-defined bed of the river, so that the increased liquid flow increases in the main river bed, moving the sediments downstream and resulting in the necessary depths. Thus, through the processes of regularization part of the river turns into a meandering regime and consequently stable. The regularization must be performed in the best possible agreement with the conditions of nature.

The regularization works are usually adopted in rivers that require interventions along extensive sections of the river, due to widespread problems of aggradation. Depending on the erosion and sedimentation rates, adopt only dredging can fail over a short period of time, returning the river to its original conditions.

To carry out works to stabilize the river, it is mainly used dykes and groins.

The groins may be normal or inclined to the margin, with upstream or downstream inclination. The spikes may be normal or inclined to the margin, upstream or downstream. In your end there is a tendency of erosion caused by eddies formed perpendicular to the groin. The length of the spike depends on the layout chosen for the new riverbank. In very mobile riverbeds, however, it is not recommended to be too long, or else must be constructed gradually, waiting for the sedimentation between them to extend, which can be speeded up by the construction of small and intermediaries groins. The distance between groins should be large enough so that the solution continuous to be economical, yet not exceed the minimum required distance to allow the formation of chains of flows in the space between them.

The dykes are longitudinal to the river and, in case of being supported in the margins; they work as shields or coverings the margins. Often, when the dikes are far from land, it is build up interiors spikes in order to strengthen them and prevent the formation of new channels in case of it breaks, and also increase the deposition of material.

In the case of inland navigation, the regularization of the river bed is not normally focus in the middle of the riverbed, where the speeds and turbulence of the flow is higher, as well as the high transportation of big solids, like tree trunks, as in the case of the Madeira River.

Due to the large number of variables involved in the process of river regularization and to the performing of dredging, deep studies must be carried out in order to analyze the unique conditions of each river, beyond the use of physical and mathematical models as tools for decision support, being also indispensable to test the solutions direct in the rivers. It is suggested, therefore, that the execution of these works be done in steps, attempting to assess the reactions of each step on the river themselves.

A successful case is the Mississippi River in the United States, consisting on a plain river, with many meander sections and a high sedimentation rate. Many dikes and spikes were built in this river enabling navigation in difficult sections and upgrading commercial shipping to a level of 300 million tons of cargo per year.

Once the problems with fixed riverbed are generally of small extension, and with the development of techniques for the construction of dams and locks, regularization works for fixed riverbed sections are hardly used.

The main rivers studied that require interventions of this type are: Araguaia, Tocantins, Parnaíba, and sections of the Tapajós, Madeira and Jacuí rivers.

The summary of the main interventions in the selected rivers in this study is presented in Table 2, item 2.5.

2.4 Criteria and considerations adopted for the estimation of the costs of the physical interventions

The identification of the obstacles to navigation, the proposed solutions, and the estimative costs of the interventions were based on existing and available information. So, when known and quantified a natural obstacle to navigation, the estimated costs was based directly on the information (volumes) provided and on the unit costs considered in this study; when the quantification of the work needed to overcome an obstacle is more difficult due to the lack of information and to the high uncertainty involved, the cost estimative was based on benchmarks from other similar works and projects considered suitable by Arcadis Logos experts.

It is emphasized that the costs indicated consist on estimations, subject to changes according to new field surveys and the development of additional studies. The main criteria adopted for the estimation of costs are as follows:

- It was considered that the Hydroelectric Power Plants planned to be built in the selected rivers, according to Hydroelectric Master Plans approved by ANEEL, will be built until the the horizon in 2031, so no interventions are predicted to be necessary in the sections hereafter flooded by the reservoirs;
- Unit Cost of Dregding: 15 R$/m³;
- Unit Cost of rock demolition: variable between 300 e 600 R$/m³;
- The costs of regularization of rivers oscillated around the median value of R$ 4 Million/linear km of river, with variations depending on the particular conditions of each river;
- The estimated costs are linked to the convoys type adopted for each waterway;
- The preliminary dimensions considered for the navigable channels followed PIANC standards;
- The estimation of the cost of remodeling or reconstruction of bridges followed DNIT reference values;
- The preliminary analysis of the regional costs of the physical interventions indicated that there is no significant variation between the overall values of unit costs between the regions of Brazil. While the costs of materials and equipment are higher in the North and Northeast, in comparison to the South and Southeast, the costs of manpower are lower, balancing the overall costs;
- When the level of uncertain concerning the costs of physical interventions is high, it was opted for conservative values;
- The values considered already cover the costs of signaling; and
- It was not considered the social and environmental costs of the proposed physical interventions.

2.5 Physical Interventions Costs

The following tables present briefly the physical interventions proposed in the riverbeds. It is emphasized that the costs related to the construction of locks systems are presented in section 3 of this Annex.

Table 2. Physical Interventions on the selected rivers

River	Convoy Mín	Convoy Máx	Problem	Solution	Estimate Cost (R$)
Jacuí	Self Propelled convoy (16m x 110m x 2,5m)		Localized sedimentation areas (Sand bars e river islands) and rocks - Maintenance is required	Rock demolition / Dredging	80.000.000
			Localized sedimentation areas (Sand bars e river islands), rocks e river bank erosion, along 170 km	River bank strenghtening / Dredging / Rock demolition / Signaling	680.000.000
Taquari			Low water depth, rock outcrops and sand bars, located downstream of the Bom Retiro dam	Rock demolition / Dredging	500.000.000
Solimões / Negro rivers)	4x5 (55m x 268m x 4,0m)		During dry season there are some restrictive stretches for large ships due to the presence of moving sandbars and some rocks in the margins	Signaling	50.000.000
Amazon river / Canal de Breves			Narrowing sections, lack of signaling	Readjustment of routes / Signaling	250.000.000
Madeira	4x5 (55m x 268m x 2,5m)		River bank erosion, sedimentation, river islands, which are critical during ebb season on the upstream river sections	River banks strenghtening / Dredging	800.000.000
			During the ebb season, upstream to Manicoré, rapids occur and rocks appear. The most critical section is between	Rock demolition	1.000.000.000
				Signaling	200.000.000
Paraguai	4x4 (44m x 268m x 2,5m)		Small radius bend (Volta do Rebojo)	Channel improvements	50.000.000
			Bridges (BR-262 e railway) with narrow spans, splitting is required	Span enlargement and heightening of bridges	200.000.000
	3x2 (22m x 198m x 2,5 m)		Narrow sections, with high sinuosity index, sedimentation and low depths, mainly between Morrinhos and Cáceres (140 km), during dry season	Channeling / Dredging / Rock demolition / River bank strenghtening	2.048.000.000
Parnaíba	2x2 (22m x 138m x 2,5m)		Sedimentation restrictions (Sand bars, river islands), rocks and low water depth between Teresina and UHE Castelhano, along 95 km, with 19 m of height difference	River bank strenghtening / Dredging / Rock demolition / Signalings	860.000.000
			Low water depth between the end of the reservoirs and the upstream dams, along 60 km	River bank strenghtening / Dredging / Rock demolition / Signalings	900.000.000
			Low water depth between the end of the reservoirs and the upstream dams, along 30 km	River bank strenghtening / Dredging / Rock demolition / Signalings	450.000.000
Balsas			Low water depth between the end of the UHE Uruçuí reservoir and the UHE Taboa, along 20 km	River bank strenghtening/ Dredging / Rock demolition / Signalings	300.000.000

Table 2. Physical Interventions on the selected rivers (continuation)

River	Convoy Mín	Convoy Máx	Problem	Solution	Estimate Cost (R$)
São Francisco	2x2 (16m x 118m x 1,8m)	2x4 (32m x 118m x 1,8m)	Section downstream from the UHE Sobradinho of 40 km long, with granite bottom, which restricts the navigation of convoys with a draught of 2,0 m	Rock demolition of the Channel	24.000.000
			The convoys passing through the Sobradinho Lock need to be splitted and a mooring point is required	Improvement of the current lock and construction of additional structures	15.000.000
			Sand bars, river islands, low water depths between Pilão Arcado and Ibotirama along 305 km	Dredging / Signalings	5.500.000
			River bank erosion, sinuosity sections, narrowing between Xique-Xique and Ibotirama, along 200 km	River bank strenghtening	64.000.000
			Meleiro rock formation, with 40.000 m³ of quartzo	Rock demolition	24.000.000
			Sand bars, river inslands, low water depth between Ibotirama and Bom Jesus da lapa, along 140 km	Dredging / Signalings	5.500.000
			River bank erosion, sinuosity sections, narrowings between Ibotirama and Bom Jesus da Lapa, along 140 km	River bank strenghtening	30.000.000
			Sand bars, river islands, low water depth between Bom Jesus da Lapa and Pirapora, along 590 km	Dredging / Signalings	14.000.000
			River bank erosion, sinuosity sections and narrowings between Bom Jesus da Lapa and Pirapora, along 590 km	River bank strenghtening	50.000.000
			Limestone formation between Bom Jesus da Lapa and Pirapora, with a volume of approximately 100.000m³	Rock demolition	30.000.000
Tietê	2x2 (22m x 138m x 2,5m)		Downstream to the UHE Nova Avanhandava, there is a 5 km section composed with basaltic rocks that restrict the navigation of convoys with draughts higher than 2,5 m	Rock demolition of the Channel	360.000.000
			The span of the SP-191 is small, only Tietê convoy (2x1) can pass	Widening of the span and heightening of the bridge	20.000.000
			The span of the SP-147 is small, only Tietê convoy can pass	Widening of the span and heightening of the bridge	20.000.000
			Sedimentation restrictions, rocks, narrowings, high sinuosities at the end of the UHE Barra Bonita reservoir up to Salto, with a height difference of 50 m, and 250 km long	Construction of 4 dams with locks (Anhembi, Laranjal, Tietê and Porto Feliz) e 2.700.000m³ of Dredging works + Rock demolition	2.700.000.000
			4 Bridges and 1 footbridge that restricts the navigation of commercial convoys in Tietê and Porto Feliz	Bridge reconstruction	90.000.000
Araguaia	2x2 (22m x 138m x 2,5m)		Sand bars, river islands, rocks and low water depths, between the end of the UHE Marabá reservoir (next to Araguatins) and the UHE Santa Isabel dam, with about 32 km long	River bank strenghtening / Dredging / Rock demolition / Signalings	200.000.000
			Sand bars, river islands, rocks and low water depth between the end of the UHE Santa Isabel (next to Xambioá) and the UHE Araguanã dam, with about 30 km long	River bank strenghtening / Dredging / Rock demolition / Signalings	200.000.000
			Sand bars, river islands, rocks and low water depth between the end of the UHE Araguanã reservoir and the Conceição do Araguaia municipality, with about 210 km long	River bank strenghtening / Dredging / Rock demolition / Signalings	1.800.000.000
			Several rock outcrops, Sand bars, river islands, sinuosity sections and low water depth along 485 km and height difference of 40 m. ***	River bank strenghtening / Dredging / Rock demolition / Signalings	4.000.000.000
			Several rock outcrops, sand bars, river islands, river bank erosion, sinuosity sections, narrowings and low water depth along 500 km and height difference of 60m. ***	River bank strenghtening / Dredging / Rock demolition / Signalings	4.000.000.000

Table 2. Physical Interventions on the selected rivers (continuation)

River	Convoy		Problem	Solution	Estimate Cost (R$)
	Mín	Máx			
Tocantins	2x2 (22m x 138m x 2,5m)	3x2 (22m x 200m x 2,5m)	Long Rock outcrops (Pedral de São Lourenço) at the end of the UHE Tucuruí reservoir, with 42 km long	Rock demolition	660.000.000
			Sandbar, river islands, rocks, low water depth between the city of Tauri and Marabá, with 52 km long	River bank strenghtening / Dredging / Rock demolition / Signalings	180.000.000
			Sand bars, illhas fluviais, rocks and low water depth between the end of the UHE Marabá reservoir (next to São Sebastião do Tocantins city) and the UHE Serra Quebrada (next to Imperatriz city), with 40 km	River bank strenghtening / Dredging / Rock demolition / Signalings	700.000.000
			Sand bars, river islands, rocks and low water depth between the end of the UHE Serra Quebrada reservoir (next to Porto Franco city) and the UHE Estreito (próximo à cidade de Estreito) dam, with about 32 km long	River bank strenghtening / Dredging / Rock demolition / Signalings	200.000.000
			Sand bars, river islands, rocks and low water depth between the end of the UHE Estreito reservoir and the UHE Tupiratins dam, with about 71 km long	River bank strenghtening / Dredging / Rock demolition / Signalings	450.000.000
Tapajós	2x2 (22m x 138m x 2,5m)	3x2 (22m x 200m x 2,5m)	River bank strenghtening / Rock demolition / Dredging / Signaling	Dreadging	80.000.000
			Section with rapids and rocks, 20 km long and height difference of 14 m, downstream of the future UHE São Luis do Tapajós	Channel / Barragem com eclusa / Rock demolition / Signaling	500.000.000
			Section with several rocks between the end of the UHE Jatobá reservoir and the dam UHE Chacorão	Rock demolition / Dredging / Signaling	560.000.000
			Height difference of about 10 m. Distance of 150 km from the UHE Chacorão reservoir end and the beggining of the Cachoeira Rasteira rapid	Rock demolition / Dredging / Signaling	500.000.000
			Access to Cachoera Rasteira terminal	Construction of a road	461.000.000

3. Construction of Lock Systems

The main criteria and considerations for estimating the size and cost of the locks are indicated below:

- The estimated costs can change significantly due to the refinement of studies;
- The dimensions of the locks have been estimated according to the convoys adopted for each waterway and each strategy, with the maximum dimensions of 24m x 210m. Convoys adopted are those presented in Section 5.2 of this report. The table below shows the convoys considered;

Table 3. Convoys Adopted

River	Selected Stretch	Convoy	
		Required Minimum Quality Level	Realistic Maximum Quality Level
Amazon	Foz - Coari	4x5 (55m x 268m x 4,0m)	4x5 (55m x 268m x 4,0m)
Madeira	Itacoatiara - Porto Velho	4x5 (55m x 268m x 2,5m)	4x5 (55m x 268m x 2,5m)
Tapajos	Santarém - Itaituba	2x2 (22m x 138m x 2,5m)	3x2 (22m x 200m x 2,5m)
	Itaituba - Cachoeira Rasteira		
Tocantins	Vila do Conde - Marabá	2x2 (22m x 138m x 2,5m)	3x2 (22m x 200m x 2,5m)
	Marabá - Miracema do Tocantins		
Araguaia	Maraba-Conceicao	2x2 (22m x 138m x 2,5m)	2x2 (22m x 138m x 2,5m)
	Conceicao-São Felix		
	São Felix-Aruana		
Parnaiba	Teresina-Urucui	2x2 (22m x 138m x 2,5m)	2x2 (22m x 138m x 2,5m)
	Urucui-Santa Filomena		
	Urucui-Balsas		
Paraguay	Foz rio Apa - Corumbá	4x4 (44m x 268m x 2,5m)	4x4 (44m x 268m x 2,5m)
	Corumbá - Cáceres	3x2 (22m x 198m x 2,5 m)	3x2 (22m x 198m x 2,5 m)
Tietê - Paraná	Três Lagoas - Pereira Barreto	2x2 (22m x 138m x 2,5m)	2x2 (22m x 138m x 2,5m)
	Pereira Barreto - Pederneiras		
	Pederneiras - Salto		
South (Jacuí - Taquari)	Rio Grande - Porto Alegre	Self Propelled (16m x 110m x 4,5m)	Self Propelled (16m x 110m x 4,5m)
	Porto Alegre - Triunfo	Self Propelled (16m x 110m x 4,5m)	Self Propelled (16m x 110m x 4,5m)
	Triunfo - Cachoeira do Sul		
	Triunfo - Estrela		
Sao Franscisco	Petrolina - Ibotirama	2x2 (16m x 118m x 1,8m)	2x4 (32m x 118m x 1,8m)
	Ibotirama - Pirapora		

- Extrapolation of the costs between the different locks was based on the internal chambers dimensions and on the falls of the locks in question;
- The estimated costs consider the necessary civil works, electromechanical systems, auxiliary channels and operating systems;
- The locks expected to be constructed in planned Hydroelectric Power Plants will be built simultaneously with the corresponding power plants;
- The implantation of double locks, in parallel, (mainly Top Quality Strategy) was adopted to ensure reliability and flexibility to the waterway system. The Costs were estimated in two different ways: A) If the lock systems are going to be built together, the total cost has been adopted as 1.8 X Cost of the construction of an individual lock. B) In the case of building an additional lock system to an existent one, the cost was adopted for the new as a new locks system;
- It was chosen conservative values of costs, depending on the technical, political and economic uncertainties involved;
- Costs are valid for the date base of December 2012;
- It was not considered social and environmental costs of the proposed works.

3.1 Tocantins Waterway

The estimated cost of locks proposed to be implemented on the Tocantins River were based on the document "Diretrizes da Política Nacional de Transporte Hidroviário", elaborated by the Ministry of Transport in December 2010, and based on the costs of the lock systems of the HPP of Tucuruí, concluded in December 2011. These values were analyzed and critically evaluated in Arcadis Logos. Moreover, it was considered that the costs mentioned for the Tocantins River locks refer to a dimension of 25m x 210m.

The minimum convoy adopted by the PHE to Tocantins Waterway System was defined as 2x2, with barges of 11m x 60m, resulting in the need for a lock with dimensions of approximately 24m in width and 150m in length.

The greatest convoy adopted (Top Quality) was defined as 2x3, barges of the same size, resulting in the need of a lock with dimensions of 24m in width and 210m in length.

Based on the data collected, the values were corrected and updated to the date of December 2012, resulting in the following costs:

Table 4. Estimated Costs of Locks in Tocantins Waterway System

Waterway System	Tocantins - Araguaia		
river	Tocantins		
Locks	Dimensions	Drop (m)	Estimated Cost (R$)
UHE Marabá	24m x 150m x 3,5m	23	350.000.000
	2 X (24m x 210m x 3,5m)		810.000.000
UHE Serra Quebrada	24m x 150m x 3,5m	27	400.000.000
	2 X (24m x 210m x 3,5m)		738.000.000
UHE Estreito	24m x 150m x 3,5m	26	640.000.000
	2 X (24m x 210m x 3,5m)		1.296.000.000
UHE Tupiratins	24m x 150m x 3,5m	14	200.000.000
	2 X (24m x 210m x 3,5m)		450.000.000

It is noteworthy that since the Estreito power plant is already built and in operation, the costs of the locks on this HPP are substantially higher than the estimated values of the locks of Marabá, Serra Quebrada, Tupiratins and Ipueiras, considered to be built simultaneously with the construction of the correspondents HPPs. This additional cost is due the increased technical complexity involved in the construction of locks on dams already built. Besides, the lock system of HPP Estreito will need an intermediate channel with about 500 m length, burdening the costs for transposition of ships on this HPP.

3.2 Araguaia Waterway

The cost presented in the document "Diretrizes da Política Nacional de Transporte Hidroviário" for the lock of Santa Isabel (R$ 131,75 million) was considered divergent and lower than the estimated costs for the locks in other waterway systems. Thus, the costs of the locks on Araguaia River were adopted based on the costs of the locks planned for Tocantins River, adjusted according to the slope and internal dimensions of the chambers of the locks. The values considered were:

Table 5. Estimated Costs of Locks in Araguaia Waterway System

Waterway System	Tocantins - Araguaia		
river	Araguaia		
Locks	Dimensions	Drop (m)	Estimated Cost (R$)
UHE Santa Isabel	24m x 150m x 3,5m	26	410.000.000
UHE Araguanã	24m x 150m x 3,5m	14	220.000.000

For comparison purposes, the PNLT-2012 (National Plan for Transportation Logistics) does not consider the construction of a hydropower plants on this river and adopts the construction of an artificial canal, parallel to the rapids of Santa Isabel, with a cost of R$ 600 million, concordant with the solution and cost estimates in this study, which considers the construction of a lock in the future HPP Santa Isabel.

The lock system proposed for HPP Marabá, considered both in Tocantins and Araguaia Waterway System, has dimensions linked to the Tocantins Waterway System and has maximum dimensions of 24m by 210m, higher than the dimensions considered in the locks of Santa Isabel and Araguanã. The reason is related to the necessity of matching dimensions of Marabá lock with other locks already built and designed in this study to the Tocantins River.

3.3 Tapajós – Teles Pires Waterway

The same way as the lock systems in the Tocantins River, the costs of the locks of the Tapajós - Teles Pires WaterwaySystem was based on the conclusions of that document, prepared by the Ministry of Transportation, and updated to the base date of 2012. It was considered that the costs of the locks for the Tapajós River, presented in this document, refer to locks with 24m x 210m long. The proposed values proved to be consistent with the cost of the newly built lock of Tucuruí, with the estimated cost for the lock at Lajeado, in Tocantins River, and with the new locks planned for the Tietê River.

The minimum convoy adopted for use in Tapajós - Teles Pires waterway has 2x2 dimensions (barges of 11m x 60m) and the maximum considered has 3x2 dimensions (barges of the same size).

Thus, in the strategies that support the minimum convoy passage, were considered locks which allow the passage of a convoy 2x2, resulting in a dimension of 24m x 150m, smaller than the dimensions estimated by the Ministry of Transport.

On the strategies that consider the maximum quality it was considered systems of double locks, with dimensions of 24m x 210m, taking the document from the Ministry of Transportation as the main basis for the estimations of the cost.

The table below shows the final values considered.

Table 6. Estimated Costs of Locks in Tapajós – Teles Pires Waterway System

Waterway System	Tapajós - Teles Pires		
river	Tapajós - Teles Pires		
Locks	Dimensions	Drop (m)	Estimated Cost (R$)
Downstream of UHE São Luís do Tapajós	24m x 150m x 3,5m	14	500.000.000
	2 X (24m x 210m x 3,5m)		900.000.000
UHE São Luís do Tapajós	24m x 150m x 3,5m	36	650.000.000
	2 X (24m x 210m x 3,5m)		1.555.200.000
UHE Jatobá	24m x 150m x 3,5m	29	300.000.000
	2 X (24m x 210m x 3,5m)		691.200.000
UHE Chacorão	24m x 150m x 3,5m	25	450.000.000
	2 X (24m x 210m x 3,5m)		1.339.200.000

It is emphasized that the lock required in the future HPP São Luís do Tapajós has 36 m drop, which increases considerably the costs compared to the other locks.

Downstream of HPP São Luís do Tapajós there is a section of 20 km length, with a 14m drop. The proposed solution to make the section navigable consists on a system of canals and locks, crossing the section now occupied by a series of rapids made by a high hardness rock.

3.4 Tietê - Paraná Waterway

In this study it is predicted the construction of lock systems in the HPPs Três Irmãos, Nova Avanhandava, Promissão Ibitinga, Bariri and Barra Bonita, parallel to the existing ones. Furthermore, in the section between the end of the Barra Bonita Reservoir and the city of Salto (SP) is predicted the construction of four new hydropower power plants, which will require systems locks. All the new lock systems were considered with internal chambers with 24m x 144m of dimensions.

To estimate the costs for lock systems in Três Irmãos, Nova Avanhandava, Promissão Ibitinga, Bariri and Bonita HPPs were adopted the values mentioned in the document "Diretrizes da Política Nacional de Transporte Hidroviário", which are coherent with the costs of locks in other waterway systems.

Arcadis Logos presented recently to ANEEL, the Revision of the Hydroelectric Master Plant, between the end of Barra Bonita reservoir and the tailrace channel of HPP Tietê, which calculated the costs for the construction of locks in future HPPs Anhembi and Laranjal. These dams have about 15 m drop and the locks were designed with internal chambers with 24 m wide and 144 m long, with the expected cost of approximately R$ 200 million per lock, and R$ 350 million per dam. The dimensions of this locks were defined by Waterways Department of the State of São Paulo, the body responsible for maintaining, monitoring, enforcement and planning of waterways of the State of São Paulo. The estimated cost of these locks were compared to the values indicated in the document "Diretrizes da Política Nacional de Transporte Hidroviário" for new locks in the existing HPPs in the Tietê River, which were considered concordant.

Thus, for the locks of Três Irmãos, Bariri, Ibitinga, Promissão, Nova Avanhandava and Barra Bonita were adopted the size and cost of the mentioned document from the Ministry of Transport, updated to the date of December 2012. To set the locks upstream of Barra Bonita were adopted the experience values of of Arcadis Logos.

Table 7. Estimated Costs of Locks in Tietê - Paraná Waterway System

Waterway System	Tietê - Paraná		
river	Tietê		
Locks	Dimensions	Drop (m)	Estimated Cost (R$)
UHE Três Irmãos	24m x 144m x 3,5m	51,0	900.000.000
UHE Nova Avanhandava	24m x 144m x 3,5m	31,0	840.000.000
UHE Promissão	24m x 144m x 3,5m	28,0	370.000.000
UHE Ibitinga	24m x 144m x 3,5m	24,0	330.000.000
UHE Bariri	24m x 144m x 3,5m	24,0	330.000.000
UHE Barra Bonita	24m x 144m x 3,5m	25,0	330.000.000
UHE Anhembi	24m x 144m x 3,5m	13,5	200.000.000
UHE Laranjal	24m x 144m x 3,5m	13,0	200.000.000
UHE Tietê	24m x 144m x 3,5m	12,0	200.000.000
UHE Porto Feliz	24m x 144m x 3,5m	13,0	200.000.000

It is highlighted the following considerations:

The Três Irmãos HPP has a drop of 51m, and the current lock system consists of two chambers, interspersed by a canal of about 900m length. This configuration justifies the higher cost expected for a new locks system.

Nova Avanhandava HPP, as in the previous situation, has a lock system composed of two chambers and an intermediary canal, in concrete, with 600m, resulting in high costs.

3.5 Parnaíba Waterway

To determine the costs of the locks in Parnaíba River the following considerations were made:

- The PHE proposes a 2x2 convoy in Parnaíba WS, with 22 m wide and 140 m long;
- It is expected, in the present study, the construction of lock systems in the HPPs planned by Electricity Sector (HPPs Castelhano, Estreito , Cachoeira , Uruçuí and Ribeiro Gonçalves) with the dimensions of 24 m wide and 150 m long;
- The unfinished lock of HPP Boa Esperança has 50 m long and 12 m wide, inadequate for the passage of the reference convoys proposed in this study. Furthermore, the unfinished infrastructure and neglected for 30 years was considered unsuitable for use. Thus, it is proposed to build a new system of locks in this HPP, whose costs have been estimated according with the locks revised as the assumptions mentioned in the previous items.
- It was considered that the costs of the locks in Parnaíba river, presented in the document "Diretrizes da Política Nacional de Transporte Hidroviário" are related with locks with dimensions of 12m x 50m, far from the dimensions proposed in this study;
- Due to the similarities between the locks proposed on the Parnaíba and the new planned locks on the Tietê river, the adopted cost in Parnaíba were based on Tietê locks, making further adjustments due to the drop of each lock;

The costs adopted are presented below:

Table 8. Estimated Costs of Locks in Parnaiba Waterway System

Waterway System	Parnaíba		
river	Parnaíba e Balsas		
Locks	Dimensions	Drop (m)	Estimated Cost (R$)
UHE Castelhano	24m x 150m x 3,5m	15,5	200.000.000
UHE Estreito	24m x 150m x 3,5m	25,0	300.000.000
UHE Cachoeira	24m x 150m x 3,5m	15,4	200.000.000
UHE Boa Esperança	24m x 150m x 3,5m	44,0	520.000.000
UHE Uruçuí	24m x 150m x 3,5m	29,6	400.000.000
UHE Ribeiro Gonçalves	24m x 150m x 3,5m	53,0	600.000.000
UHE Canto do Rio	24m x 150m x 3,5m	30,0	400.000.000
UHE Taboa	24m x 150m x 3,5m	40,0	600.000.000

3.6 South Waterway

This study considers, for the scenario of maximum quality, the duplication of the existent locks in Jacuí River, especially the locks of Amarópolis and Anel de Dom Marco, and the existent lock of Bom Retiro, in Taquari river. The existing locks have 17 m wide and 120 m long, with falls varying between 5 and 8 m.

To estimate the costs of these new lock systems have been adopted the reference values of the new planned locks on the Tietê River. Further adjustments have been made in the prices, depending on the difference of falls of the locks, which are lower on the locks of the South Waterway System. It was also considered also a minimal cost of implementation, which limited limited inferiorly the costs of the locks. The values considered are presented in the following table.

Table 9. Custos previstos para as eclusas do SH do Atlântico Sul

Waterway System	Atlântico Sul		
river	Lagoa dos Patos, Jacuí, Taquari		
Locks	Dimensions	Drop (m)	Estimated Cost (R$)
Amarópolis	17m x 120m x 3,5m	4,6	90.000.000
Anel de Dom Marco	17m x 120m x 3,5m	7,1	95.000.000
Bom Retiro	17m x 120m x 3,5m	8,0	95.000.000

ANNEX C: STRUCTURE OF CBA-MODEL

Objectives

Specifically for agricultural commodities soy, soymeal and corn from the central states of Brazil, competition exists between several routes for the export of these commodities. Given the number of options and the possible changes in the future, the construction of a combined cost benefit and modal split model was deemed to be an adequate solution to assess the different options in an efficient and consistent manner. The CBA_MS model serves two main goals:

1. Providing information on transport flows for different IWT strategies
2. Providing information about transport costs as an input for CBA analysisanalysis

Regions and commodities

For each relevant Brazilian state a separate model has been constructed:

1. Mato Grosso (22 micro regions)
2. Goiás + DF (19 micro regions)
3. Maranhão (21 micro regions)
4. Tocantins (8 micro regions)
5. Bahia (32 micro regions)
6. Piauí (15 micro regions)
7. Mato Grosso do Sul (11 micro regions)

The numbers of transport chains (routes) differ per region. For Mato Grosso 23 routes have been constructed. For other states like Piauí or Tocantins the number is less. The user can add additional routes.

The commodities in the models are:

1. Soy (exports)
2. Soymeal (exports)
3. Corn (exports)
4. Fertilizers (imports)

In the diagnosis phase of the project forecasts per state have been made for these products. The production per micro-region is obtained from IBGE (agricultural production by micro-region 2011). The share in 2011 is kept constant in the period 2011 - 2031. For the exports of soymeal the share of soy is used. The imports of fertilizers are calculated on the basis of the production in tons of soy and corn. This procedure results in the export of soy, soymeal and corn and the imports of fertilizers per micro-region for the period 2011 – 2031. A more detailed description can be found in the Diagnosis report.

Transport chains

For each micro-region transport chains (= route form micro-region to seaport) have been selected. For Mato Grosso in total 23 transport chains have been selected, consisting of existing transport chains (e.g. by road to Santos or by IWT to Itacoatiara) and transport chains that will be developed (new rail connections, new waterways and new road connections to ports). Each transport chain can be selected or deselected. In this way alternatives can be built. An example: In alternative 1 the transport chains (routes) via Tapajós, Tocantins and Araguaia are not selected. In Alternative 2 these routes are selected. By comparing the results from alternative 1 and alternative 2 the effects of the new routes on modal/route choice and ultimately on transport cost (savings) can be assessed.

Set up of the CBA model

The CBA calculation sheet is the core of the model. The calculation is done per micro-region. For each micro region a number of routes are defined. For these routes the transport costs, including transshipment costs, are calculated. The first step is to determine the three least costs routes. The main reason to choose for three routes is that in reality producers will almost always use more than one route to assure exports in case one of the routes is blocked due to strikes, weather conditions or accidents. Three routes seem to be an adequate number of possible routes. Note that for each micro region within a state these three routes may be different. A look at the map of e.g. Mato Grosso makes clear that northern production regions (like Alto Teles Pires) have other least cost routes than southern production regions (like Rondonópolis).

The transport costs are used to calculate the market share of each of these three routes. The philosophy behind this is that the cheaper a route, the higher the market share. A logit model is used for calculation the market shares of the routes. The formula: Share = $EXP^{\alpha * TC}$ In this formula α stands for the logit exponent which is -0.02. This is based on information from other research on market share in port choice projects. TC stands for (normalized) transport costs.

With the share of routes (in tons) and the costs of these routes (in R$ per ton) all necessary calculation have been made.

Description of worksheets CBA model

Dashboard

The dashboard is the central place for input of parameters and output of calculations.

INPUT options

A. Selection of strategy

The first option (in cell A1) is to select a strategy for waterways. The choice is between Maintenance+ (M+=1), Expand (EXP=2), Top Quality (TQ=3) or Mixed (4). The choice for M+, EXP or TQ defines the capacity and transport costs per ton for all waterways involved. A choice for Mixed strategy gives the opportunity to make a choice of either M+, EXP or TQ per waterway. In this way a mixed strategy of waterways can be evaluated. In row 11 the mixed strategy can be defined. Notice that this is only effective if cell A1 has the value 4.

B. Selection of routes

In rows 2 and 3 the routes that should be included in the evaluation can be selected. 1 (green) means that a route is selected. 0 (red) means that a route is deselected. The selection of two alternatives makes it possible to assess the differences between two sets of routes. It is possible to select strategy 2A as alternative 1 and strategy 2B as alternative 2. The results are given for both alternatives. Another option is to select no waterways in alternative 1 and all waterways in alternative 2. The result is the contribution of the waterway system as a whole in the transport system.

C. Selection of commodity

The models include soy, soymeal, corn and fertilizers. In row 69 the commodity can be selected. It is also possible to select the total of the mentioned commodities. Only one commodity should be selected. If more than one is selected, the leftmost cell will be used. This selection is used for two goals: calculation the tons in a selected year or the net present value (NPV) calculation. Any year between 2011 and 2031 can be selected in cell R80 (selection of forecast year). If a year between 2011 and 2020 is selected, make sure that cell R78 has the value 1. If calculations op NPV have to be made, the years between 2011 and 2020 should be left out, because in this period the investments will be made and no benefits occur. Deselecting the years between 2011 and 2020 can be done by giving cell R78 the value 0.

D. Selection of input parameters

A number of input parameters can be changed. In the cells R70 – R75 the discount rate, the logit exponent, the costs of road transport and the transshipment costs can be set. To make this effective cell R 69 should have the value 1. If not the default value is chosen. The discount rate (default value 6.25%) is important in calculation the net present value (NPV). The higher the discount rate, the less future costs and benefits contribute to the results. The logit exponent is important in the calculation of the markets share (see tab CBA_Model for more information). The formula: Market share = $EXP^{\alpha * TC}$. In this formula α stands for the logit exponent (-0.02) and TC represents the transport costs. The value of -0.02 is derived from other studies on transport costs and market share. The costs of road transport are calculated on the basis of the cost model form the University of Sao Paulo. Based on the results of this model a function is calculated between distance and transport costs. The formula: TC = 33.41 + 0.16* distance. The Constant (33.41) and the variable part (0.16) can be changed. The transshipment costs (R74 and R75) are estimated at R$ 5 per ton for both transshipment between road and IWT and road and rail. These figures are based on the interviews. It is possible to use other transshipment values and evaluate the effects on the results.

E. Selection of forecast year and include / exclude 2011-2020

Cell R78 should have a value 1 to select the years between 2011 and 2020. Any other value excludes this period. The reason behind this option is the calculation of the NPV. The assumption is that investments will take place between 2015 and 2020 and the first benefits will occur in 2021. For NPV calculations the years between 2011 and 2020 should be left out. However to calculate the market share in e.g. 2015 the period 2011 – 2020 should be included. Cell R80 should be given a value between 2011 and 2031 to select the forecast year.

Output

The results are presented in an information block, four result blocks and a summary. The first block (row 4 to 12) gives information on the transport chains. For every transport chain in the model the mode of transport and the terminals are given. The color conventions are: road is red, IWT is blue and rail is green. If a mode occurs in the information block, it is also represented in the result blocks with the same color. A number of transport chains is empty and can be used for additional chains. The tons per ship given in row 12 correspond with the strategy (cell A1= 1, 2 or 3) or row 11 in case of mixed strategy (A1=4)

Result block 1 (row 14 to 22): modal split in ton-kilometers (* 1,000)

For every selected route the ton-kilometers are calculated. Note that only the colored cells can contain information on logical grounds. If e.g. a route contains only road and IWT, rail transport will not be possible. Only red cells (for road) and blue cells (for IWT) can in that case have a value. Green cells are used for rail transport. Not every colored cell will contain information because not all routes will probably be used. The results are divided in results for alternative 1 and results for alternative 2. If the same routes are selected, the results for alternative 1 and alternative 2 will be the same. If however for alternative 1 and alternative 2 different sets of routes are selected, the results will most likely differ[21].

Result block 2 (row 24 to 32) vehicle kilometers (* 1,000)

This block contains information on vehicle kilometers. This information is important for calculation e.g. emissions of CO_2 or NO_x. It is important to mention that the assumption is that all vehicles will have a load of 100% in one direction and 0% in the opposite direction. This means that the calculated kilometers with cargo have to be multiplied by two to get the total vehicle kilometers. For road transport the load is 50 tons, for rail 2.000 tons and for waterway transport is depends on the strategy. The tons for IWT are given in row 12 (tons per ship).

Result block 3 (row 34 to 42) modal split in tons (* 1,000)

This block contains information on transported tons. The presentation is similar to the other blocks. Per route the transported number of tons is given. Note that road transport will always be present as no IWT or rail terminal is directly accessible from the production area. Pre haulage by road is always necessary.

Result block 4 (row 44 to 52) Transport costs in R$ (* 1,000)

Gives the results of the costs per route (tons multiplied by transport costs per ton). Only cells with information in the previous blocks will have transport costs.

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[21] It is (theoretically) possible that routes differ in alternative 1 and 2 and results are the same. The explanation is that routes that are selected in alternative 1 and deselected in alternative 2 are not used in alternative 1. Deselecting will in that case have no influence on the results.

Summary (row 54 tot 65)

In the summary the results of the individual chains are added to give a total per transport mode. The first information item is transport costs. These are given per mode for alternative 1 and alternative 2. If differences between these two alternatives exist, this is given in cells D57 to D60. The differences in transport costs between alternatives represent the most important benefits from investments in waterway infrastructure.

The modal split in ton-kilometers is given in totals and percentages. The transport performance, measured in ton-kilometers is the most reliable way to compare modalities because both the tons and the distance are considered in this measurement.

The last (additional) information item is on transport distance per mode.

Input Worksheets

The next three sheets (TC, Distance + Costs and Exports_Import) are all inputs for the calculations

TC (Transport Costs)

TC calculates the transport costs for IWT and rail. The most important assumptions are given. The actual calculation of the transport costs takes place with the help of the IWT calculation model developed for PHE by the University of Sao Paulo. In the tab, for each chain the assumptions are given and the transport costs per mode of transport are presented. For inland waterways the results are given per strategy. The results of TC will be used in tab Distance + Costs.

Distance + Costs

For each transport chain the distance per mode of transport is calculated. For road transport this is the distance to the first terminal (IWT or rail) or, in the case only road transport is used, the distance to the seaport. The distances are calculated with the help of Google maps. Adjustments have been made in cases where specific routes are used (especially in the vicinity of Sao Paulo) or in case no roads existed (Cachoeira Rasteira). The second part of this sheet consists of the transport costs. For road a function is used (TC road = 33.41 + 0.16* distance). For other modes the results from sheet TC are used as an input. Notice that the transport costs for IWT depend on the strategy chosen. If a chain is not defined or not selected, the transport costs for road have been set to 9.999 to prevent this route from being among the three cheapest routes.

Exports_Import

The forecasts for exports of agricultural products are based on the diagnoses report. These results are refined to a micro-region level. The production of soy and corn in 2011 per micro-region (source IBGE) has been used as a starting point. For each micro-region per state the exports of soy, soymeal and corn can be found in this sheet. The imports of fertilizers have been calculated by using the production of soy and corn. The bigger the production of soy and corn is, the bigger the imports of fertilizers.

CBA_Model

This sheet constitutes the core of the calculations. In the first part (columns C to Z) the transport costs per selected route are given. If a route is not selected in the sheet ‘Dashboard’, the value is set to 9.999 to prevent the route from being a low cost route. The next part of the CBA_Model (columns AB, AC and AD) selects the lowest three routes per micro-region. The transport costs are then used to calculate the market share of these routes. In order to do this a logit model is used. The larger the transport costs differences, the larger the differences in market share. To eliminate the role of currencies the transport costs are normalized (without normalization the results will be different for R$, Euro or $). To give an indication the following example: If transport costs are 50% higher, the market share is 2.7 times lower (73-27). If transport costs are 100% higher, the market share is 7.4 times lower (88-12). The transport costs are then calculated by multiplying the transport costs per ton and the tons transported.

A1chain1… A3chain2

These six sheets extract results from the worksheet **CBA_Model**. In A1chain1 the lowest cost route is extracted. Some calculations are carried out to determine the transport performance (ton-kilometers), the tons transported and the transport costs. The same is done for all other chains (A1chain2-3 and A2chain 1-3). The results of these calculations are used in worksheet **‘Dashboard’** to produce the totals for the routes.

ANNEX D: MCA DATA INPUT

The tables below consolidate and summarize the information regarding the details of the four core strategies and the five Development Strategies that arose from the Workshop with the Ministry. These have served as input or the Multi-Criteria Analysis performed in order to compare all strategies under a hierarchical structure and thus aid with the decision-making process for choosing the preferred strategy.

Maintenance+

MAINTENANCE+			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable River Systems	8	number
	Navigable River Sections	16	number
	Total Waterway Size	6,060	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	9.75	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	18.19	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	46.24	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	12.5%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	3,603	R$ MM
	Yearly Waterway Maintenance Costs	187	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	44	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	2,088	R$ MM / year
		214.26	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	60	number****
	Quilombola Communities Crossed	7	number****
	INCRA Communities Crossed	377	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	37	number****
	Sustainable-Use Conservation Units Crossed	218	number****
	Top Priority Areas for Conservation Crossed	538	number****
	Priority Areas for Conservation Crossed	79	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	304	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	418	number****
	Existing Physical Limitations to Navigation (dams and bridges)	8	number****
	Dams Planned to be Implemented on Waterways	1	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Expansion 2a

EXPANSION 2a			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable River Systems	10	number
	Navigable River Sections	25	number
	Total Waterway Size	10,750	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	58.87	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	18.19	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	95.36	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	75.7%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	32,413	R$ MM
	Yearly Waterway Maintenance Costs	1,119	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	1,479	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	10,668	R$ MM / year
		181.23	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	214	number****
	Quilombola Communities Crossed	24	number****
	INCRA Communities Crossed	739	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	99	number****
	Sustainable-Use Conservation Units Crossed	320	number****
	Top Priority Areas for Conservation Crossed	925	number****
	Priority Areas for Conservation Crossed	195	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	673	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	1,784	number****
	Existing Physical Limitations to Navigation (dams and bridges)	19	number****
	Dams Planned to be Implemented on Waterways	23	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Expansion 2b

EXPANSION 2b			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable River Systems	8	number
	Navigable River Sections	19	number
	Total Waterway Size	8,220	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	30.14	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	65.59	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	114.03	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	38.7%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	13,460	R$ MM
	Yearly Waterway Maintenance Costs	437	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	751	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	5,801	R$ MM / year
		192.48	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	77	number****
	Quilombola Communities Crossed	22	number****
	INCRA Communities Crossed	524	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	74	number****
	Sustainable-Use Conservation Units Crossed	234	number****
	Top Priority Areas for Conservation Crossed	716	number****
	Priority Areas for Conservation Crossed	140	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	498	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	931	number****
	Existing Physical Limitations to Navigation (dams and bridges)	9	number****
	Dams Planned to be Implemented on Waterways	6	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Top Quality

TOP QUALITY			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable River Systems	10	number
	Navigable River Sections	27	number
	Total Waterway Size	12,180	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	77.80	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	65.59	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	161.69	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	100.0%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	46,555	R$ MM
	Yearly Waterway Maintenance Costs	1,679	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	2,614	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	13,633	R$ MM / year
		175.23	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	228	number****
	Quilombola Communities Crossed	24	number****
	INCRA Communities Crossed	812	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	121	number****
	Sustainable-Use Conservation Units Crossed	324	number****
	Top Priority Areas for Conservation Crossed	1,023	number****
	Priority Areas for Conservation Crossed	199	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	794	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	2,078	number****
	Existing Physical Limitations to Navigation (dams and bridges)	20	number****
	Dams Planned to be Implemented on Waterways	26	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Workshop Strategy 1 (Alt. 4)

WORKSHOP STRATEGY 1 (Alt. 4)			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable River Systems	10	number
	Navigable River Sections	27	number
	Total Waterway Size	12,180	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	74.93	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	65.59	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	158.82	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	96.3%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	37,051	R$ MM
	Yearly Waterway Maintenance Costs	1,271	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	2,099	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	13,593	R$ MM / year
		181.41	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	228	number****
	Quilombola Communities Crossed	24	number****
	INCRA Communities Crossed	812	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	121	number****
	Sustainable-Use Conservation Units Crossed	324	number****
	Top Priority Areas for Conservation Crossed	1,023	number****
	Priority Areas for Conservation Crossed	199	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	794	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	2,078	number****
	Existing Physical Limitations to Navigation (dams and bridges)	20	number****
	Dams Planned to be Implemented on Waterways	26	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Workshop Strategy 2 (Alt. 5)

WORKSHOP STRATEGY 2 (Alt. 5)			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable Waterway Systems	8	number
	Navigable Waterway Sections	17	number
	Total Waterway Size	6,840	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	20.08	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	50.70	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	89.09	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	25.8%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	11,283	R$ MM
	Yearly Waterway Maintenance Costs	372	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	444	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	3,815	R$ MM / year
		190.01	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	72	number****
	Quilombola Communities Crossed	7	number****
	INCRA Communities Crossed	444	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	40	number****
	Sustainable-Use Conservation Units Crossed	222	number****
	Top Priority Areas for Conservation Crossed	635	number****
	Priority Areas for Conservation Crossed	83	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	360	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	640	number****
	Existing Physical Limitations to Navigation (dams and bridges)	9	number****
	Dams Planned to be Implemented on Waterways	4	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Workshop Strategy 3 (Alt. 6)

WORKSHOP STRATEGY 3 (Alt. 6)			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable Waterway Systems	9	number
	Navigable Waterway Sections	19	number
	Total Waterway Size	8,250	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	37.58	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	50.70	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	106.59	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	48.3%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	17,814	R$ MM
	Yearly Waterway Maintenance Costs	621	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	886	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	7,045	R$ MM / year
		187.46	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	160	number****
	Quilombola Communities Crossed	7	number****
	INCRA Communities Crossed	590	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	45	number****
	Sustainable-Use Conservation Units Crossed	236	number****
	Top Priority Areas for Conservation Crossed	732	number****
	Priority Areas for Conservation Crossed	87	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	414	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	1,043	number****
	Existing Physical Limitations to Navigation (dams and bridges)	9	number****
	Dams Planned to be Implemented on Waterways	12	number****
	Year of the Latest Planned Dam	2026	year*****
* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.			
** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.			
*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).			
**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.			
***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.			

Workshop Strategy 4 (Alt. 7)

WORKSHOP STRATEGY 4 (Alt. 7)			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable Waterway Systems	9	number
	Navigable Waterway Sections	21	number
	Total Waterway Size	9,630	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	47.72	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	65.59	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	131.62	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	61.3%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	19,711	R$ MM
	Yearly Waterway Maintenance Costs	634	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	1,170	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	9,055	R$ MM / year
		189.75	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	165	number****
	Quilombola Communities Crossed	22	number****
	INCRA Communities Crossed	670	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	79	number****
	Sustainable-Use Conservation Units Crossed	248	number****
	Top Priority Areas for Conservation Crossed	813	number****
	Priority Areas for Conservation Crossed	144	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	552	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	1,334	number****
	Existing Physical Limitations to Navigation (dams and bridges)	9	number****
	Dams Planned to be Implemented on Waterways	14	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

Workshop Strategy 5 (Alt. 8)

WORKSHOP STRATEGY 5 (Alt. 8)			
Categories	**Data Description**	**Value**	**Unit**
Waterway Size	Navigable Waterway Systems	8	number
	Navigable Waterway Sections	20	number
	Total Waterway Size	9,090	km
Waterway Cargo Flow (forecast)	Agricultural Commodities* from Waterway Developments	40.68	MTPA in 2031
	Cargo Flow Due to Organic Growth (for the already navigable sections)	18.31	MTPA in 2031
	Cargo Flow Due to New Developments	65.59	MTPA in 2031
	Total Cargo Flow for Waterway (sum of the three above)	124.57	MTPA in 2031
	Percent of Agricultural Commodities* Transported via Waterway	52.3%	% in 2031
Economic Aspects	Total Waterway Investment Costs (necessary physical measures)	16,881	R$ MM
	Yearly Waterway Maintenance Costs	543	R$ MM / year
	Yearly Transport Cost Savings for Agricultural Products**	1,048	R$ MM / year
	Yearly Transport Costs for Agricultural Commodities*** (waterway and connecting road and/or rail modes from farm to seaport)	7,792	R$ MM / year
		191.56	R$ / ton / year
Social Aspects	Indigenous Areas Crossed	160	number****
	Quilombola Communities Crossed	22	number****
	INCRA Communities Crossed	551	number****
Environmental Aspects	Protection-Only Conservation Units Crossed	74	number****
	Sustainable-Use Conservation Units Crossed	234	number****
	Top Priority Areas for Conservation Crossed	716	number****
	Priority Areas for Conservation Crossed	140	number****
Physical Aspects	Sections with Need of Dredging (below 3 meters)	498	number****
	Physical Disturbances (sand banks, rocky outcrops, waterfalls or rapids)	1,170	number****
	Existing Physical Limitations to Navigation (dams and bridges)	9	number****
	Dams Planned to be Implemented on Waterways	11	number****
	Year of the Latest Planned Dam	2026	year*****

* The agricultural commodities considered are soy, soy meal and corn for export and the import of fertilizer from each of the 127 production micro-regions analyzed.

** The transport cost savings represents the cost difference that all producers in the waterway's hinterland would have when transporting their cargo over water instead of over road and/or rail, including all necessary transshipment costs.

*** The transport costs include other modal connections necessary for the waterway, such as pre-haulage by road from the production area to the waterway terminal, the section on the waterway and the final connection to port that may or may not be done by rail (if available, it is generally the cheapest option).

**** These numbers are calculated on the same 10 km measurement unit utilized for the Diagnose Report.

***** Assuming that when a dam is planned for an unspecified year after 2021, it will be built in the middle of the next energy planning period of ten years, thus in 2026.

ANNEX E: MCA ROBUSTNESS CHECKS

Score Checks

The first step in the robustness check is to assess whether a wrong score could modify the rankings. The following scores were each subjected to a 100% uncertainty ratio.

- Since the economic dimension is measured by the cost-benefit of the agricultural commodities flow only, this is a score to check for robustness;
- The second score for which some uncertainty may apply is the criterion chosen to measure the stakeholder support, as further explained in the MCA result description;
- Lastly, due to the lack of reliable and country-specific studies over the impacts of waterway for social regional development, this is also a criterion that is subject to check.

The way the robustness is checked is the following: the MCA results are run over two thousand (2,000) random iterations with each of the three scores having up to 100% of uncertainty. The graph below portrays the percentage of the times (out of the 2 thousand iterations) that each of the strategies ranked from first to nine.

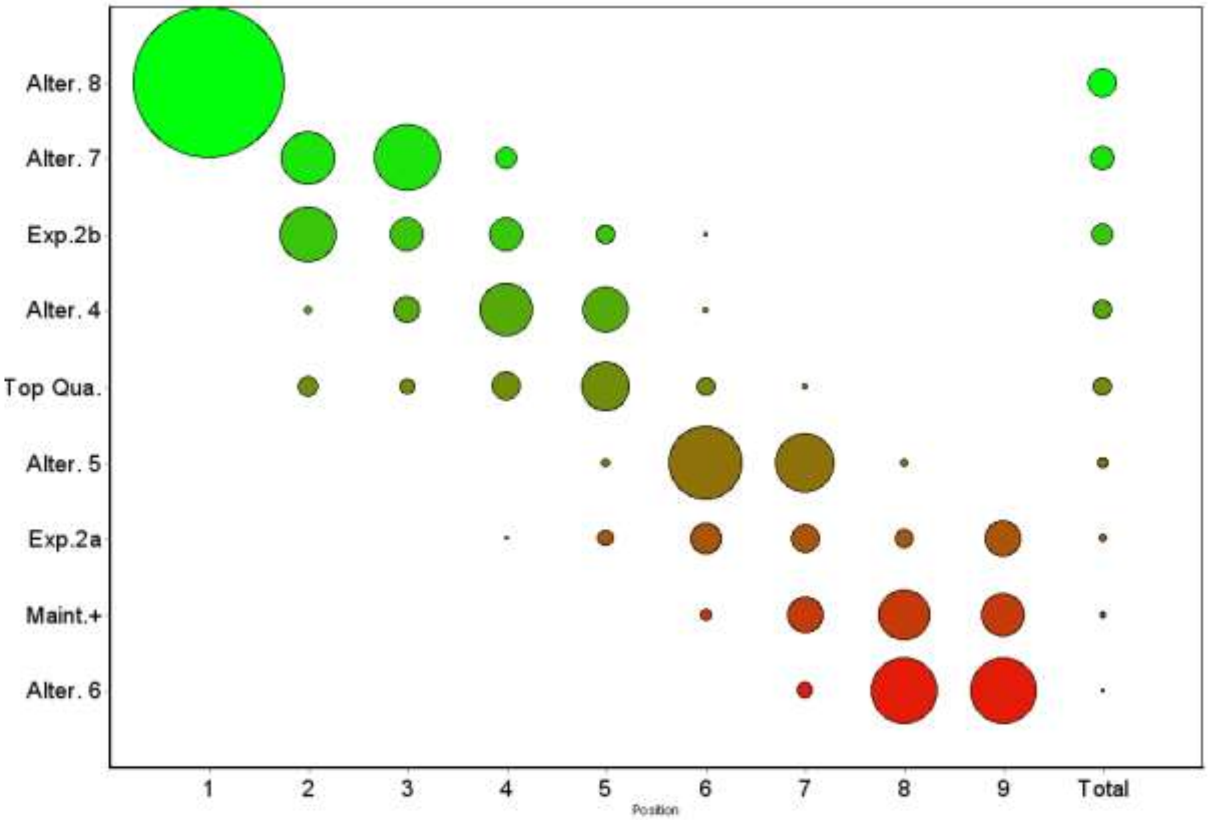


Figure 1: Score Robustness Check

The big green bubble for Alt. 8 as the top ranking strategy shows it has a 100% chance of keeping this position (out of 2 thousand iterations). Although the top strategy remained consistent to the robustness check, even under the heavy uncertainty of 100% for each of the three scores assessed, the same cannot be said for the remaining strategies.

Under the uncertainties set, strategy Alt. 7, remains as the second-highest ranking one in 37% of the time. Alt. 7 has a 45% hance of becoming the third-highest ranking strategy and a 15% hance of falling to fourth place. Expand 2b, on the other hand, has a 38% probability of stepping up as the second highest-ranking score, keeping its third place on 23% of the simulations and stepping down to fourth, fifth and sixth on 23%, 14% and 3% respectively.

It can be observed from the score-uncertainty graph that there are four blocks of rankings: i) the first block is the top strategy (Alt. 8), consistently the highest ranking one; ii) the other four strategies (Alt. 7, Expand 2b, Alt. 4 and Top Quality) could all alternate rankings to become the second-highest strategy; iii) the third block comes with strategies Alt. 5 and Expand 2a, which are consistently out-ranked by the two first blocks; iv) finally, the lowest-ranking strategies Maintenance+ and Alt. 6 could be interchanged as the lowest ranking strategies.

The conclusion that can be derived from the robustness check on the three chosen scores is that the top strategy is strong enough to sustain eventual errors in the scores evaluated, with a clear difference in its consistency as top one. Strategies Alt.7 and Expand 2b could alternate rankings to become the second-highest strategy, meaning they could both be second-best options.

Weight Checks

The second step in the robustness check is to assess whether a wrongly assigned weight could modify the rankings. This analysis is done on the objectives and criteria level, and not on the dimension level once the choice of weights over the dimensions cannot be wrong as it simply states the preference structure. The following weights were each subjected to a 100% uncertainty ratio.

- Between the two objectives (maximize internal waterway transport goal and maximize cost-effectiveness, originally set as 20% and 80%, respectively) that represent the economic dimension;
- Between the criteria (average conservation areas, priority areas for conservation, speleology areas and dredging needed by 100 km, originally set as 30%, 20%, 20% and 30%, respectively) under the objective to minimize environmental vulnerability that partially represents the environmental dimension;
- Lastly, between the criteria (average sensitive social areas crossed by 100 km and safety concerns, originally set as 60% and 40%, respectively) under the objective to minimize social vulnerability that partially represents the social dimension.

The way the robustness is checked is the same as for the scores, this time randomly varying the weights over two thousand iterations with each of the three weights having up to 100% of uncertainty. The graph below portrays the percentage of the times (out of the 2 thousand iterations) the strategies ranked from first to eight.

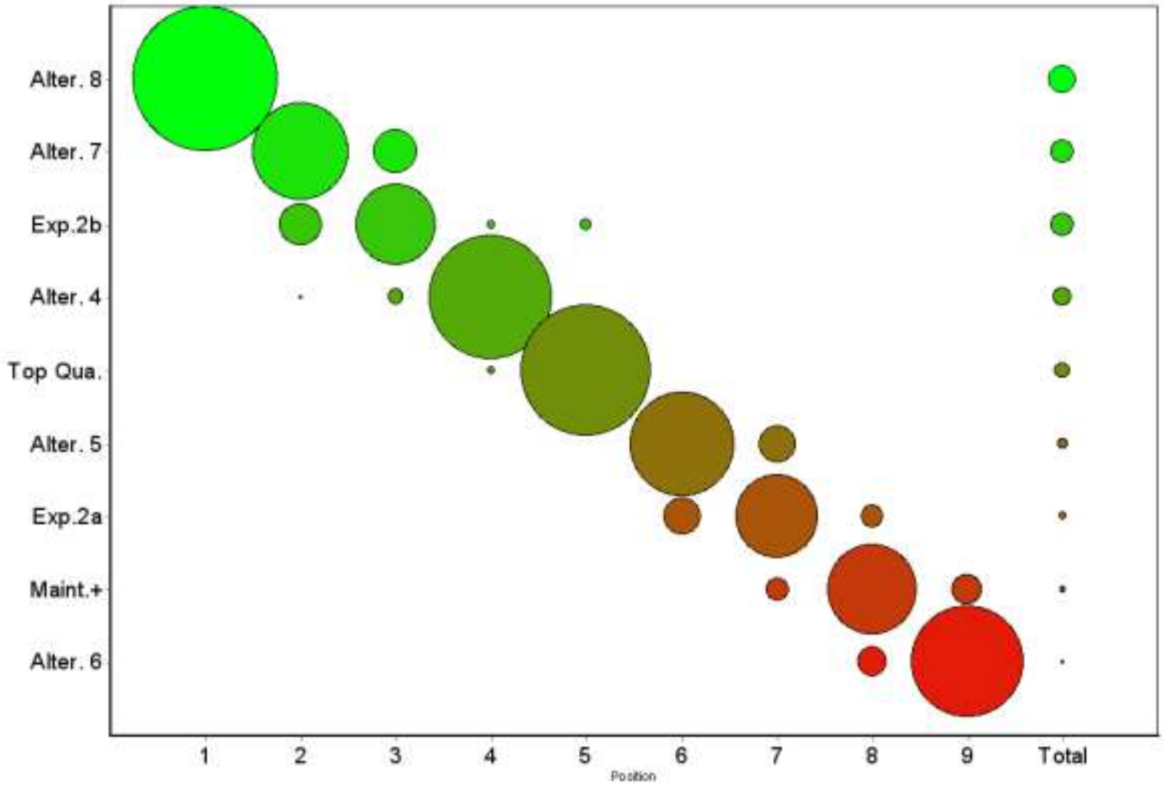


Figure 2: Weight Robustness Check

Once again the top strategy (Alt. 8) maintains its position regardless of the uncertainty over the weighting structure. The ranking positions that interchange the most are again the next two highest ones, albeit by very small margins. The structure of the graph shows that the uncertainties assigned to the weightings could not affect any of the results.

Alt. 8 consistently maintains its top ranking throughout 100% of the times, whereas Alt. 7 does so for 68% of the time and Expand 2b for 56% of the times. As for Alt. 4, it keeps its fourth place on 85% of the times, whislt Top Quality remains as fifth on 91% of the times.

Much in the same pattern as for the iterations that checked for the score uncertainty, the top three strategies are robust even under weight uncertainties. Neither of the uncertainties provided sufficient changes in the scores as to alter the final results.

Sensitivity Checks

The third step in the robustness check is to assess some reversal point for the main objectives in terms of weighting and scores.

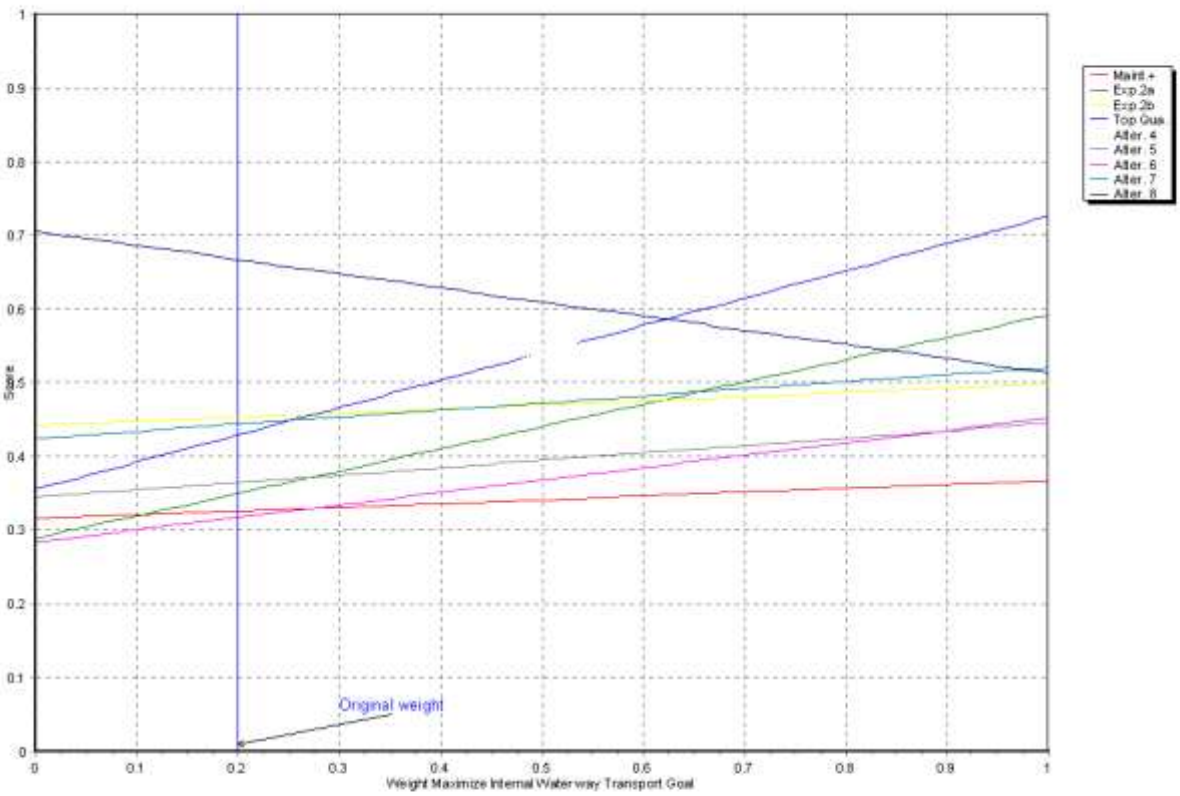


Figure 3: Weight Sensitivity Check

The graph above shows the behaviour of the strategies under the weight for the maximization of the Internal Waterway transport goal. If the original weight of 20% were to be set at 63%, then Top Quality would be the highest-ranking strategy, followed by Alt. 4, both dropping Alt. 8.

Another set of sensitivity was performed in order to check at which Cost-Benefit ratio would strategy Alt. 8 hand its first position to the second positioned Alt. 7. As pictured in the graph below, Alt. 8 score would need to have a net benefit of R$ 3.87 per ton in NPV instead of the actual R$ 30 per ton in NPV in order to drop to second-place.

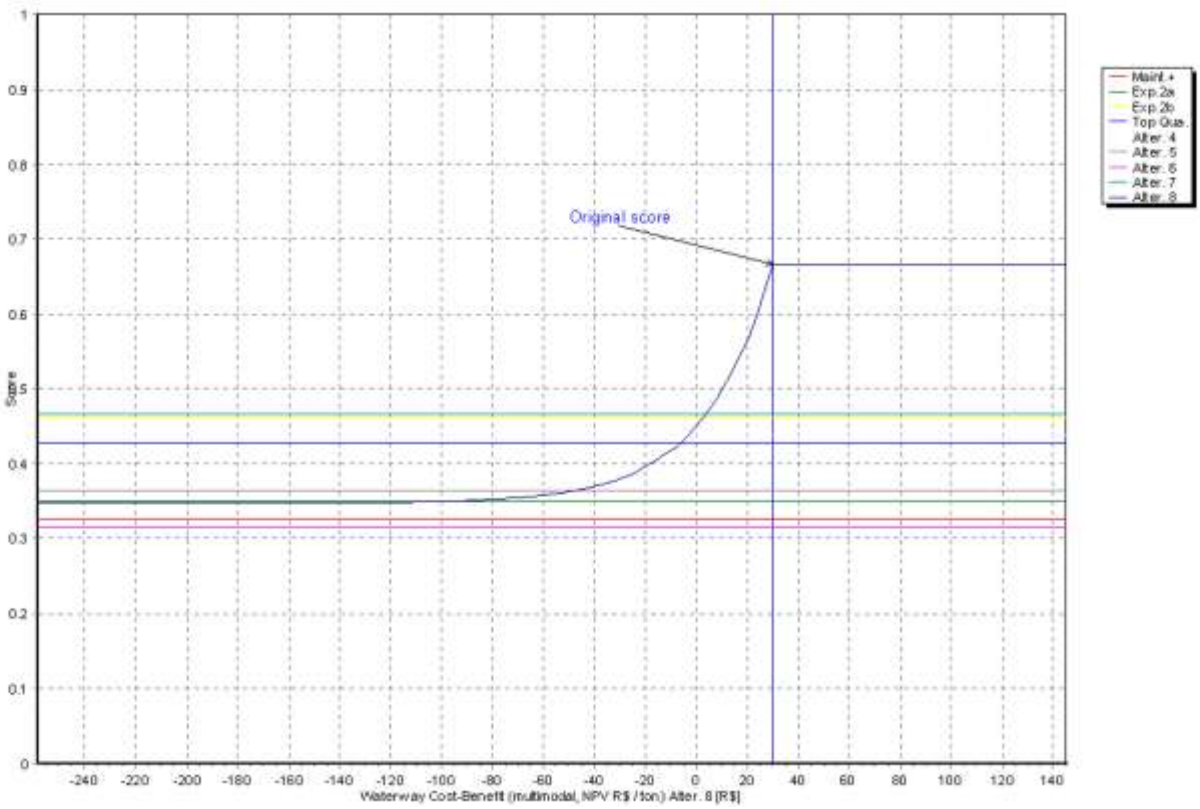


Figure 4: Score Sensitivity Check

A sensitivity assessment for all weights simultaneously was performed in order to check at which weight combination would Alt. 8 drop as the top ranking strategy, and it was found to be the following:

- Economic Sustainability: 0.104
- Institutional Cohesion: 0.279
- Environmental Sustainability: 0.285
- Social Sustainability: 0.332

The main conclusion from the two robustness checks and the sensitivity analysis is that the MCA results are valid and indeed Alt. 8 is the highest-ranking strategy. Given the checks performed, it can be concluded that the two following strategies, Alt. 7 and Epand 2b are interchangibly secon-best alternatives. Just the same, it is understood that Alt. 4 and Top Quality could both be considered third-best options.

ANNEX F: LOCATION OF TERMINALS – SENSITIVITY ANALYSIS

In this plan, some terminal locations are being suggested. Aiming at identifying the environmental conditions that might be restrictive for their implementation, a summary with these information were gathered and included in this report. It is important to note that only two terminals are proposed in locations without port facilities (Cachoeira Rasteira - MT and Miracema do Tocantins – TO).

The table below (Table 10) presents the section of the river where the terminal is planned, as well as the description of the environmental condition. Cachoeira Rasteira is the only location where Indigenous Community exists, and therefore is problematic from the environmental point of view.

It is important to point out that exact terminal locations will only be determined by developing a detailed study with the involvement of several stakeholders.

Table 10 - Proposed terminals and their environmental conditions

Environmental Conditions Analysis		
Terminal	**Section**	**Comentáriver**
Santarém	River Amazon - section 69	Marroom comunities on the opposite bank of the Amazon River
Itacoatiara	River Amazon - section 124	Conservation unities along the River, but port facilities already exist
Manaus	River Amazon - section 143	Conservation unities along the River, but port facilities already exist
Belém	River Pará - section 11	-
Porto Velho	River Madeira - section 107	Mining areas and conservation unities, but port facilities already exist
Itaituba	River Tapajós - section 28	Two Indigenous communites in the city, but located on the Tapajós River left bank, but these are distant from the possible terminal location
Cachoeira Rasteira	River Teles Pires - section 16	The potential terminal área is located within and Indigenous Territory (Kayabi)
Marabá	River Tocantins - section 45	Indigenous communities and INCRA settlements in the vicinity, but not at the Marabá city.
Miracema do Tocantins	River Tocantins - section 123	
Conceição do Araguaia	River Araguaia - section 50	Conservation unities and INCRA settlements (distant from the River banks)
São Félix do Araguaia	River Araguaia - section 94	On the opposite River bank of the city, an Indigenous Community is present, in the vicinity, INCRA settlements exist, but not at the city
Aruanã	River Araguaia - section 141	-
Nova Xavantina	River das Mortes - section 54	-
Juazeiro	River São Francisco - section 73	-
Ibotirama	River São Francisco - section 129	Indigenous communities in the vicinity, but not along the River
Pirapora	River São Francisco - section 203	-
foz Apa	River Paraguay - section 1	-
Corumbá	River Paraguay - section 57	Conservation unit, but port facilities already exist
Cáceres	River Paraguay - section 121	Conservation unit, but port facilities already exist
Teresina	River Parnaíba - section 40	Conservation unit, but port facilities already exist
Uruçuí	River Parnaíba - section 85	-
Balsas	River Parnaíba - section 24	-
Santa Filomena	River Parnaíba - section 129	Conservation unity / There is already some infrastructure in the city
São Simão	River Paranaíba - section 17	-
Três Lagoas	River Paraná - section 71	-
Pereira Barreto	River Tietê - section 2	-
Anhembi	River Tietê - section 53	Conservation unities and existing mining registers / There is already infrastructure in the city
Salto	River Tietê - section 73	Existing mining registers / There is already infrastructure in the city
River Grande	Lagoa dos Patos - section 3	Existing mining registers / There is already infrastructure in the city
Porto Alegre	Lagoa dos Patos - section 31	There is already infrastructure in the city
Triunfo	River Jacuí - section 6	Conservation unities and existing mining registers / There is already infrastructure in the city
Cachoeira do Sul	River Jacuí - section 22	Conservation unities / There is already infrastructure in the city
Salto	River Tietê - section 73	Existing mining registers / There is already infrastructure in the city

In this sense, in the paragraphs below the reasons behind the choice of Cachoeira Rasteira will be presented, as well as the points of attention that should be considered when choosing to implement the terminal at this location.

Also, it should be noted that the choice of the terminal location was developed during the Strategy phase but previously to the Cost-Benefit Analysis elaboration. This terminal location was an input for this analysis.

The Cachoeira Rasteira terminal is located at the Apiacás-MT municipality, and it is inserted in the Tapajós Waterway System, more specifically on the Teles-Pires River. This Waterway System has potential to become a strategic route for agricultural products transport, once it enables the connection between important producing areas of the Center-West and the international markets.

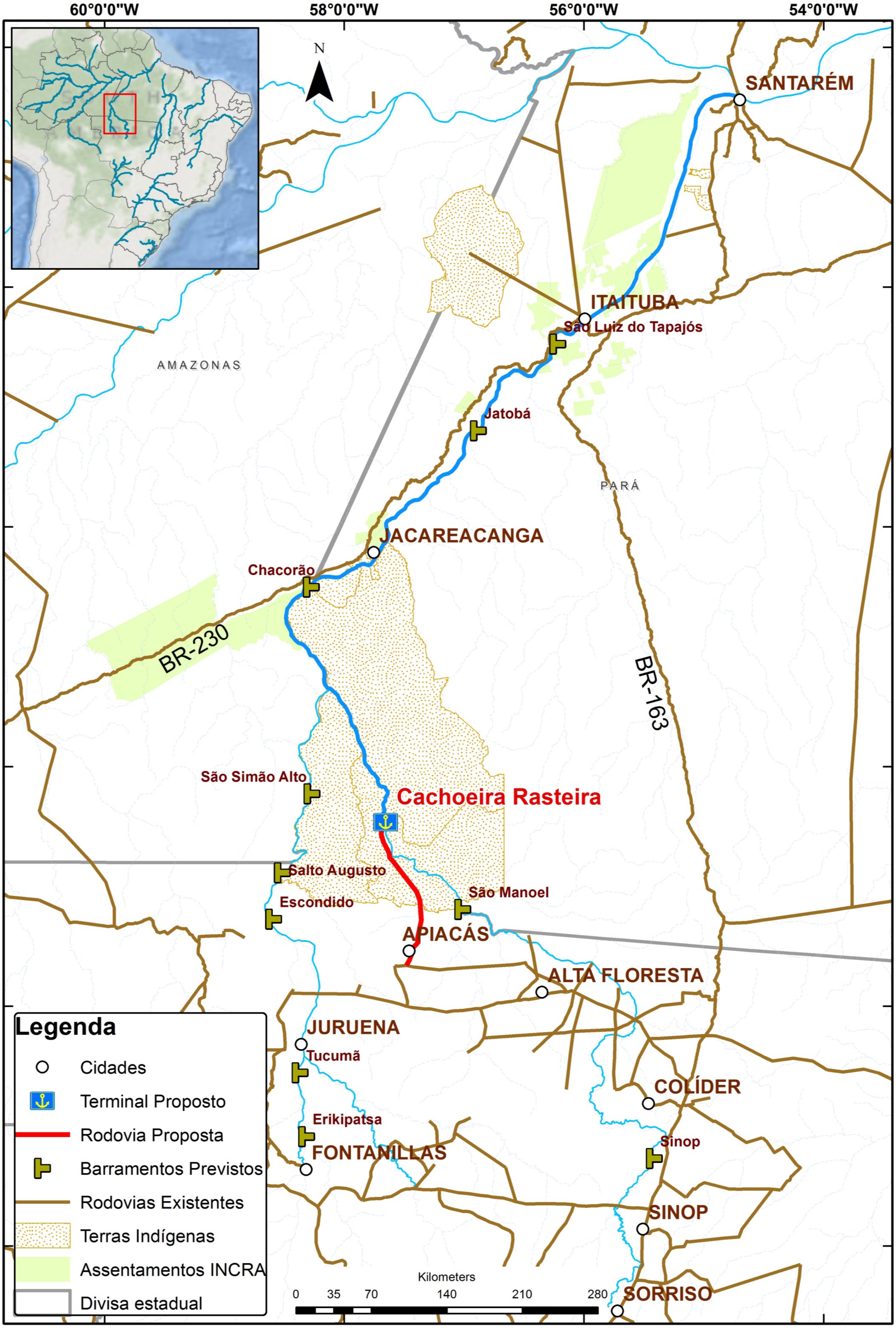
The starting point for determining the location of Cachoeira Rasteira was an APROSOJA document that was handed during the stakeholder consultation phase, in which 4 potential places were suggested:

- Cachoeira Rasteira; or
- Alta Floresta; or
- Nova Canaã do Norte; or
- Sinop.

The Map 1 presents those locations, as well as the under construction and planned dams.

To evaluate the best location, an evaluation considering environmental, navigability conditions and economic criteria was performed. The data that concerns the first two criteria were derived from the diagnosis report.

The Figure 5 presents the longitudinal profile of the Tapajós and Teles-Pires Rivers, indicating the dams (planned and under construction).


60°0'0"W
58°0'0"W
56°0'0"W
54°0'0"W
2°0'0"S
4°0'0"S
6°0'0"S
8°0'0"S
10°0'0"S
12°0'0"S
N
SANTARÉM
ITAITUBA
São Luiz do Tapajós
AMAZONAS
Jatobá
PARÁ
JACAREACANGA
Chacorão
BR-230
BR-163
São Simão Alto
Cachoeira Rasteira
Salto Augusto
Escondido
São Manoel
APIACÁS
ALTA FLORESTA
JURUENA
Tucumã
COLÍDER
Erikipatsa
FONTANILLAS
Sinop
SINOP
SORRISO
Legenda
Cidades
Terminal Proposto
Rodovia Proposta
Barramentos Previstos
Rodovias Existentes
Terras Indígenas
Assentamentos INCRA
Divisa estadual
Kilometers
0 35 70 140 210 280

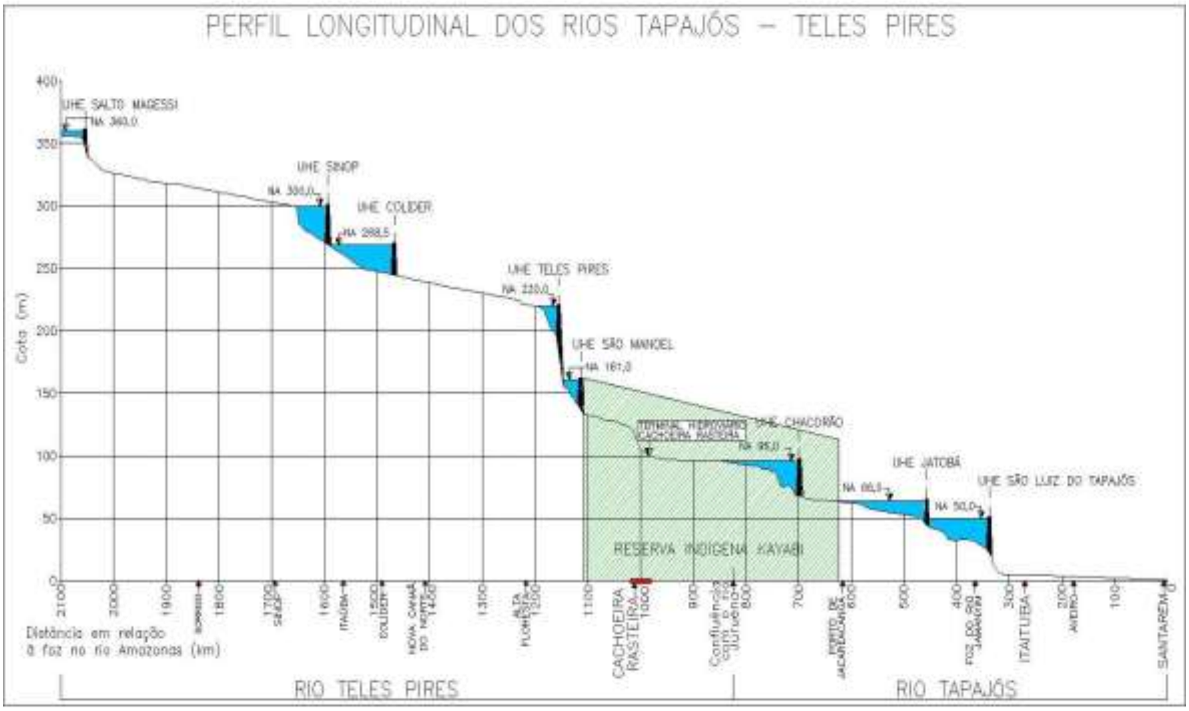


Figure 5: Longitudinal profile of the Teles Pires and Tapajós rivers with the location of the hydroelectrics planned.

The potential terminal of Cachoeira Rasteira is located in an Indigenous Territory named Kayaby, and nearby two others were identified: Munduruku e Apliaká do Pontal e Isolados. To navigate from this terminal up to the mouth of the Tapajós River, three locks must be constructed with the planned Hydropower plants (UHE São Luiz do Tapjós, UHE Jatobá and UHE Chacorão). The navigability conditions from Itaituba up to Cachoeira Rasteira are problematic, due to low water levels, siltation and natural obstacles, which hamper the navigation, that will only be possible if dams are built. For the economic criteria, the transportation cost analysis was based on a route which the origin is at Sorriso and the road destination is Cachoeira Rasteira. The distance between those is about 580 km (note that a 100 km road access from MT-268 up to the terminal is required).

The Alta Floresta potential terminal is not located in an Indigenous Territory; nevertheless, the navigability conditions upstream to Cachoeira Rasteira are restrictive, due to low water levels, high River's declivity, natural obstacles and narrow sections. The navigation between Cachoeira Rasteira and Alta Floresta will only be enabled if locks are built together the São Manoel and Teles Pires Hydropower plants. For the economic criteria, the transportation cost analysis was based on a route which the origin is at Sorriso and the road destination is Alta Floresta. The distance between those is about 330 km.

The Nova Canaã do Norte potential terminal, as the aforementioned one, it is not located in an Indigenous Territory; however, in the vicinity, three INCRA settlements exist (Monte Verde – P.A. Veraneio, Novo Paraíso, Rondon – Distrito Ouro Branco). Due to existing natural obstacles and narrow sections, the navigation between Nova Canaã do Norte and Alta Floresta is restrictive. For the economic criteria, the transportation cost analysis was based on a route which the origin is at Sorriso and the road destination is Nova Canaã do Norte. The distance between those is about 330 km.

The Sinop potential terminal is not located in and Indigenous Territory; however, several navigation restrictions are encountered on the section between Sinop and Nova Canaã do Norte, such as a bridge connecting the Municipality of Sinop-MT and Tabaporã-MT, natural obstacles, sinuosity sections and high River's declivity. To enable the navigation, locks must be constructed together with the Colíder and Sinop Hydropower plants. For the economic criteria, the transportation cost analysis was based on a route which the origin is at Sorriso and the road destination is Sinop. The distance between those is about 115 km (BR-163).

Considering the aforementioned distances, the table below presents a comparative summary of the relation between the transport costs from Sorriso up to Santarém-PA city for each terminal location, indicating the percentage that the cost is higher in relation to the minimum calculated (a terminal at Sinop).

Table 11: Comparison of the relation between the transport costs from Sorriso up to Santarém-PA

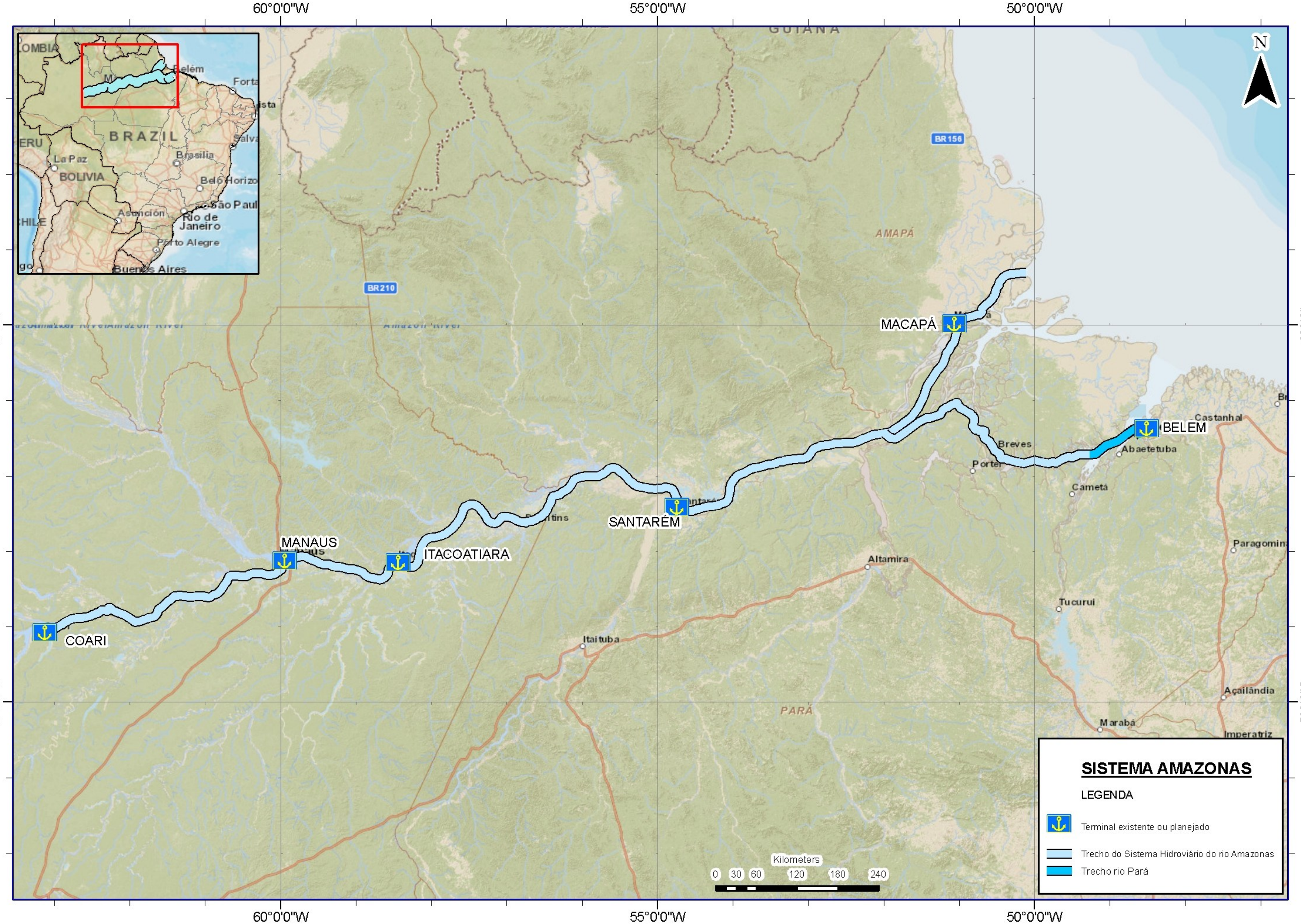
Terminal	Road distance from Sorriso up to the Terminal (km)	Waterway distance up to Santarém (km)	Comparative
Cachoeira Rasteira	580	1082	65%
Alta Floresta	379	1282	34%
Nova Canaã do Norte	326,4	1482	30%
Sinop	114,2	1682	0%

From this table, it can be seen that, from the economic point of view, Sinop would be the best location for a terminal; Nevertheless, four additional locks (upstream to Cachoeira Rasteira), at least, are necessary, also risks that some hydropower plants will not be built must be considered, as only the Colíder, Teles-Pires and Sinop are under construction. Due to the fact that locks are not planned in these dams, and they are in this stage, the construction cost of the lock after the dam will be approximately 25% higher if constructed simultaneously. Besides, the physical River conditions present a bottleneck to navigation.

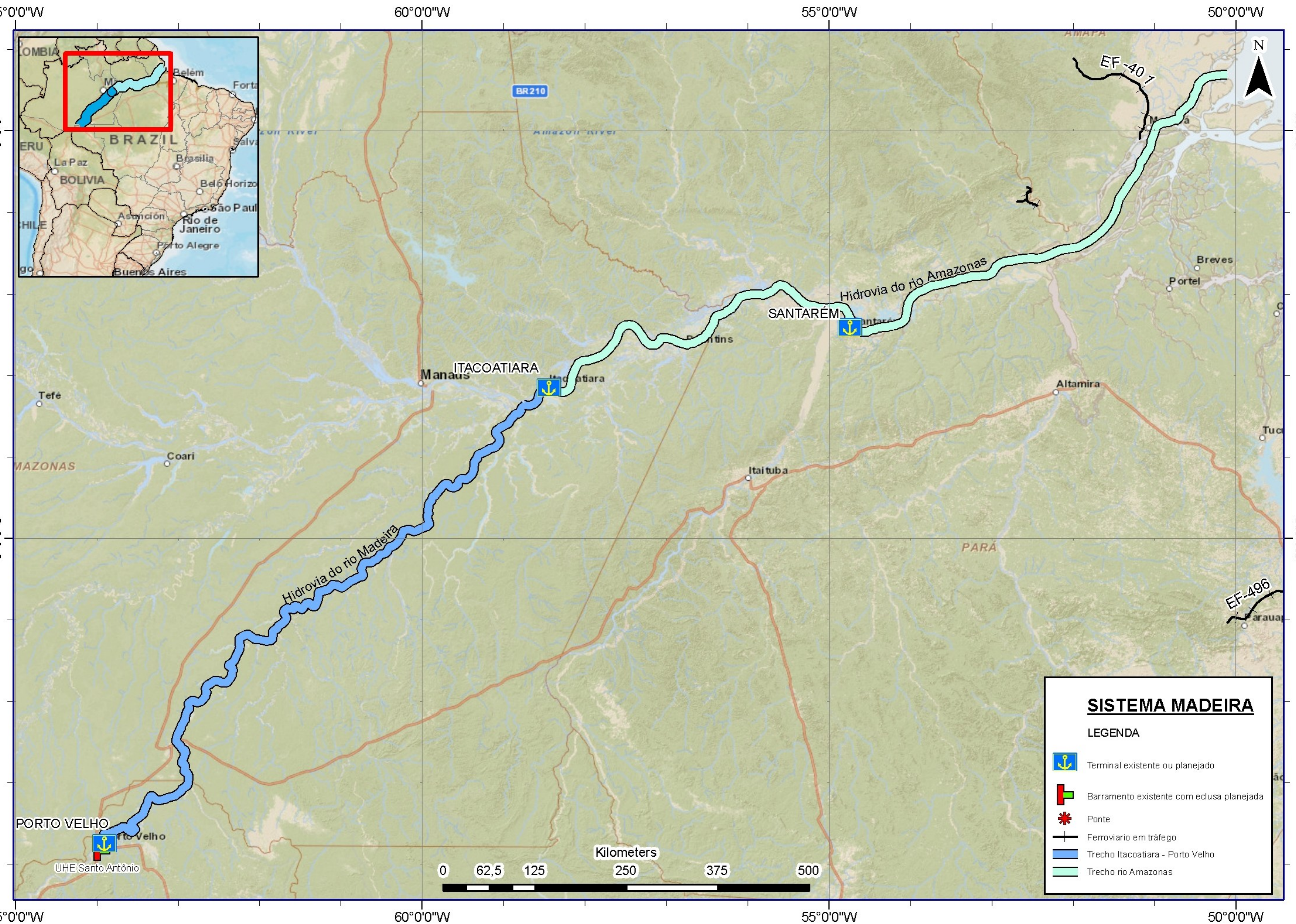
In order to enable navigation to the potential Alta Floresta and Nova Canaã do Norte terminals, two additional locks (upstream to Cachoeira Rasteira) need to be built, one with the Teles-Pires and another with the São Manoel Power Plants. The latter is under the design phase. As it has been aforementioned, the physical River conditions are constraints to navigation.

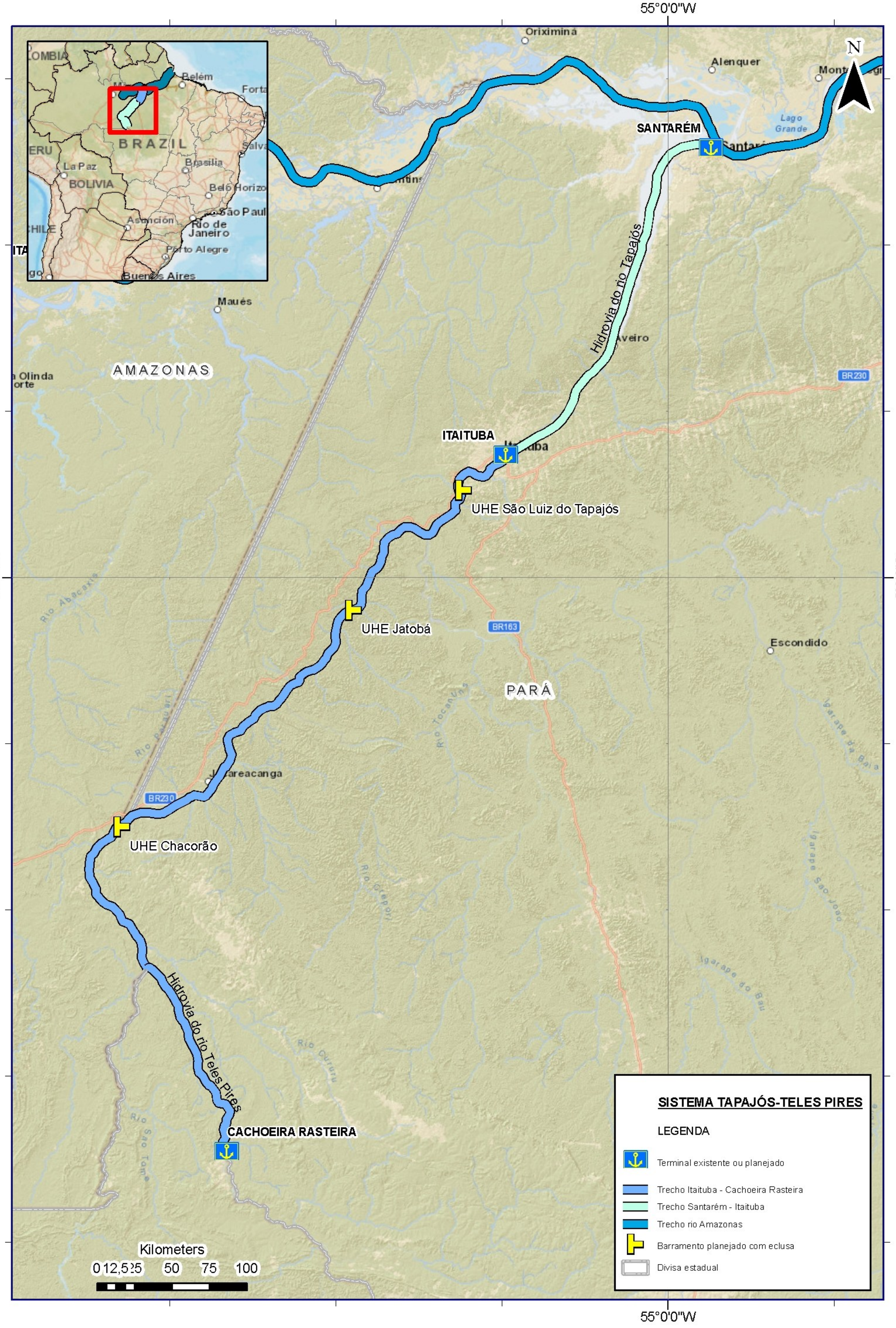
Based upon the presented arguments, a terminal in Cachoeira Rasteira was considered the best option among the others, but it should be pointed out that due to the socio-environmental impact that would be caused by implementing an intermodal terminal at this location, this alternative requires an additional detailed study, in which a consultation to representatives of traditional communities is necessary. If the project shows its feasibility, additional projects and complementary activities that aim at mitigating and compensating impacts must be foreseen. Besides, an efficient political coordination is required to make the project feasible.

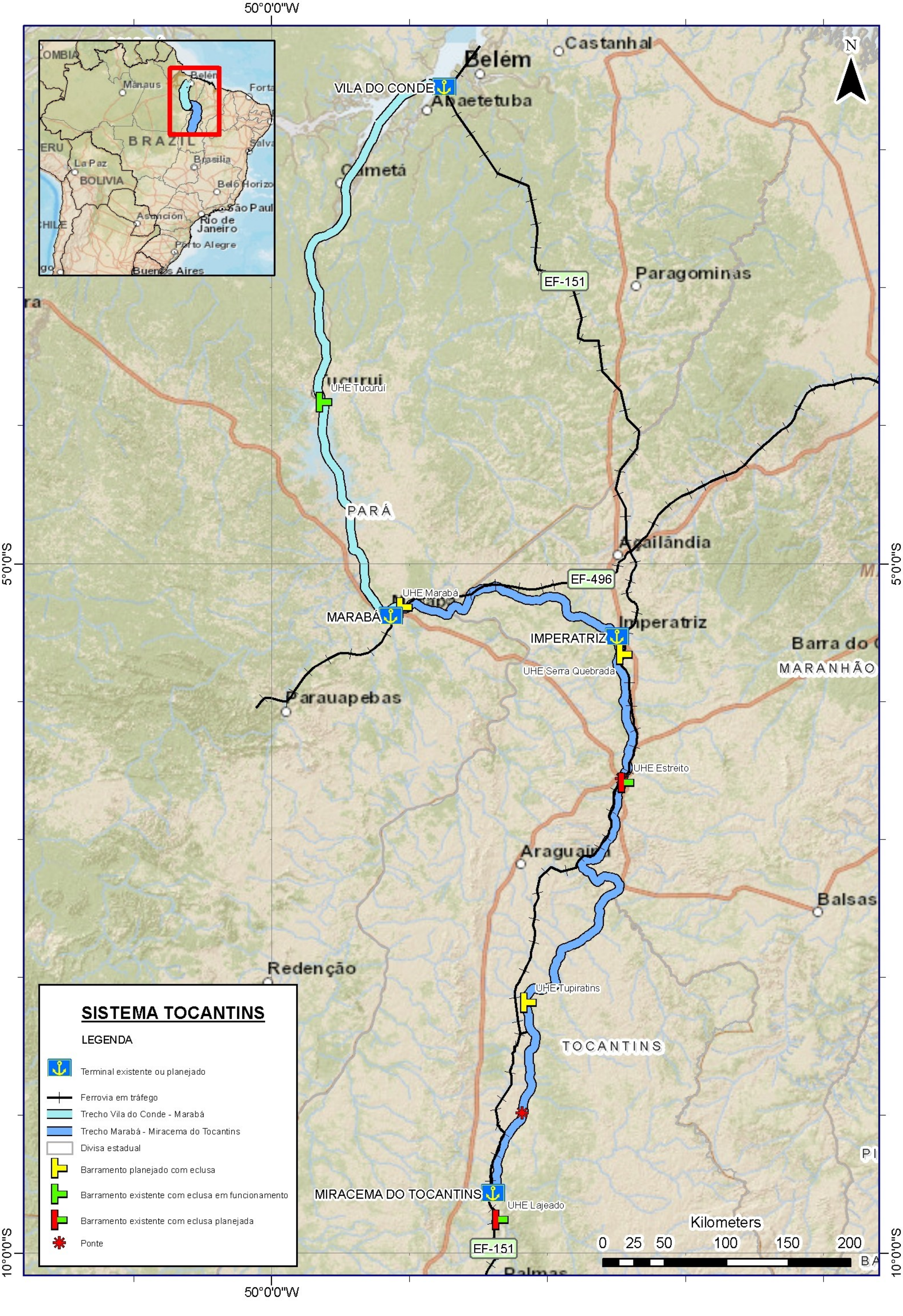
ANNEX G: SCHEMATIC MAPS OF THE WATERWAYS SYSTEMS



SISTEMA AMAZONAS
LEGENDA
Terminal existente ou planejado
Trecho do Sistema Hidroviário do rio Amazonas
Trecho rio Pará
Kilometers
0 30 60 120 180 240
COARI
MANAUS
ITACOATIARA
SANTARÉM
MACAPÁ
BELÉM
60°0'0"W
55°0'0"W
50°0'0"W
0°0'0"
5°0'0"S
AMAPÁ
PARÁ
BR 156
BR 210
Altamira
Itaituba
Tucuruí
Marabá
Breves
Portel
Cametá
Abaetetuba
Castanhal
Paragominas
Açailândia
Imperatriz
BRAZIL
BOLIVIA

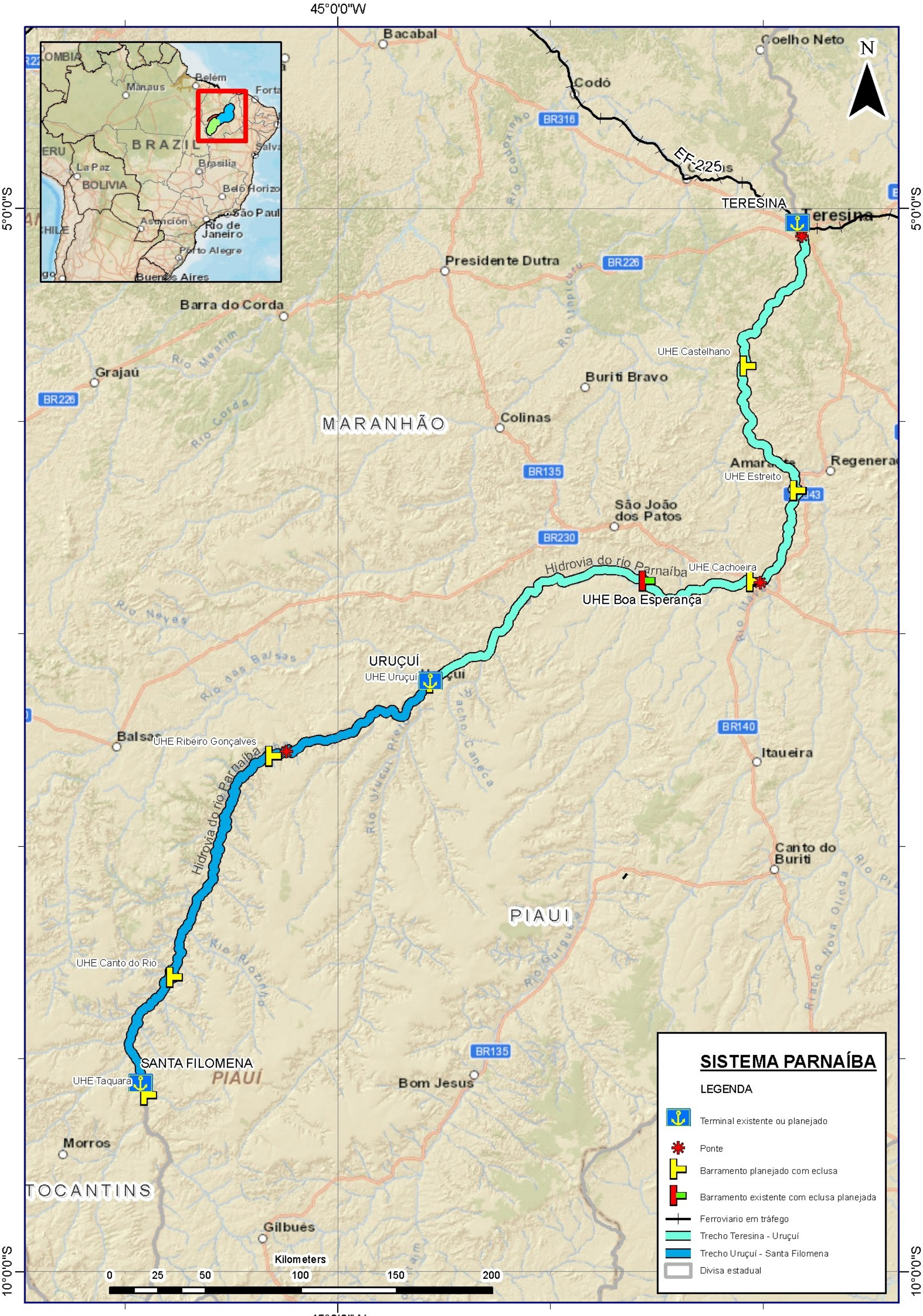

SISTEMA MADEIRA
LEGENDA
Terminal existente ou planejado
Barramento existente com eclusa planejada
Ponte
Ferroviario em tráfego
Trecho Itacoatiara - Porto Velho
Trecho rio Amazonas
Kilometers
0
62,5
125
250
375
500
65°0'0"W
60°0'0"W
55°0'0"W
50°0'0"W
0°0'0"
5°0'0"S
PORTO VELHO
UHE Santo Antônio
Hidrovia do rio Madeira
ITACOATIARA
Manaus
SANTARÉM
Hidrovia do rio Amazonas
Parintins
Altamira
Itaituba
Tefé
Coari
Breves
Portel
EF-401
EF-496
BR210
PARÁ
BRAZIL
BOLIVIA
Belém
Brasília
La Paz
Asunción
Rio de Janeiro
Porto Alegre
Buenos Aires
N


SISTEMA TAPAJÓS-TELES PIRES
LEGENDA
Terminal existente ou planejado
Trecho Itaituba - Cachoeira Rasteira
Trecho Santarém - Itaituba
Trecho rio Amazonas
Barramento planejado com eclusa
Divisa estadual
55°0'0"W
5°0'0"S
SANTARÉM
ITAITUBA
UHE São Luiz do Tapajós
UHE Jatobá
UHE Chacorão
CACHOEIRA RASTEIRA
Hidrovia do rio Tapajós
Hidrovia do rio Teles Pires
AMAZONAS
PARÁ
Oriximiná
Alenquer
Maués
Aveiro
Escondido
BR230
BR163
Rio Abacaxis
Rio Tocantins
Rio Crepori
Rio Cururu
Rio São Tomé
Lago Grande
BRAZIL
BOLIVIA
La Paz
Brasilia
Belém
Rio de Janeiro
Porto Alegre
Buenos Aires
Kilometers
0 12,5 25 50 75 100



SISTEMA TOCANTINS
LEGENDA
Terminal existente ou planejado
Ferrovia em tráfego
Trecho Vila do Conde - Marabá
Trecho Marabá - Miracema do Tocantins
Divisa estadual
Barramento planejado com eclusa
Barramento existente com eclusa em funcionamento
Barramento existente com eclusa planejada
Ponte
50°0'0"W
5°0'0"S
10°0'0"S
Belém
Castanhal
VILA DO CONDE
Abaetetuba
Cametá
EF-151
Paragominas
UHE Tucuruí
PARÁ
Açailândia
EF-496
UHE Marabá
MARABÁ
IMPERATRIZ
Imperatriz
UHE Serra Quebrada
Barra do C
MARANHÃO
Parauapebas
UHE Estreito
Araguaína
Balsas
Redenção
UHE Tupiratins
TOCANTINS
MIRACEMA DO TOCANTINS
UHE Lajeado
EF-151
Palmas
Kilometers
0 25 50 100 150 200
BRAZIL
Manaus
Belém
Forta
Brasília
La Paz
BOLIVIA
Belo Horizo
São Paul
Rio de Janeiro
Asunción
Porto Alegre
Buenos Aires

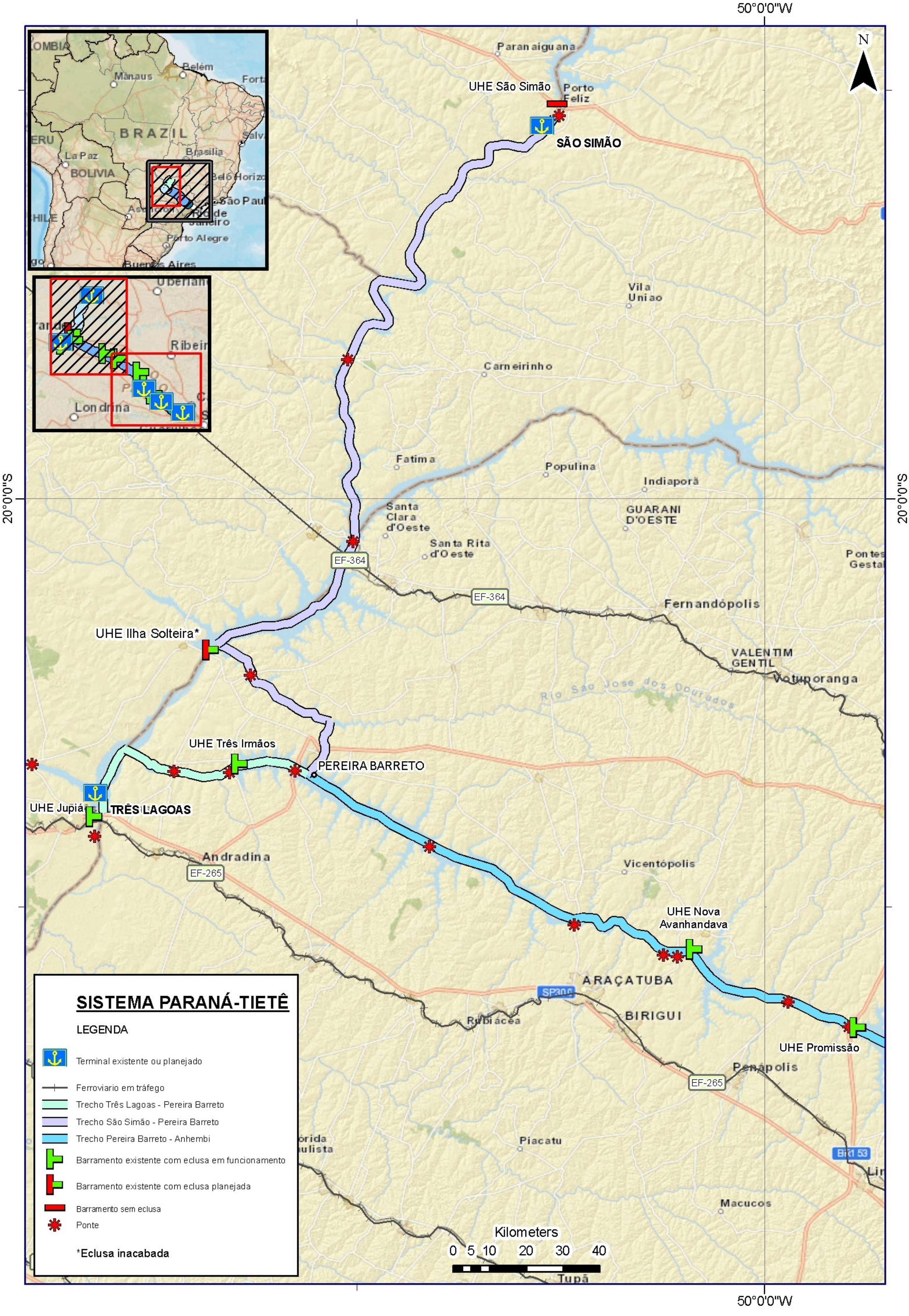
50°0'0"W
45°0'0"W
5°0'0"S
10°0'0"S
15°0'0"S
VILA DO CONDE
Belém
Castanhal
Abaetetuba
Cametá
Tucuruí
EF-151
Paragominas
São Luís
EF-496
EF-225
Bacabal
Codó
Açailândia
MARANHÃO
MARABÁ
UHE Marabá
Imperatriz
Barra do Corda
Parauapebas
UHE Santa Isabel
UHE Araguanã
Araguaína
Balsas
Redenção
Hidrovia do rio Araguaia
Palmas
TOCANTINS
SÃO FÉLIX DO ARAGUAIA
EF-151
Barreiras
EF-151
São Miguel do Araguaia
Porangatu
EF-151
Uruaçu
ARUANÃ
Kilometers
0 37,5 75 150 225 300
SISTEMA ARAGUAIA
LEGENDA
Terminal existente ou planejado
Ferroviario em tráfego
Trecho Vila do Conde - Marabá
Trecho Marabá - Conceição do Araguaia
Trecho Conceição do Araguaia - São Félix do Araguaia
Trecho São Félix do Araguaia - Aruanã
Ponte
Barramento planejado com eclusa
BRAZIL
Belém
Manaus
Fortaleza
Salvador
Brasília
La Paz
BOLIVIA
Belo Horizonte
São Paulo
Rio de Janeiro
Asunción
Porto Alegre
Buenos Aires



SISTEMA PARNAÍBA
LEGENDA
Terminal existente ou planejado
Ponte
Barramento planejado com eclusa
Barramento existente com eclusa planejada
Ferroviario em tráfego
Trecho Teresina - Uruçuí
Trecho Uruçuí - Santa Filomena
Divisa estadual
Kilometers
0 25 50 100 150 200
45°0'0"W
5°0'0"S
10°0'0"S
N
TERESINA
Teresina
UHE Castelhano
UHE Estreito
UHE Cachoeira
UHE Boa Esperança
Hidrovia do rio Parnaíba
URUÇUÍ
UHE Uruçuí
UHE Ribeiro Gonçalves
UHE Canto do Rio
SANTA FILOMENA
UHE Taquara
MARANHÃO
PIAUI
PIAUÍ
TOCANTINS
Bacabal
Coelho Neto
Codó
EF-225
BR316
BR226
BR135
BR230
BR140
Presidente Dutra
Barra do Corda
Grajaú
Buriti Bravo
Colinas
São João dos Patos
Regenera
Itaueira
Canto do Buriti
Balsas
Bom Jesus
Morros
Gilbués
Rio Mearim
Rio Corda
Rio Codozinho
Rio Itapicuru
Rio Neves
Rio das Balsas
Rio Uruçuí Preto
Riacho Caneca
Rio Riozinho
Rio Gurguéia
Riacho Nova Olinda
BRAZIL
Manaus
Belém
BOLIVIA
La Paz
Brasília
Belo Horizonte
Asunción
Rio de Janeiro
Porto Alegre
Buenos Aires

45°0'0"W
40°0'0"W
10°0'0"S
15°0'0"S
PETROLINA
Petrolina
UHE Sobradinho
Juazeiro
EF-116
PILÃO ARCADO
Senhor do Bonfim
EF-430
XIQUE-XIQUE
Jacobina
Irecê
BAHIA
Barreiras
IBOTIRAMA
BR242
Itaberaba
EF-025
EF-116
Bom Jesus da Lapa
Jequié
Guanambi
Brumado
Vitória da Conquista
EF-025
Janaúba
Montes Claros
PIRAPORA
Pirapora
EF-040
Kilometers
0 25 50 100 150 200
Belém
Manaus
BRAZIL
La Paz
BOLIVIA
Belo Horizonte
São Paulo
Rio de Janeiro
Asunción
Porto Alegre
Buenos Aires
SISTEMA SÃO FRANCISCO
LEGENDA
Terminal existente ou planejado
Barramento existente com eclusa em funcionamento
Ponte
Ferroviario em tráfego
Trecho Petrolina - Ibotirama
Trecho Ibotirama - Pirapora

SISTEMA PARAGUAI
LEGENDA
Terminal existente ou planejado
Ferroviario em tráfego
Trecho Corumbá - Cáceres
Trecho Foz do rio Apa - Corumbá
Ponte
Divisa estadual
CÁCERES
Cáceres
Poconé
BR70
Hidrovia do rio Paraguai
Lagoa Uberaba
Roboré
El Carmen
CORUMBÁ
BR262
Bolivia, Plurinational State of
Paraguay
Brazil
MATO GROSSO DO SUL
EF-265
Miranda
FOZ DO RIO APA
Pôrto Murtinho
Rio Melo
20°0'0"S
Kilometers
0 20 40 80 120 160
BRAZIL
BOLIVIA
Manaus
Belém
La Paz
Brasília
Asunción
Rio de Janeiro
Porto Alegre
Buenos Aires



SISTEMA PARANÁ-TIETÊ
LEGENDA
Terminal existente ou planejado
Ferroviario em tráfego
Trecho Três Lagoas - Pereira Barreto
Trecho São Simão - Pereira Barreto
Trecho Pereira Barreto - Anhembi
Barramento existente com eclusa em funcionamento
Barramento existente com eclusa planejada
Barramento sem eclusa
Ponte
*Eclusa inacabada
Kilometers
0 5 10 20 30 40
50°0'0"W
20°0'0"S
N
UHE São Simão
SÃO SIMÃO
Porto Feliz
Paranaiguana
UHE Ilha Solteira*
UHE Três Irmãos
PEREIRA BARRETO
UHE Jupiá
TRÊS LAGOAS
UHE Nova Avanhandava
UHE Promissão
Andradina
ARAÇATUBA
BIRIGUI
Penápolis
Vicentópolis
Fernandópolis
VALENTIM GENTIL
Votuporanga
Rio São José dos Dourados
Santa Clara d'Oeste
Santa Rita d'Oeste
GUARANI D'OESTE
Indiaporã
Populina
Fatima
Carneirinho
Vila Uniao
Pontes Gestal
Rubiácea
Piacatu
Macucos
Tupã
EF-364
EF-265
SP300
BR153
BRAZIL
BOLIVIA
Manaus
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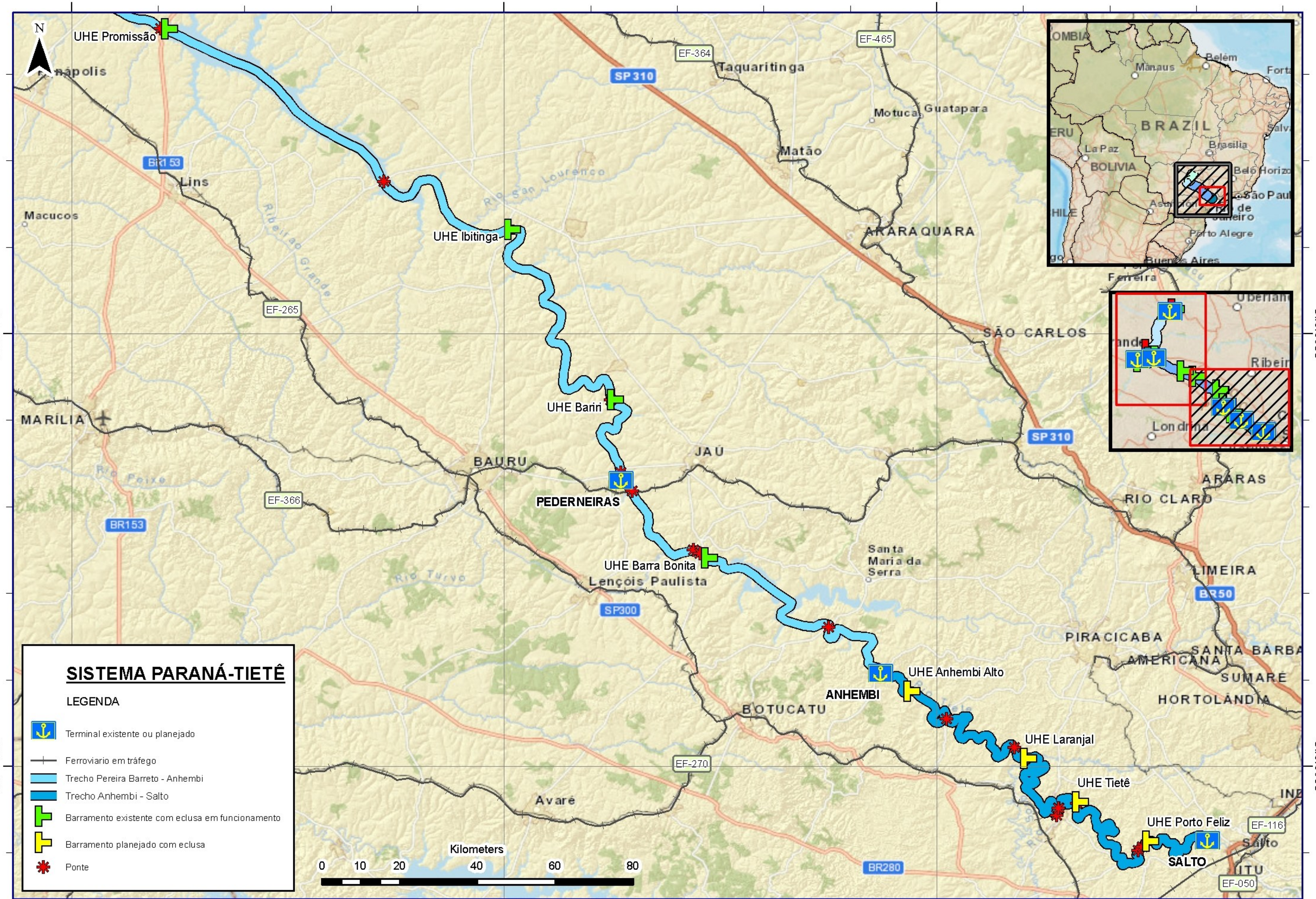
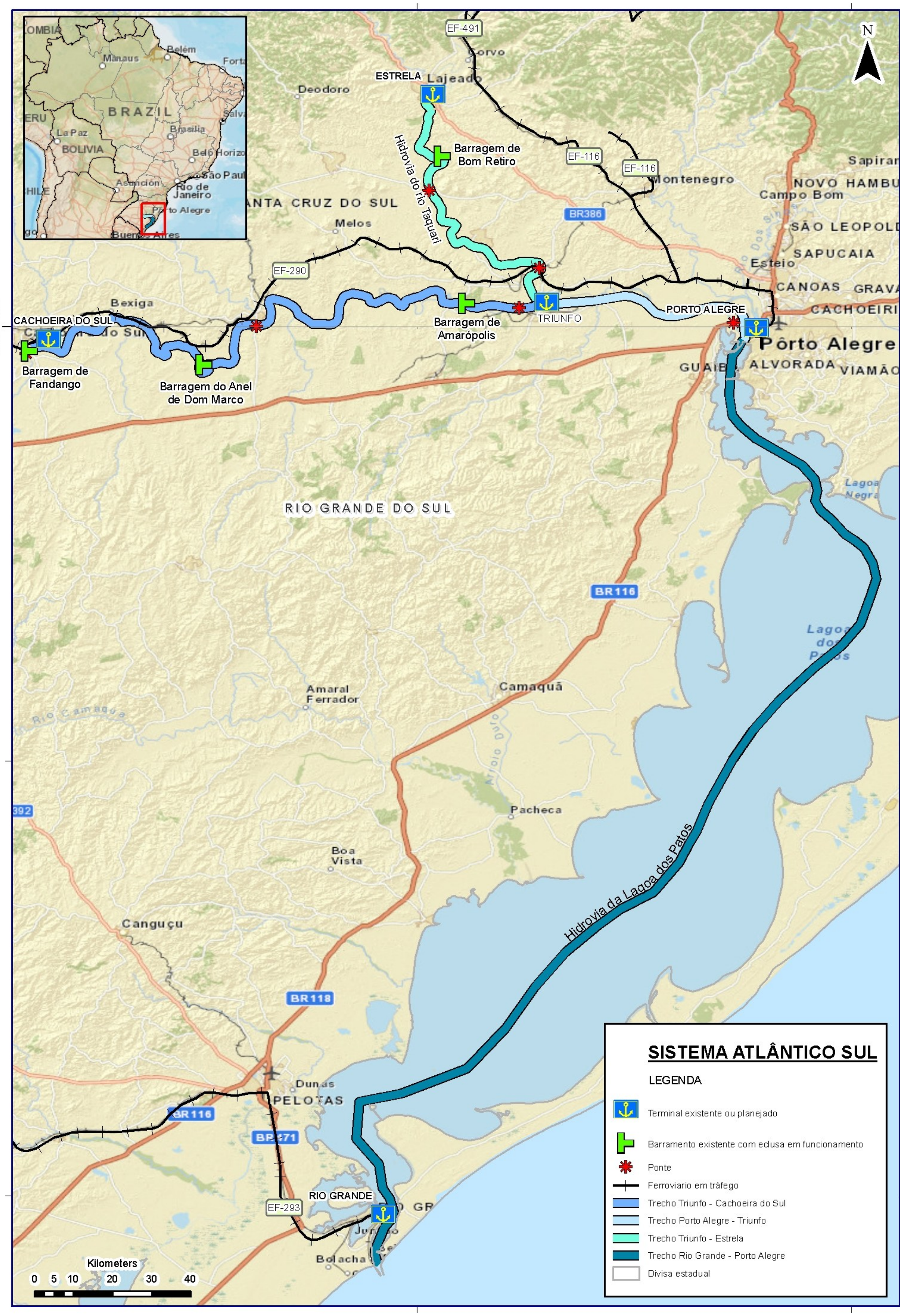
Rio de Janeiro
Porto Alegre
Buenos Aires
Uberlan
Ribeir
Londrina



SISTEMA PARANÁ-TIETÊ
LEGENDA
Terminal existente ou planejado
Ferroviario em tráfego
Trecho Pereira Barreto - Anhembi
Trecho Anhembi - Salto
Barramento existente com eclusa em funcionamento
Barramento planejado com eclusa
Ponte
Kilometers
0 10 20 40 60 80
50°0'0"W
49°0'0"W
48°0'0"W
22°0'0"S
23°0'0"S
N
UHE Promissão
UHE Ibitinga
UHE Bariri
PEDERNEIRAS
UHE Barra Bonita
ANHEMBI
UHE Anhembi Alto
UHE Laranjal
UHE Tietê
UHE Porto Feliz
SALTO
Lins
Macucos
MARÍLIA
BAURU
JAÚ
Lençóis Paulista
BOTUCATU
Avaré
Taquaritinga
Matão
Motuca
Guatapara
ARARAQUARA
SÃO CARLOS
ARARAS
RIO CLARO
LIMEIRA
PIRACICABA
AMERICANA
SANTA BARBA
SUMARÉ
HORTOLÂNDIA
Santa Maria da Serra
ITU
Salto
SP 310
SP300
BR153
BR280
BR50
EF-364
EF-465
EF-265
EF-366
EF-270
EF-116
EF-050
Rio São Lourenço
Ribeirão Grande
Rio Peixe
Rio Turvo
BRAZIL
BOLIVIA
Manaus
Belém
Brasília
La Paz
Porto Alegre
Buenos Aires
Uberlândia
Londrina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LEGENDA
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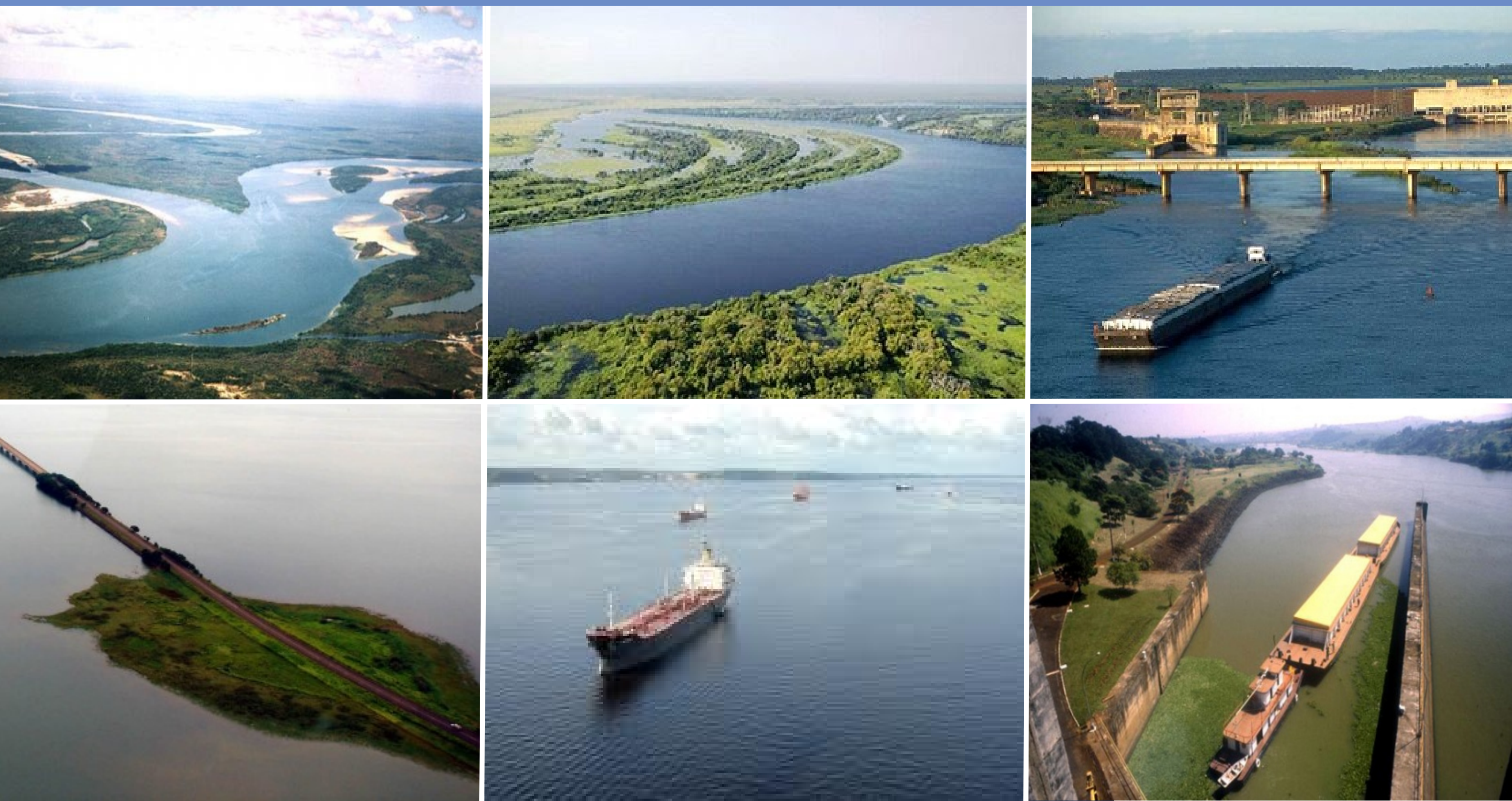
Barramento existente com eclusa em funcionamento
Ponte
Ferroviario em tráfego
Trecho Triunfo - Cachoeira do Sul
Trecho Porto Alegre - Triunfo
Trecho Triunfo - Estrela
Trecho Rio Grande - Porto Alegre
Divisa estadual
ESTRELA
Barragem de Bom Retiro
Hidrovia do rio Taquari
CACHOEIRA DO SUL
Barragem de Fandango
Barragem do Anel de Dom Marco
Barragem de Amarópolis
TRIUNFO
PORTO ALEGRE
RIO GRANDE
Hidrovia da Lagoa dos Patos
RIO GRANDE DO SUL
30°0'0"S
Kilometers
0 5 10 20 30 40
N

Ministério dos Transportes



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