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Paper 98 - Preliminary Environmental Impact Assessment due to the Tietê-Paraná Waterway Traffic Interruption

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ABSTRACT: Since 2001, the Paraná River basin have faced certain years with severe hydrologic situations of draughts that increases in 2013, 2014 and 2015. This highly affects the hydropower generation and the navigation depth on the Tietê-Paraná Waterway, causing partial interruption of navigation traffic and reduces the production of hydropower energy. The navigation interruption starts on May 2014 until nowadays, affecting agricultural commodities cargo moved in the waterway. This situation obliges to transfer the waterway cargo to road transportation. This paper intends to evaluate preliminary environmental impacts due

1 INTRODUCTION

The uses of rivers by navigation in Brazil were important in the past to achieve the occupation of the territory, especially in the North of the country, via the Amazon Basin, and in the South, via the Paraná and its tributaries and also the Paraguay River. As we can detect, the waterways were considered an important transportation system for the nation. In 1869, was defined the "Plano Moraes" (Moraes was a military engineer) based on his studies entitled "Navegação Interior no Brasil" (Inland Navigation in Brazil). His studies alerted for the possibilities to provide a wide integrated system of waterways, with less interventions at relatively low costs (canals and small dams and locks). Figure 1 try to locate his proposal, including the possibilities of basins interconnections

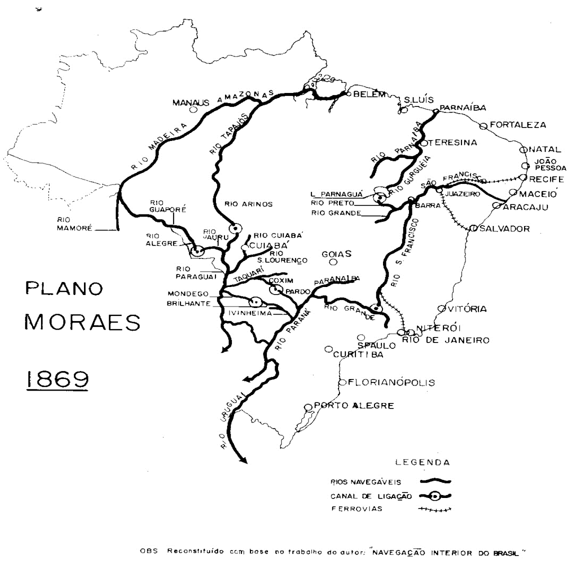


Figure 1: Transportation Plan to Brazil, year 1869, based on waterways

The Paraná River and the Tietê River, as well as the other tributaries of the river basin, were used for navigation ever since before Brazil's discovery by the indigenous population that inhabited the region. After Brazil's discovery and the settlement of the very first colonies by the Atlantic coast, these rivers and the great majority of other rivers throughout the Brazilian territory served as the first means of penetration in the interior of Brazil for territorial recognition by the Portuguese colonizers, especially in the 18th century. At that time, these waterways also served as way of access indigenous slave capture. Furthermore, it served as exploratory routes for the search of precious metals and stones through exploratory expeditions.

With the occupation of the interior of Brazil, initiating with the forestry resource exploitation and other derived products, navigation blossomed, especially in the Paraná River and some of its tributaries, such as the Iguaçu River, the Paranapanema River, Ivinheima River, some sections of the Grande River and of the Mogi-Guaçu tributary river. It started out with lumber and yerba mate, being the latter an extractive produce. With that, throughout the years, navigation was complemented with livestock and coffee beans transportation. Coffee beans was the first major agro production in the Paraná River Basin, and, by consequence, the navigable sections of the Paraná River Basin played an important role. The implementation of railways originating from State's capitals, especially São Paulo State, and from maritime ports for exportation, such as Santos and Paranaguá caused these railways to connect to the most extreme sections of these waterways (Paraná River in Presidente Epitácio and Panorama).

Nonetheless the railways represent a reduction or even an elimination of the navigation in the most extreme river sections in the River Basin, on the other hand, the railways served to connect the interior to the maritime ports for cargo exportation (mainly coffee beans and lumber). In special, production zones where the railway did not reach, but it had access to navigation vias, maintaining the transportation flow thanks to the waterway intermodality with a railway that would reach maritime ports.

With the emergence of highway transportation, the Brazilian industry opted for this modality. Due to this option, the industry started to favor the implementation of highways or improvements on terrestrial pathways on the River Basin area. Thanks to the swiftness of this modality and the relatively low cost of the fuel, the industry amplified other railway ramifications. This caused many of the navigable river sections to disappear (as in the case of the Iguaçu River and the Mogi-Guaçu River in the Paraná River Basin).

2 THE WATERWAY DESCRIPTION

2.1 *The Waterway Implementation*

The Interstate Commission of the Paraná-Uruguay River Basin was created circa the 1950's. It came to be by the union of the States in which the River Basin is located. It aimed to plan increase the economic and regional development of the backlands, supported by the electrical production and the low cost transport due to the availability and utilization of the water resources. Back then, there was already a concern regarding the regional development, which was based on the multiple utilization of water for electricity generation and on waterway transportation. This initiative was led by the State of São Paulo, which started the infrastructure preparation on the Tietê River and the Paraná River. By doing so, it followed the on going trend to develop from east to west and to connect with the Paraná River, which navigation happened with greater intensity.

Hitherto, even with the institutional changes that have occurred in Brazil and in the States, this concept is still respected in the Tietê and Paraná Rivers. Unfortunately, the same did not happen in the other major tributaries of the Paraná River Basin, such as the Paranaíba River, the Grande River, Paranapanema River and Iguaçu River, in which the building of hydroelectric dams has drained the exploration potential, did not have it implemented the transposition work for navigation.

The implementation of the waterway done on the Tietê River and the Paraná River, jointly done by the State of São Paulo with the federal government, in a multitude of covenants and agreements ever since. From the 1960's on, an implementation of the hydroelectric dam work on the Bariri, Barra Bonita, Jupiá and Ilha Solteira in the Paraná River was started. It was followed by the building of the Ibitinga and Promissão, and much of the work on these hydroelectric dams as well as civil works on the projected multiple purpose dams. These were built with the federal government support through the Executive Comission on the Tietê-Paraná Navigation System, which was formed by federal and State of São Paulo agencies, lasting until 1975.

This implementation was done in steps and basically following the order of the installation of the hydroelectric dams in the Paraná River and Tietê River. In this opportunity, the civil work of the dams were built simultaneously. However, in some cases, the installation of the equipment for the complete functioning of the locks occurred decades after the dams being built, amplifying the navigable sections in sequences and giving continuity to the existing ones. In chronological order, the conclusion of the dams were, in the Tietê River, initially the Bariri in 1969, Barra Bonita in 1973, Ibitinga and Promissão in 1986 and the two dams and intermediary canals of Nova Avanhandava in 1991. In addition, the latter were done jointly with the Pereira Barreto Canal, which is an artificial canal with interlinked to the Tietê River with the Paraná River in the reservoir of Ilha Solteira dam, to the dams and intermediary canal of Três Irmãos and, in the Paraná River, to the Jupiá dam in 1998, as well as Porto Primavera dam in 1999. Thus, it is possible to say that the Tietê Paraná-Waterway switched to operate in an integrated manner nowadays. Only from 1999 is that the link with the Paraná River, be it South or North Stretch became viable.

Meanwhile, the partial use of the waterway in the middle section of the Tietê River, already from 1981 (dams from Bariri and from Barra Bonita, after being amplified with the operationalization of the Ibitinga in 1986) implementing the transportation which became known as the Alcohol Waterway (sugar cane and ethanol). With the entrance of the Pereira Barreto Canal and the Nova Avanhandava from 1999, the transit of soy beans and years later of soy beans derivates (oil and midding) linking it from the São Simão terminal, on the Paranaíba margins (North Stretch on the Paraná Waterway) until the terminals in Pederneiras in the Tietê River with railway connections, or the Anhembi-SP and Conchas-SP, upstream the same river as well as in Santa Maria da Serra – SP to the margins of the Piracicaba River, tributary of the Tietê River.

In the case of the Paraná River, the waterway has always been navigable, from Guaíra – PR up to the Jupiá Dam, which was concluded without the equipment installation in the dam circa 1974. Later on, with the end of the filling of the Itaipu dam (happening in the year of 1983), on the extreme end of the Paraná River, due to the flooding in Salto de Sete Quedas in Guaíra – PR, the section was amplified in additional 175 km. These were immediately incorporated by the existent navigation in the called South Stretch of the Paraná River.

In this stretch starting years 1950, lumber and a kind of tea leaves called "yerba-mate" were the important cargos. Passing the years, from the years 1970, that cargo became progressively alternate to farm grains like coffee beans, soybeans, corn and wheat and processed products such as oil and grain middings. The cargo barge convoys inbound on terminals at the South Stretch at the Paraná River, such as Hernandarias at the Paraguayan border, Santa Helena or Guaíra (State of Paraná) and navigate upstream to the North until the terminals of Presidente Epitácio and Panorama (State of São Paulo), out bounding directly to railways that goes to Port of Santos at the Atlantic Ocean.

2.2 *The Paraná Waterway*

The MERCOSUL Waterway is known the whole system of waterways composed by the Paraguay-Paraná Waterway and the Tietê-Paraná Waterway (Figure 2).

The Paraguay-Paraná Waterway System is an important waterway for Brazil, and has also an important connection for the neighbor countries of the south of the continent (Argentina, Bolívia, Paraguay and Uruguay). In fact, with the Tietê-Paraná Waterway system that connects Argentina and Paraguay, both waterways systems would be an important factor to the development of this region. The extension of the waterway in Brazil is 1.270 km, considering that on this length, 58 km are border with Bolivia, and 322 km border with Paraguay. Downstream, the remaining waterway connects to the Paraná River and, at the delta, with the Uruguay River, and the La Plata River directly to the Atlantic Ocean. The total stretch from the city of Caceres at the Paraguay River, upstream in Brazil, passing through Asunción in Paraguay, to Nueva Palmira at Uruguay River, downstream in Uruguay, is 3.442 km of a natural waterway for tow barges convoy. At the Rio de La Plata are located Buenos Aires, Argentina, and Montevideo in Uruguay. Also maritime ships could achieve the city of Asunción located 1.630 km from the Atlantic Ocean. The waterway stretch of the Paraná River from the mouth of the tributary Paraguay, passing through the Lock and Dam Yaciretá (24 m high, Argentina and Paraguay borders) until the Itaipu Dam (120 m high, Brazil and Paraguay borders, no navigation Trêspassing) is about 5.745 km of navigable inland waterways. The complete waterway is also called the MERCOSUL Waterway, as seen on Figure 2 below.

Figure 2: MERCOSUL Waterway

The so called Tietê-Paraná Waterway is part of the composed MERCOSUL Waterway by the Upper Paraná River, upstream the confluence of the Iguaçu River, at the border from Brazil, Paraguay and Argentina, and its tributaries, one of them the Tietê River, as seen on Figure 3 below.

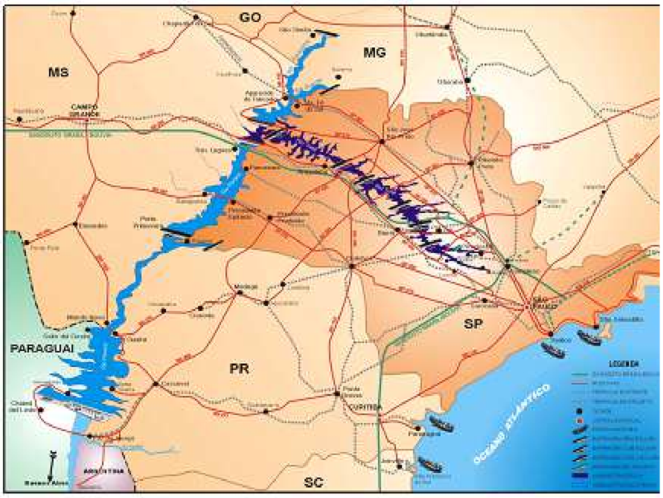


Figure 3: Tietê-Paraná Waterway

The Tietê-Paraná Waterway System is the number two in order of importance in Brazil considering only the shallow draft navigation. This system has important tributaries, the Paranaiba (170 km), the Grande (80 km) and the São José dos Dourados (37 km). Another important affluent is the Tietê (554 km) and its tributary Piracicaba (22 km). The Tietê is connected to the Paraná upper reach, by an artificial by-pass canal called Pereira Barreto Canal with 17 km long. The total length of navigable waterways at the Paraná basin is 1.581 km (see Table 1). It is important to mention that this waterway is mostly provided with hydropower plants with locks, therefore an artificial waterway quite similar to the Tennessee Valley Authority. The Table 2 below presents a summary description of the dimensions of the existing locks in this waterway.

PARANÁ		
MAIN RIVERS	EXTENSION	TOTAL
PARANÁ	701 km	
PARANAÍBA	170 km	1.581 km
GRANDE	80 km	
SÃO JOSÉ DOS DOURADOS	37 km	
PEREIRA BARRETO (Artificial Channel)	17 km	
TIETÊ (Piracicaba)	576 km	
PORTS AND TERMINALS (cargo)	-	> 20
CARGO (year 2013)	-	5.654.630 ton

Source: AHRANA

Table 1: Tietê-Paraná Waterway Distances

LOCK	DIMENSIONS (m)				RIVER
	LENGTH	WIDTH	DEPTH	HEAD	
BARRA BONITA	12,00	142,0	3,0	25,5	TIETÊ
BARIRI	12,00	142,0	3,0	24,0	TIETÊ
IBITINGA	12,00	142,0	3,0	24,3	TIETÊ
PROMISSÃO	12,00	142,0	3,0	27,5	TIETÊ
NOVA AVANHANDAVA upp.	12,00	142,0	3,0	17,5	TIETÊ
NOVA AVANHANDAVA low.	12,00	142,0	3,0	21,5	TIETÊ
TRÊS IRMÃOS upp.	12,10	142,0	4,0	24,0	TIETÊ
TRÊS IRMÃOS low.	12,10	142,0	4,0	24,5	TIETÊ
JUPIÁ	17,00	210,0	4,0	22,0	PARANÁ
PORTO PRIMAVERA	17,00	210,0	4,0	19,2	PARANÁ

Source: ANTAQ, AHRANA

Table 2: Tietê-Paraná Waterway–Lock Dimensions

The main navigable stretch of the waterway is part of the Paraná River, from the Itaipu Dam downstream south, and upstream north until the São Simão Dam at the Paranaíba River and until the Água Vermelha Dam at the Grande River. The total length of this stretch is about 1.020 km, passing bay part of the lower Tietê River, the Três Irmãos Lock and Dam, the Pereira Barreto Canal and the São Jose dos Dourados River at the Ilha Solteira reservoir. This stretch are divided in two sections; one from the mouth of the Tietê River to the north until São Simão and Água Vermelha (North Stretch), and the second, south to the Tietê mouth until de Itaipu Dam (South Stretch).To navigate in this stretch of Paraná Waterway, there are three lock passages add an artificial canal, from north to the south: the Canal Pereira Barreto, the system of locks with intermediary canal of Três Irmãos L&D, the Jupiá L&D and the Porto Primavera L&D (Table 2 above).

The tributary Tietê River is navigable from the mouth at the Paraná River, from west to east, until Santa Maria da Serra at the tributary Piracicaba River, or the Conchas and Anhembi at the Tietê River itself. This complete section corresponds to approximately 576 km. To navigate this section is necessary to go through six L&D passages, from west to east, Três Irmãos, and Nova Avanhandava, both systems of two locks with intermediary canals, Promissão, Ibitinga, Bariri and Barra Bonita (Table 2 above).

Important ports and terminals at the Paraná Waterway System for cargo movement are more than 20 in the whole system, moving during 2013, 5.654.630 tons by shallow draft navigation (see Table 1 above).

3 THE PROBLEM

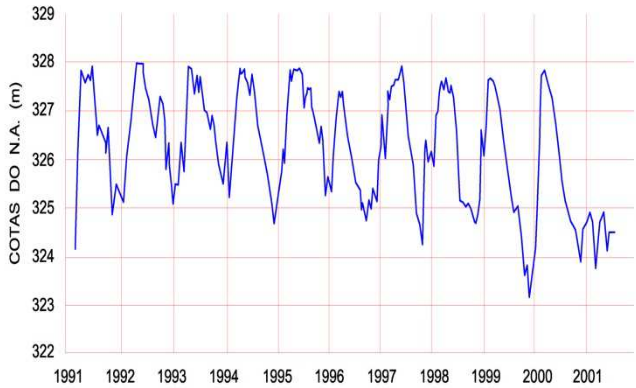
The water scenario in the whole Paraná River Basin has been suffering considerable changes throughout the past decades. It can be said that, in general, there has been an increase in the precipitation intensity, not necessarily meaning that this corresponds to an increase in the precipitation accumulated in the same periods. In other words, the precipitations have been more intense, causing floods, especially during the summer, but the draught periods have also been more intense and for longer periods of time.

The first critical season of the river tides behavior phenomenon with impact to the navigation on the Tietê-Paraná Waterway navigation occurred in 2001. In this occasion, an agreement was reached with the energy generation sector for the maintenance of the minimal levels for navigation (due to the definitions of the depth available in the dams). This agreement obliged the sector to reduce its capacity of generation during draught periods. The generation/production energy system in Brazil is interlinked nationally through a net of distribution, which makes the energy produced in the North of the country be consumed in the South and vice-versa, according to the supply and demand, giving the system great flexibility and security.

That year, as the north of the country precipitation regimes were not as affected as the Midwest and Southeast, where are located the Paraná River basin, such compensation of hydropower energy production and transmission allowed the retention of the minimum water levels for not stop the navigation, thanks to a care operation in hydropower dams of the rivers Tietê, Paranaiba and Grande.

In this case, the critical reservoir of the Paraná River is the Ilha Solteira Dam, which is interconnected, with the same operation water levels, to the Rio Tietê, through the São José dos Dourados River and the Pereira Barreto Canal, which flows into the Três Irmãos Dam.

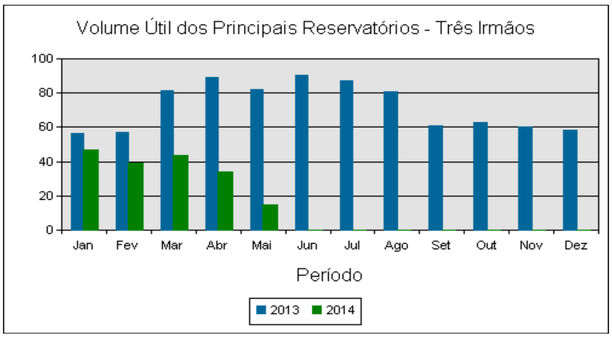
Graphic 1 below shows the behavior of the water levels for the period 1991 to 2001 in Ilha Solteira Dam plant coinciding approximately with the levels of Três Irmãos Dam, due to they are interconnected as already mentioned.

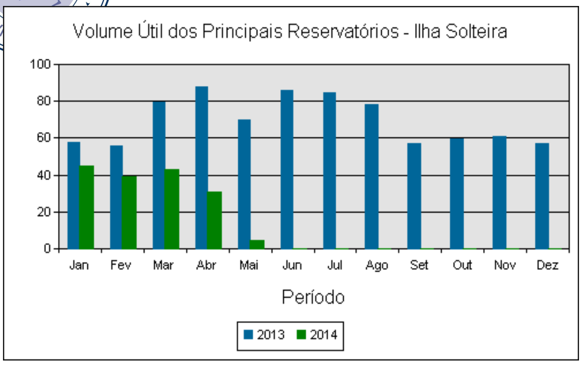


Graphic 1 – Upper Water Level of Ilha Solteira HPD and Três Irmãos L&D

This phenomenon happened again in the years 2013 and 2014 in aggravated form, due to low rainfall in the basin from 2013 to 2014 and to 2015, which were insufficient and well below expectations, to recover the volumes of the basin's reservoirs, and the the hydraulic generation system in the Midwestern and Southeastern regions return to critical conditions of water levels.

This situation was reflected extensively across the river basin, with damage including to water supply for consumption in their cities. Graphic 2 below shows the useful volumes of Ilha Solteira and Três Irmãos reservoirs for power generation in the years 2013 and 2014, and in May 2014 was reached the lower limit of its capacity, forcing the power generation was drastically reduced, with lower levels being more lowered, a situation that caused the interruption of navigation in this stretch of the local waterway.





Graphic 2 – Hydropower generation volume availibility-2013 and 2014
Três Irmãos L&HPD and Ilha Solteira HPD

The interruption of the navigable stretch was particularly motivated by the situation of the water levels of these two reservoirs operating interconnected. The non-recovery of water levels in 2013 was due to low rainfall in the basins of the Grande and Paranaiba Rivers, which are tributaries of the Paraná River, and both responsible for maintaining the levels of Ilha Solteira reservoir. The interconnection of these two reservoirs also ended up causing the lowering of the Três Irmãos reservoir, because the flow of the Tietê River would not be enough to also filled the Ilha Solteira reservoir on the Paraná River.

By 1976, they were designed and set construction conditions to Paraná River interconnection and operation with the Tietê River through the Três Irmãos dam on the Tietê River, connected to the Ilha Solteira dam in the Paraná River by the artificial canal to be opened (Pereira Barreto Canal, Figure 4), the hydrological conditions, energy production expectations and navigation in this section have been optimized and defined the operating conditions for both reservoirs and canal as follows:

- Minimum Water Lewel: 323,00 m, and 319,00 m quota for the entry threshold lock door (upper lock Três Irmãos, and lower lock of Nova Avanhadava, the next lock on the Tietê River);
- Maximum Water Level: 329,00 m
- Pereira Barreto Canal: 316,00 m (botton) - This value was established considering that water level variations between the reservoirs may occur within the canal in either directions. For this reason, the canal sections dimensions and its limits were defined in order to avoid critical velocities for the navigation inside the canal.

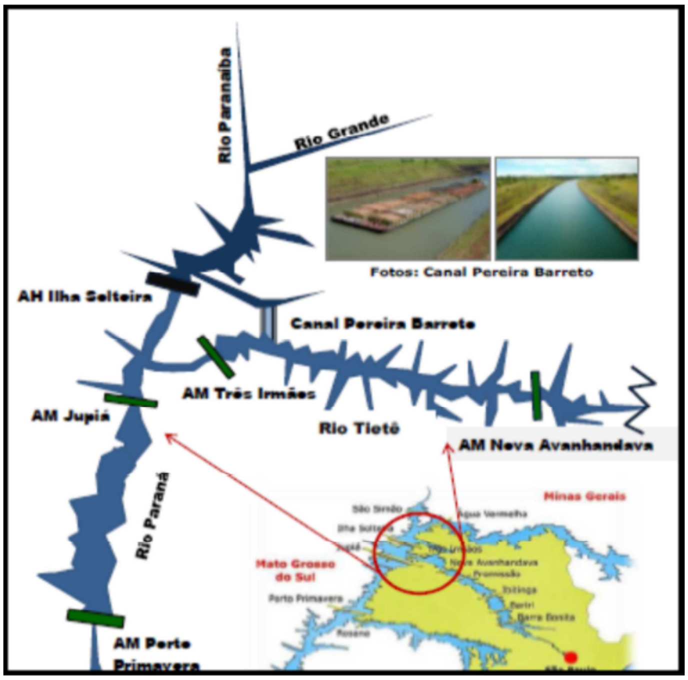


Figure 4 – Interconnection of the waterways Tietê and Paraná

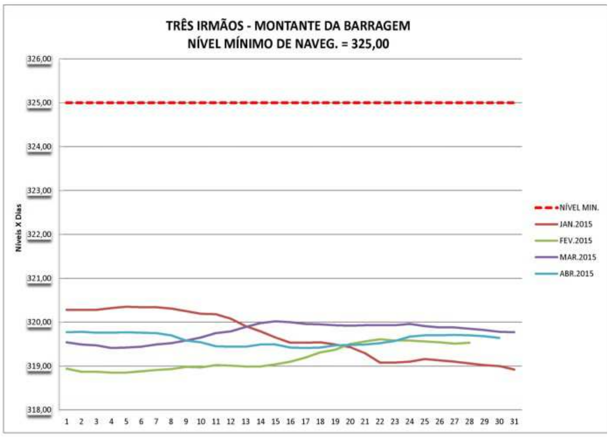
There is yet another depth restriction for navigation in this stretch, which is the current position of the bottom of the canal entrance of Nova Avanhandava lower lock, that require the maintenance of the actual water levels in Três Irmãos reservoir in quota 325,00 m, to allow safe traffic at maximum load of the navigation convoys, which is 2.50 m maximum draft. This restriction is an improvement work scheduled to perform with federal budget, together with the state of São Paulo, probably still start in 2015, allowing traffic with maximum draft (2,50 m) for the minimum navigation water level 323,00m which is the same as the Nova Avanhandava locks.

This adverse hydrological situation forced the stoppage of waterway traffic in this stretch (Três Irmãos reservoir on the river Tietê, the Pereira Barreto Canal linking the Tietê and Paraná rivers and the Ilha Solteira reservoir), thereby isolating the waterway of the Tietê River the other spans, North and South Stretch of the Paraná Waterway, and these two together. Considering the existing logistics systems operating in the waterway only remained in operational condition part of the Tietê River waterway that was the beginning of navigation at the waterway, sugar cane and methanol, as well as the extraction and transport of sand.

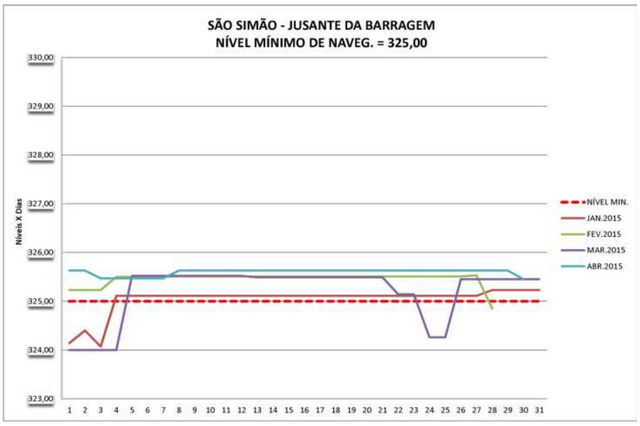
The North Stretch was stopped completely because its viability depended necessarily to connecting the River Tietê as east possible, even the Conchas and Anhembi terminals. At the South Stretch Waterway the interruption had frustrated a wooden pulp transport logistics for cellulose that barely started and that too was bound to the Tietê river terminals. As for the other charges in that stretch, agricultural bulk that had been his great reason to exist was already paralyzed due to the constant downgrades of water levels of the Itaipu reservoir. This downgrade causes the interruption of the waterway in Guaira region, due to the partial reappearance of existing waterfalls in the stretch before the flood reservoir of Itaipu, emerging partially, exposing rocks of the navigation channel bottom. But this issue will not be discussed herein.

The authorities forced by the situation, decreed the traffic disruption since May 2014, a situation that continues today, July 2015. The situation of reservoirs capacity of the Grande and Paranaiba rivers are in very critical situation today and probably one single rainy season may not be sufficient to retrieve the entire system. So there is a huge risk that the interruption of navigation could be extending until 2016 at least.

Graphics 3 and 4 below give the situations of daily water levels from January to April of 2016, to the reservoir of the Três Irmãos in Tietê River, and daily water levels in Paranaíba River, downstream the São Simão Dam, where finished the navigable stretch, upper end of Ilha Solteira reservoir. In both graphs, the red dashed lines indicate the level 325,00 m what is now the minimum limit quota for the navigation in this stretch.



Graphic 3 – Upper Water Level Três Irmãos Reservoir



Graphic 4 – Downstream Water Level at São Simão Dam – Paranaíba River

PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

The predominant economic activities along the waterway is the prime determinant of cargo composition. It is an area of intense activity in the agro industrial sector, which serves to bring soybean and sugar cane produced in Brazil's Central-West region to market. This type of cargo is most suitably transported with current means (i.e. flatboats with capacity of carrying up to 6.000 tons of granary goods).

The waterway divides into two tributaries, one flowing North and the other South, as it emerges from interior into the countryside of Southeast Brazil. Here it reaches the limits of the agro industrial producing areas. It is through these branches that cargo joins the transportation infrastructure system that unites the region of the Três Irmãos Dam. From there, it goes solely through the Tietê River to agro product processing centers or ports where cargo exported, as can be seen in Figure 03.

It is in this unique passage, downstream to the Nova Avanhandava Dam and upstream to the Três Irmãos Dam, where the interruption is located. This disruption in transport is due to the low river and reservoirs levels caused by tidal changes and the activities of hydroelectric dam operations.

As a consequence, such cargo has switched from fluvial convoy transportation to highway transportation. The impact of such consequences is significant. As observed in Figure 5, the transport through the river had been increasing gradually and consistently in the last five years.

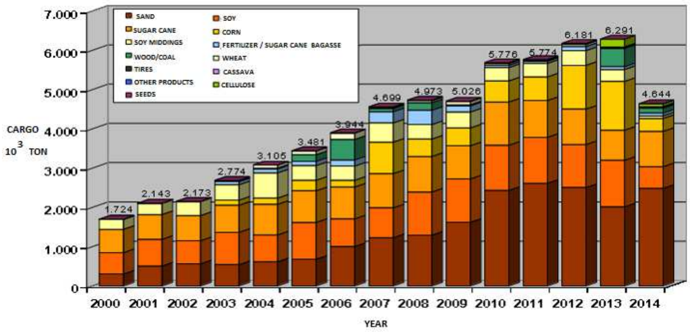


Figure 5 – Total Cargo Tonnage per Year

The Paraná Waterway has a significant contribution, due to its cargo insertion in the waterway system (north and south tributaries).

Cargo loads originating from this area of restricted transport that would have passed through can be observed on Table 3 below.

YEAR	ORIGIN	DESTINATION	DISTANCE (Km)	CARGO O/D (10^3 NTKM)	NORTH STRETCH (10^3 NTKM/year)
2010	São Simão	Anhembi	760	403.949	1.362.015
		Santa Maria da Serra	738	119.345	
		Pederneiras	655	838.719	
2011	São Simão	Anhembi	760	203.256	1.354.917
		Santa Maria da Serra	738	118.172	
		Pederneiras	655	1.033.487	
2012	São Simão	Anhembi	760	170.599	1.496.909
		Santa Maria da Serra	738	138.315	
		Pederneiras	655	1.187.995	
2013	São Simão	Anhembi	760	396.654	1.673.753
		Santa Maria da Serra	738	190.052	
		Pederneiras	655	1.087.045	
2014*	São Simão	Anhembi	760	71.881	376.545
		Santa Maria da Serra	738	56.744	
		Pederneiras	655	247.919	
2015					0

Table 3 – North Stretch Transported Cargo
(*) navigation interrupted on May 2014

These cargo loads were transported by highway due to the urgent need to alter the ways of shipping goods mentioned above. Trucks, which are largely available and easily mobilized, proved to be the most effective alternative.

Due to the growing demand for reduced transportation costs and economy driven nature of shipping, the sector's projections for 2015 are approximately 1.9 billion NTKM/year (International System). The environmental impact of this extra pollutant gas emission for 2015 is assessed.

This growth is having major environmental impact and is further increasing greenhouse gas emissions. This is causing Brazil to fall even shorter of meeting the stipulated quotas established in international compromises and ratified through the National Policy Regarding Climate Change (Federal Law n. 12.287/2009).

The most efficacious means for reigning in GHGs in the transportation sector are: the substitution of fossil fuels for biofuel, technological advances in the efficiency of transportation vehicles, logistical improvements in the demand of goods and services e.g. reducing distances between supplying centers and consumers, and the evidence based shift in transportation means.

Knowing this and given the nature of this paper, there is an easily identified regression. Despite expectations, there has been a shift to transport via trucks instead of more efficient means of transportation, such as trains, fluvial convoys or especially polyducts. The latter transportation means would further develop the transport logistics optimization and markedly improve efficiency of transportation vehicles with greater capacity.

Ferreira (2011) indicates that the Sao Paulo Secretary of Logistic and Transportation estimated that the great potential contribution would originate from the rationalization (optimization) of the cargo transportation system, particularly the highway system. At the time, during 48% of transits trucks would be empty. This is in comparison to rates in Europe of 22-24% and in the USA 16-18%, according to the State Policy Management Committee on Climate Change (2010).

The optimization of the transport system in existence and the substitution of more efficient means not only contributes to the reduction GHGs but also other pollutants and atmospherically contaminants by reducing of energy consumption and logistics costs.

Transportation by barges that allow for multiple variations and that offer an ample range of configurations for the diverse types of cargo, can bring benefits to the population's health, as these are considered motor-less transport.

In fact, the additional benefits that occur from the promotion of optimized logistics and efficient modes of transport by GHGs emission policies are extremely significant. Be it by its contribution to the improvement of the population's health conditions or by its contribution to the economic development, these benefits cannot be disregarded when developing analysis and studies on the economic viability of such policies.

It is through studies on the technical, economic and environmental viability that methodologies to estimate the major environmental and social impacts resulting from switch of cargo transportation from waterway to highway are developed. These impacts are also a result of tidal changes and the priority given to the power generation sector for the exploitation of water resources. These resources in theory should be exploited through a regimen of multiple uses.

Three procedures were evaluated for the measurement of GHGs emissions. The first methodology is the one proposed in the Sectorial Plan on Transportation and Urban Mobility for Mitigation and Adaptation to Climate Changes, established by the Brazilian Ministry of Transportation and published in 2013.

It is assumed that the emissions total is the result of a combination of emission factors obtained in national and international references in net tonne kilometer (NTKM). These are multiplied by the times in which vehicles are identified as those associated to interior navigation.

Another methodology that was considered by the authors is the one developed by the Departamento Hidroviário do Estado de São Paulo in its Study on the Technical and Economic Viability. This study aims to evaluate GHGs in the face on going reduction program. This study is based on economic data extracted from the research done by the Instituto de Pesquisa Econômica Aplicada (IPEA), an institution linked to the Secretary of Strategical Studies of the Presidency of the Brazilian Republic.

Finally, with the methodology chosen by this article in mind, the National Department of Infrastructure in Transports has conducted a myriad of studies on the Technic Economic and Environmental Viability, on a national level, in order to detail the foreseen actions or to establish the additional subsidy to the Strategical Waterway Program (SWP). Especially, one study has been done for the Paraná River Basin.

For such evaluation related to the main polluting substances emitted by combustion engine, the data on the emission of polluting gases per NTKM of each mean of transportation is used as the basis on Table 4.

MODAL	CO_2 (g/10^3 NTKM)	NOx (g/10^3 NTKM)	CH_6 (g/10^3 NTKM)
Highway	116.000	4.617	286
Railway	25.000	317	50
Waterway	20.000	254	41

Table 4 – Polluting Gases Emission Rate per NTKM x Modal

Supported in the Kyoto Protocol (2005), the fact that the different greenhouse gases have varying degrees of atmospheric effects make it necessary to calculate the global warming contribution potential of each gas by a single standard. Carbon equivalent is the preferred standard.

The widely accepted carbon dioxide pollution potential proportionality is used as a basis in this case. Thus, the equivalence below (Table 5):

	CO_2	NOx	CH_6
Global Warming Potencial	1	310	21

Table 5 – Global Warming Potential of the studied gases

In order to calculate the pollution rate of the aforementioned transportation methods in carbon equivalents (GHGs) the following formula was applied:

$$tCO_{2(Modal)}^{Eq} = \sum Pot_{Modal}^{Gas} * T_{Modal}^{Gas}$$

$tCO_{2(Modal)}^{Eq}$: CARBON EQUIVALENT EMISSION PER NTKM / MODAL

Pot_{Modal}^{Gas} : GAS POTENTIAL GLOBAL WARMING

T_{Modal}^{Gas} : POLLUTING GASES EMISSION RATE PER MODAL

The carbon equivalent emission rate by NTKM for each modal is:

MODAL	tCO_2eq (g/10^3 NTKM)
Highway	1,553276
Railway	1,243200
Waterway	0,996010

Table 6 – Polluting gases emission rate per NTKM/transportation means

The following equation is used to calculate the total carbon equivalent emissions caused by the increase of pollutant emissions:

$$G = \left(tCO_{2(Rodo)}^{Eq} - tCO_{2(Hidro)}^{Eq}\right) \times TKU$$

For the 2015, is presented an evaluation of the total emission increment. Knowing the transferred cargo and the distances to be traveled via highway, there is a total of the emission increment:

- Total Cargo in NTKM = 1.857.866.065

Total Emission Increment = G

G = (1,553276 – 0,996010) x 1.857.866.065

G = 2,70 M tCO_2eq

4 CONCLUSIONS

The purpose of this article was not to exhaust the subject of the impacts due to the partial interruption of navigation of the Tietê-Paraná Waterway, caused by adverse hydrological precipitation regimes in the period 2013-2015. These impacts go beyond the environmental issue that this document just tried to carry out a very preliminary assessment, limited to the valuation of the impact due to emissions of pollutants in the atmosphere, according to methodologies used in other similar studies of environmental impact assessment. In this study case, the extra pollutant emission is about 2,70 M tCO_2eq, that indicates a significant increment.

Other indicators could also be included, such as the risk of accidents, whereas in the case studied, the load transfer was carried out of the waterways for road transportation considering the logistics possibilities for the cargo traffic cargo that have left to be transported by the interrupted waterway. As in the case of Brazil, the accident index follows the global trend to be higher risk in road transport compared to water transportation, which would certainly increase the cost values

The difficulty in obtaining the necessary information, we do not assessed the economic and financial losses caused by the cargo that must have transferred between modes of transport, the waterway for road, Because it was an event not expected, probably the transfer occurred with losses to exporters that should honor their delivery contracts already signed, with prices considering an intermodal logistic, which was necessarily replaced by a more expensive option of transport.

This interrupt situation may also have brought the desistance of this logistics option for the future of transportation in the region, with negative consequences for the economy, due to insecurity and lack of reliability of this mode of transport. Combined with the higher shipping cost for lack of choice of transportation, may also affect the farm bulk and byproducts, whereas the processing facility of agricultural products already watched in the region, expecting to rely on water transport.

This traffic disruption in the period caused significant layoffs in barge transportation companies, also in indirect services that the navigation requires, affecting local economies of many cities within the zone, which had the navigation as a source of economic generation. Some shipyards in the region halted their work, with layoffs of employees, and other reduces its

Finally, the authors hope that this modest paper can serve to motivate the Brazilian authorities responsible for environmental protection and the multiple uses of water, to the importance of use of water for navigation.

That natural goodness should be shared responsibly while preserving the quantity and quality respecting all users, ensuring access and rational use and ensuring the economic benefit that can provide while minimizing losses to society in general.

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