5. THE IMPORTANCE OF RIVERS FOR THE TRANSPORTATION SYSTEM OF THE AMAZON

Camilo Domínguez *

1. GENERAL CHARACTERISTICS OF WATER BASINS IN THE AMAZON

The tropical and, for the most part, equatorial climate in the Amazon, averages monthly temperatures above 20º C, and produces intense evaporation. This is true both for the Atlantic Ocean and for the continent. This evaporation is constantly being recycled horizontally and vertically. Atlantic evaporation moves in the form of clouds that produce rain from the east to the west. By the time they reach the Andes, the clouds have unloaded all of the rain. Nevertheless, much of this rain reevaporates, or it is transpired in the form of gas through plants and animals and soon replenishes the clouds that move into the continent. A water column is formed by the humidity that rises and the rain that falls. This column rises thousands of meters from the ground (Salati; Marques 1984: 85-125). However, not all water reevaporates, some of it remains in the ground and drains away in the form of millions of small underground springs that flow into the Amazonas River. Due to that fact, the soil in the forest is always damp, and there are flooded palm forests. They are called aguajes, cananguchales or miritizais and are found in plain areas. This great amount of

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water gathers in the form of sub-basins and basins. They take the opposite way in relation to cloud masses and drain away towards the east, seeking the Atlantic Ocean to renew the cycle.

As expected in the case of such a large water basin, the main tributaries have enough space to take in water from hundreds of thousands of square kilometers. Each one of them is by far longer and greater than many of the biggest rivers in the world. That is the case with the Negro River, the Madeira River, the Xingú River and the Tapajós River. The Amazon basin can offer a total of 50,000 kilometers of navigable rivers to boats weighing up to 1,000 tons. About 10,000 kilometers are navigable to ships weighing 1,000 tons or more. It is impressive to watch ships from Europe or from the United States drop anchor at Leticia, an Amazon port in Colombia, over 3,000 kilometers away from the sea. It is also amazing to see gunboats as they go up the Putumayo River to Puerto Leguízamo, which is very close to the Andes.

1.1 Amazonas-Orinoco-Guyanas.

The Amazon Basin covers an area of 6,879,761 Km². It includes the territories of six countries, but most of it is located in Brazil. The characteristics of the Amazonian landscape extend over almost one million, five hundred thousand kilometers to the east and to the north, including the Guyanas and the Orinoco River basin. The humid tropical jungle forms a continuous carpet of green that reaches the basins of rivers in Guyana, Suriname and the French Guyana, as it does most of the Orinoco Basin. There is also intense vertical and horizontal humidity transport as well as diverse biota that is typical of the Amazonian region.

The Orinoco Basin has an area of 1,032,524 Km². It includes huge rivers, most of which are navigable. The Guaviare is 1,354 kilometers long, and 620 kilometers of this river are navigated by vessels. The Meta is 1,000 kilometers long, 750 kilometers of it being navigable. The Arauca is 950 kilometers long and 650 kilometers can be used for navigation. In Venezuela, there is the Apure. It is a huge river which is navigable for 800 of its total 1,110 kilometers. In addition, the navigable portion of the Orinoco itself reaches 1,700 of its total 2,500 kilometers. Eight hundred and eighty kilometers located in the lower part of this river are especially important due to the fact that vessels with increased cargo-carrying capacity, including transatlantic ships, get to Ciudad Bolivar in Venezuela using a stretch of the river that is 360 kilometers long.

The basins found in the Guyanas are not dependent on the Amazonas River or on the Orinoco River. They flow directly into the Atlantic Ocean. All of the rivers located in the French Guyana, Suriname, Guyana and in the Caroni Basin in Venezuela, which is a tributary of the Essequibo River, belong to this region. In the case of the Oiapoque River, it must be taken into consideration that the State of Amapá is partially Guyanese. If we do
not consider the Brazilian Oiapoque, the Guyanese Basin covers a total area of 356,396 Km². The main rivers in the Guyanas are the Essequibo-Cuyuní, the Corentyne, the Maroni and the Oiapoque. Navigation in these rivers is rather precarious due to the fact that most of their courses run through the hard rock formations of the Guyana Shield. This means that there are waterfalls and rapids that can only be crossed in canoes and small motorboats (Domínguez 1998: 130-135).

**TABLE 1 - SUBREGIONS OF THE GREAT BASIN**
(Distribution in square kilometers)

<table>
<thead>
<tr>
<th>Basin</th>
<th>Brazil</th>
<th>Peru</th>
<th>Bolivia</th>
<th>Colombia</th>
<th>Ecuador</th>
<th>Venezuela</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMAZON BASIN</td>
<td>4,989,361</td>
<td>762,400</td>
<td>600,000</td>
<td>336,000</td>
<td>130,000</td>
<td>61,000</td>
<td>6,878,761</td>
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<tr>
<td>ORINOCO BASIN</td>
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<td></td>
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<tr>
<td>Venezuela</td>
<td>644,423</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Colombia</td>
<td>388,101</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,032,524</strong></td>
<td><strong>622,501</strong></td>
<td><strong>600,000</strong></td>
<td><strong>336,000</strong></td>
<td><strong>130,000</strong></td>
<td><strong>61,000</strong></td>
<td><strong>8,267,681</strong></td>
</tr>
<tr>
<td>GUYANAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guyana</td>
<td>136,784</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suriname</td>
<td>110,612</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>French Guyana</td>
<td>81,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venezuela (Cuyuní)</td>
<td>28,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>356,396</strong></td>
<td><strong>136,612</strong></td>
<td><strong>110,612</strong></td>
<td><strong>81,000</strong></td>
<td><strong>28,000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>8,267,681 Km²</strong></td>
<td><strong>622,501</strong></td>
<td><strong>600,000</strong></td>
<td><strong>336,000</strong></td>
<td><strong>130,000</strong></td>
<td><strong>61,000</strong></td>
<td><strong>8,267,681</strong></td>
</tr>
</tbody>
</table>
1.2 The Upper Amazon and the Lower Amazon

The concepts of Upper Amazon and Lower Amazon are constantly used. However, there is not an exact definition for these terms. This is so because they result from a combination of morphologic, economic and social factors. In fact, they involve the characteristics of rivers, their navigability, the population density and the geopolitical relationships between the several countries where the basin is located.

In general, the Brazilian concept has prevailed. It takes the spot where the Negro River flows into the Amazonas River as the border between the Lower and the Upper Amazon. Only the lower portion of the Amazonas River, however, goes by that name, until it reaches Manaus. From there on to the north, it is called Solimões, and this is the name by which it goes until it reaches the border between Brazil, Peru and Colombia.

Andean-Amazonian countries do not use the name Solimões and prefer the term mid-Amazonas to refer to the stretch of the river that goes from the mouth of the Negro River to the mouth of the Yavarí and from the upper Amazonas to the section between the Brazilian border and the source of the Ucayali River. The most important aspect is the possibility for continuous ship navigation from east to west, although in reality it only reaches the Iquitos port.

As we can see, the names for the navigable stretch of the main riverbed of the Amazonas vary from Panamazonian country to Panamazonian country. Nevertheless, in regards to the rest of the basin, it is generally accepted that the lower Negro River, to the north, and the lower Madeira, to the south, clearly display the differences between the lower Amazon and the upper Amazon. From there on, the influences of the Andes begin to be seen in the morphology, landscape, population, economy and cultures. Between the Portuguese-Brazilian world of the lower Amazonas and the Spanish-American world of the upper Amazonas there is a transitional area that is the result of historical factors.

2. EASY AND DIFFICULT ASPECTS OF NAVIGATION IN THE BASINS

2.1 Navigation on the Sea River

If we consider the Ucayali River as the former of the Amazonas, the total length of the Sea River will be 6,518 kilometers from its source in Mount Huagra (Peru), where it is called Apurimac, to the place where it flows into the Atlantic Ocean. At first, the river goes down the eastern Andean slope for 1,433 kilometers until it reaches the plain, where it is navigable. This is at a distance of 5,085 kilometers from the ocean. From there to Pucallpa,
530 kilometers away, small motorboats with a draft of no more than 3 feet can navigate all year round. From Pucallpa on, the river is deep enough for larger motorboats and tugboats. They can have a 7-foot draft and a carrying capacity of 100 or 200 tons. These vessels navigate 890 kilometers to the place where the river meets the Marañón River, and 125 kilometers more to reach the Iquitos port. From its source to Iquitos, the Amazonas is 2,978 kilometers long, of which are navigable 1,545 kilometers.

From Iquitos to Belém do Pará, 3,540 kilometers of the Amazonas River are navigable. The flow rate increases a great deal due to the fact that the Marañón, the Huallaga, the Ucayali and, a few kilometers downstream, the Napo, a gigantic river, meet. This increase in the amount of water makes it possible for ships with a draft of up to 15 feet to go upstream to the Iquitos port. However, the increasing number of sandbanks and the lack of returning cargo have made it preferable to use the Tabatinga and the Leticia ports for the transportation of cargo on barges and tugboats 440 kilometers upstream.

When it reaches the Brazilian Amazon, the Amazonas has already covered more than half of its total course. From Tabatinga to Manaus 1,600 kilometers are permanently navigable for ships that can carry up to 25,000 tons. The flow rate of the river increases through its large navigable tributaries, like the Içá-Putumayo, the Juruá, the Purus and the Japurá-Caquetá.

From the place where the Negro River, the largest tributary of the basin in terms of flow rate, meets the Amazonas, the river takes on maritime navigation characteristics. From Manaus to the ports of Santarém, Santana and Belém do Pará there is intense river traffic. This is due to the fact that Manaus is in a privileged situation because it serves as the link between the upper Amazon and the lower Amazon. The city also absorbs a huge quantity of passengers and a great amount of cargo, providing transportation services to its millions of inhabitants. Due to this, 50% of all river traffic in the basin takes place along the 1,500 kilometers from Manaus to the mouth of the Amazonas.

The navigation of the upper Amazonas and the lower Amazonas adds up to a total of 5,085 kilometers of continuous navigation on the Sea River all year round.

2.2 Geological Structures and Navigation

There are no obstacles over the long navigable stretch in the main stream of the Amazonas. This is due to the geological structure of the Amazonas valley itself. This valley was formed during the tertiary and quaternary periods and extends from the east to the west of South America. Roughly speaking, it follows the equator line. The unconsolidated sediments that cover a deep tectonic fault, filled during the tertiary and
recent periods, have made it possible for waters to excavate a deep bed and shape it so there are no obstacles to the flow of river waters. In general, the morphology of the valley is closely related to the free navigation of rivers. As we encounter obstacles such as rapids and waterfalls, we can be almost entirely sure that we are over older geological structures or structures produced by volcanic activity.

The valley has the Andes Mountains to the west, the Guyana Shield to the north, and the Central Brazilian Shield to the south. These geological structures are made up of consolidated rocks whose ages range from the Mesozoic to the Pre-Cambrian period. A few areas are more recent (Putzer, Hannfrit 1984).

At the Andean foothills, the Amazonas valley extends over hundreds of kilometers. This allows for the navigation of rivers all the way to the foot of the mountains. However, as rivers reach the mountains, they almost immediately lose navigability. For instance, the Pongo de Maseriche, on the Marañón River, and the Pongo de Aguirre, on the Huallaga River, are obstacles that determine the furthest limits to the navigation of these rivers.

The Guyana Shield is not formed only by the mountains or table mountains that surround the upper Orinoco and its tributaries. Most of its old rock formations have been showered by meteors for millions of years and now are reduced to baselevel (peneplains and pediplains). They extend millions of square kilometers to the north of the basin. Thin layers of sand or soil cover these rocks, allowing for the growth of not very dense forests and of not very dense bush. These forest and bush formations are known by the Tupi-Guarani name of caatingas. When rivers run through these rock surfaces, rapids and waterfalls are formed. They make navigation more difficult. Therefore, navigation upstream the northern tributaries of the lower Amazonas is abruptly blocked at the Guyanese formation. This becomes especially obvious when the valley plain first meets the rocky peneplain because the different degrees of erosion result in a difference in height that forms waterfalls and rapids.

Something similar occurs to the south with the Central Brazilian Shield. The first waterfalls clearly indicate the existence of old formations and, consequently, the end of navigation or the transfer onto smaller vessels in order to continue traveling upstream.

2.3. Connections between the Orinoco and the Amazonas

Although the existence of numerous connections between the Amazonas Basin and the Orinoco Basin is constantly emphasized, it is necessary to make it clear that they are mostly still water transfers few fish can cross. This occurs during flood seasons or at the riverhead of upstream tributaries. This also occurs at passages that connect rivers that are close to one another, where canoes or medium-sized vessels are dragged from one river to the other. The only connection where there can be continuous navigation is the Casiquiare

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channel. This natural channel links the upper Orinoco and the Upper Negro River, also called Guainía. This is the biggest tributary of the Amazonas and it can be navigated by vessels weighing up to 100 tons in spite of the Cabarúa waterfall.

Due to the current socio-economic and technical conditions, it is not possible for there to be continuous navigation from the Amazonas to the Orinoco. Navigation is only possible for small boats or when it involves transfers, which are costly. This is due to the fact that there are several rapids and waterfalls that present obstacles to navigation. Along the Middle Orinoco, there are the Atures and Maipures rapids, which extend 50 kilometers. The river drops twenty meters from the upper to the lower section. In order to cross these rapids, all cargo must be unboarded and a road must be used from Puerto Ayacucho to Samariapo. The navigation of the Middle Negro River is even more problematic from the mouth of the Cauaburi to the mouth of the Içaña. There are about 10 rapids and waterfalls that extend over 200 kilometers. The most important of these rapids and waterfalls is the São Gabriel da Cachoeira waterfall, which completely blocks the passage. Another difficult transfer is necessary at this point.

Connecting the Orinoco and the Negro River to the Amazonas is an old dream. However, even though the technology is available today, it would not be a sensible thing to do. There would not be cargo or passengers to transport since traveling by sea or taking the road is faster and easier. The fact that something can be done does not necessarily mean it should be done.

2.4. Great Differences between Rising Tides and Droughts

Amazonian rivers are very different in terms of depth and the maximum and minimum amounts of water in their riverbeds. Likewise, they are very different in terms of the duration of their high and low tides. In any case, this phenomenon is less significant than what could be expected if we consider the continental dimensions of the basin.

Since the Equator line roughly coincides with the main stream of the Amazonas, the basin is located in two different climatic hemispheres. The Continental Equatorial Mass goes towards the meridians. It is located in the south during the austral summer, and it causes rains that fill southern tributaries from November to March. Tides fall in April, and they remain low until September or October. The volume of northern tributaries, on the other hand, increases due to the rains that fall from April to October, and at the end of the year their tides fall. When the Negro River and the Japurá reach peak levels, the Ucayali, the Madeira and the Xingú reach their lowest levels. If a tugboat leaves Caracará in July on the Branco River and goes down the Negro River to Manaus, there will be problems in relation to navigation on the Madeira if the purpose is to reach Porto Velho. In northern tributaries tides will be high, but in southern tributaries tides will be low.
In the lower Amazonas, a phenomenon occurs which is known as *interference* (Delgado de Carvalho. 1942; Soares. S:F:) or compensation. It involves southern and northern waters. Due to this phenomenon, high tides are not catastrophic but riverbeds are still deep. The average difference between peak levels and the lowest levels is ten and a half meters. The average depth varies from 50 to 130 meters (Soares. 1963:86). On the Solimões, the difference between the peak level and the lowest level reaches 18 meters. This is due to the influence of the austral hemisphere, which is not sufficiently compensated by the northern tributaries (Putumayo and Japurá). The average depth varies from 50 to 80 meters. This shows a certain level of *interference*, which prevents rivers from reaching their lowest levels and makes navigation easier.

When tributaries are located in only one hemisphere, be it boreal or austral, they undergo great seasonal changes in depth and, therefore, in navigability. High tides allow for fast navigation to take place, but during droughts navigation is interrupted due to the fact that there is not enough water in the riverbeds. Nevertheless, tides can rise suddenly and be catastrophic for smaller rivers when heavy rains flood the riverbeds.

3. CURRENT SITUATION AND POSSIBILITIES FOR CARGO AND PASSENGER TRANSPORTATION IN THE AMAZON

3.1. Waterways and their characteristics

River navigation has been a fundamental means of transportation in the Amazon even though since the 1930s roads have been built that go through the basins in each of the Panamazonian countries. Especially in the Brazilian Amazon, rivers have enormous potential in terms of cargo and passenger transportation due to the fact that ships can be used. This makes it possible for several thousands of tons to be transported in one single trip, and costs are very low in terms of ton/kilometer. In relation to the rest of the basin or to smaller rivers in Brazil, rivers play an important role since they are the only possible way to reach remote areas or areas where floods occur and roads cannot be built.

The relationship between river navigation, roadway transportation and airway transportation includes many factors that make one means of transportation or another more widely used. The idea that navigation is always the cheapest and most comfortable way to travel is incorrect. In fact, it depends on a number of aspects.

River navigation is slow when compared to roadway transportation and very slow when compared to airway transportation. For the hasty traveler in modern life or for the transportation of perishable fruits and vegetables, planes, buses or trucks are sought instead of boats or motorboats when a choice can be made. On the other hand, for a traveler who wants to enjoy the trip, a slow means of transportation is better than a fast one. Also, when
there is a great amount of cargo to be carried or when the cargo is very heavy, speed is less important than cargo-carrying capacity. When there is the need to transport thousands of tons at the same time, boats, lighters or barges are preferable to trucks or planes.

In relation to passenger transportation, the cost of the trip is proportional to the number of days the trip lasts. This is due to the fact that costs with the passenger’s meals are added to costs with fuel. When the trip is too long and slow, this issue becomes crucial and makes this kind of transportation uneconomic. This is why in such cases it is best to travel by bus or airplane although boat or motorboat fares seem cheaper.

The smaller the boat, the higher the cost for waterway transportation. Although a boat uses thousands of gallons of fuel per trip, the ton/kilometer relationship is extraordinarily low when compared to the terrible ton/kilometer throughput of an outboard motor. Therefore, when a river only allows for small boats to navigate, waterway transportation costs turn out really high. In this case, it is best to build roads parallel to the rivers or landing strips at arrival and departure locations.

Another factor that has an influence on the high costs for navigation in small rivers is the increase in distance due to the existence of meanders. Smaller downward inclination of the river creates greater difficulties to navigate this river. Therefore, there is a greater tendency towards the formation of meanders. Due to these meanders, the distance between two places can be doubled or tripled. This proportionally increases costs with fuel and the duration of the trip. In cases such as these, it is also preferable to build roads alongside the rivers and landing strips.

Other very important factors are the number and distribution of people living on riverbanks. The existence of large cities or the existence of many communities living on the banks of navigable rivers create the necessary supply and demand so navigation routes and companies can be founded. River traffic density is directly proportional to the population density on riverbanks. It is possible to increase river traffic through tax incentives or direct support in the form of cash or subsidized cargoes. However, if this does not lead to a concomitant increase in the number of people living in areas surrounding the basins, this effort will undoubtedly fail.

3.2. Situation in the lower Amazon

Navigation in the lower Amazonas is a lot more intense, economic and profitable than that in the Upper Amazonas. The depth of the river allows for the permanent navigation of large cargo and passenger ships. This makes the ton/kilometer and the passenger/kilometer relationship very profitable. Likewise, the existence of large cities like Belém and Manaus and of numerous medium and small populations along the way generates a relatively high demand for and supply of goods and services. This stimulates river navigation.
It is necessary to consider that most of this traffic takes place on the Amazonas River itself, involving the cities of Belém, Santarém and Manaus. This includes the stretch of the river that links these cities to Santana and Macapá, in the State of Amapá. However, when the issue is closely examined, it can be seen that the traffic that takes place within the states is greater than that which links several states in the Brazilian lower Amazonas. In the State of Pará, there are thirty small and medium-sized companies that offer trips to Marajó Island, Salgado, Monte Alegre, Santarém and Óbidos, but only larger companies that transport both cargo and passengers offer trips all the way to Manaus or Macapá. The same occurs in the State of Amazonas. Most companies travel within the state, preferably down the Amazonas River until they reach the Pará state border or up the Negro River and the Solimões until they reach the populations that live close to Manaus. Only larger companies go to Santarém or Belém do Pará. Nineteen river navigation companies are based in Manaus.

The ships that go from Belém to Manaus do not start navigating the Amazonas itself from the Atlantic Ocean through the northern channel. Instead, they go to the end of the Tocantins estuary on the Pará River and navigate through the fuco de Breves (the Breves channel) until they reach the Amazonas at Gurupá Island. The fuco link gigantic estuaries that are separated by Marajó Island. To the south, they link the Pará River, formed by the Araguaia, the Tocantins and the Amazonas (which are linked through the furos) to the Anapu and Pacajá Rivers. This is a set of estuaries, bays and channels. caboclos (a race that resulted from the miscegenation of whites and Indians) live on houses on stilts at riverbanks. There are also small villages like Vigía, Ponta de Pedras, Melgaço, Portel, Barcarena and Cametá, where the river traffic is relatively intense. To the north, there is the actual Amazon estuary. Gurupá Island separates the water of the main course of the Amazonas, to the north, from the Vieira Grande channel, to the south. Between the two channels there is a set of islands, most of which are floodable, like Caviana and Mexiana. On the banks of the Norte Channel are the ports of Macapá and Santana, where there are deep draft docks.

From the mouth of the Xingú upstream, there is a more defined channel for navigation. Commercial ships stop at the ports of Gurupá, Almeirim, Prainha, Monte Alegre, Santarém, Óbidos, Oriximiná, Juriti and Parintins before they reach Manaus (ENASA, 2001). Some of these ports are located at the mouth of large tributaries and are the starting point for the navigation in the upstream direction, along these tributaries, up to the rapids. In general, this service is provided by smaller boats, whose owners live in the villages along the rivers. These boats transport the passengers brought by ships and river ferries whose final destination is the tributaries. From Santarém, they go up the Tapajós to Itaituba. From Parintins, the Paraná do Ramos and its numerous sub-tributaries are navigated, and from Manaus the Madeira River is navigated to Porto Velho.
Manaus is a link between the lower and the upper Amazonas. Its strategic location allows for it to influence places as far as the Andes, to the west, the great Bolivian tributaries of the Madeira, to the south, and the Orinoco, to the north. Many of the ships and river ferries that go up the lower Amazonas unload their cargo in Manaus so it can be divided along thousands of kilometers of navigable ways.

The number of boats and barges that leave Manaus to go upstream the Solimões, the Madeira, the Juruá or the Purus is much lower than the number of boats and barges that navigate the lower Amazonas. Each large or medium-sized navigation company charters one or two boats weekly to reach these destinations. The most common boat lines are the following: upstream the Madeira to Humaitá and Porto Velho; from the Purús to Canutama and Lábrea, and from the Solimões to Tefé or Tabatinga. In the case of tributaries like the Japurá (Caquetá) and the Ícaca (Putumayo), navigation from Manaus is practically inexistent. However, in Tefé and Tabatinga there are local boats that travel on the Japurá, and in Tabatinga there are boats that navigate the lower Ícaca and the Javari.

The navigation of the Negro River and that of the Branco River, starting in Manaus, are very important for the States of Amazonas and Roraima. Boats go up the Negro River 315 kilometers and up the Branco River 360 kilometers until they reach the Caracaraí port. This port is located downstream of the rapids that go by the same name, which are famous for being dangerous. Due to the existence of these rapids, Caracaraí is linked to Boa Vista, the capital of Roraima, by a paved road that extends 135 kilometers. The Caracaraí port is strategically located in relation to bimodal transportation involving the Amazonas and the Orinoco. There is a road that extends 1,530 kilometers from Manaus to Ciudad Bolívar (Venezuela). It is completely paved and there are bridges that are open to trucks with gross weights up to 40 tons. Caracaraí is 950 kilometers away from Ciudad Bolívar. Transportation can continue through the navigation of the Orinoco, the Apure and the Meta, and it can also go on by roadway to the Caribbean (Caracas and Barranquilla) and to the Pacific (Buenaventura).

4. NAVIGATION ON THE ORINOCO AND HOW IT CONTINUES INTO THE AMAZON

4.1. The Orinoco

The Orinoco is one of the most voluminous rivers in the world. However, compared to the Amazonas, differences in volume are too great in relation to high and low tides. At its mouth, there is a water discharge of 35,000 cubic meters per second during the dry season. During the peak of the rainy season, the water discharge may reach 100,000 cubic meters. The reason for this extreme phenomenon is the fact that the entire basin, which is
located in Venezuela and Colombia, is only influenced by one climatic hemisphere. This means that there is rain from April to November, and the dry period, which is very intense, goes from December to March.

Over 4,520 kilometers of Orinoco basin rivers are navigable to tugboats that can carry up to 2,000 tons. Small boats that can carry up to 100 tons can navigate 700 kilometers further, which adds up to a total of 5,220 kilometers of waterways. Transatlantic ships go upstream to Ciudad Bolívar (360 kilometers) and there the cargo is transferred onto barges and boats so it can be transported upstream the Orinoco and its tributaries. The main course of the river is navigable all year round for vessels with a draft of up to 9 feet all the way to the mouth of the Apure River. From there on, vessels with an average draft of 5 feet can go upstream another 200 kilometers for eight months out of the year to San Fernando, on the Apure River. They can also go up another 250 kilometers to the El Baul port, on the Portuguesa River, which is a tributary of the Apure. These two ports offer easy and fast transportation to Caracas.

Also in regards to the navigation of the Orinoco, tugboats with drafts up to 4 or 5 feet and a carrying capacity of 2,000 tons go from the mouth of the Apure upstream. When they reach Puerto Carreño - Puerto Páez, 350 kilometers upstream, two different ways can be followed: they can continue navigating the Orinoco to the city of Puerto Ayacucho, in Venezuela, or they can go up the Meta River to the city of Puerto López, in Colombia.

From Puerto Páez to Puerto Ayacucho there are 75 kilometers where navigation conditions are bad due to the Tabaje and Borja rapids. Passengers and cargo must be transported via roadway to the small port of Samariapo, 60 kilometers upstream, in order to avoid the Atures and Maipures rapids. From there on, small motorboats that can carry from 100 to 300 tons navigate, and so do barges that can carry up to 500 tons. The navigation of the Orinoco and that of its tributaries has no navigable connection with the ocean. This is also true in relation to the place where the Orinoco meets the upper Negro River. The most important navigable stretch goes from Mor ganito, on the Orinoco, to São Gabriel da Cachoeira, on the Negro River, through the Casiquiare Channel. This stretch is 1,000 kilometers long. Another 950 kilometers are navigable to motorboats on the Guaviare and its tributaries, the Inírida and the Atabapo (Domínguez. 1998).

Barges that can carry up to 2,000 tons and have a draft of 4 or 5 feet can go upstream the Meta River from Puerto Carreño to Puerto López for a distance of 780 kilometers. They normally transport cattle during the rainy season, from April to November. The outskirts of Puerto López and Bogotá are a very important region, since one can go from one city to the other in less than six hours using a paved road. From the Boca Grande del Orinoco to Puerto López there is a road that extends 1,890 kilometers and offers great possibilities for the economic and cultural integration of Brazil, Venezuela and Colombia.
It is possible to reach the port of Buenaventura, in the Pacific Ocean, and the ports of Cartagena, Barranquilla and Santa Marta, in the Caribbean, using paved roads that go through the city of Bogotá.

4.2. Situation in the upper Amazon

The twin cities of Tabatinga (in Brazil) and Leticia (in Colombia) set the limit between the Portuguese-Brazilian world and Andean-Amazonian countries. From that point on to the west, other political and economic centers have more influence on each national portion of the Amazon. Due to this, traffic flows from west to east. Bogotá, Quito, Lima and La Paz are the reference points for the organization of Andean-Amazonian traffic flow, and traffic on the rivers is adapted to this reality. Up to Tabatinga, other economic and political centers have an influence on transportation, making traffic flow towards the east. These centers are São Paulo, Rio de Janeiro and Brasília. This is a flexible border at which boats and planes turn back. It is only crossed occasionally. Brazilian transportation lines go to Tabatinga and return to Manaus. Peruvian transportation lines go as far as Santa Rosa or Caballo Cocha then return to Iquitos. Colombian transportation lines cross the border and go a few kilometers further to Putumayo, but their reference point is Puerto Asís, in the Andes.

The former condition of the Andes as a geopolitical barrier is no longer true. On the contrary, the various trans-Andean roads have made it possible for a populated belt to be formed in the west of the Amazon. This belt is very influential due to the fact that it is a market and it can provide services. There are six trans-Andean roads that lead into the Colombian Amazon, five that lead to the Equatorial Amazon, seven that link the Andean Amazon to the Peruvian Amazon and four that lead to the Bolivian Amazon. There is also the Marginal de la Selva road, at Andean foothills, which connects almost all of the cities to one another. It also links the Trans-Andean roads and forms a corridor with many entranceways.

In the Colombian Amazon there are only two rivers which are navigable to tugboats: the Guaviare, which is part of the upper Orinoco basin, and the Putumayo-Içá, which has better connections with the Amazonas. Other rivers, like the Caquetá-Japurá and the Vaupés, flow over a rocky peneplain, and their courses are extremely tortuous. There are many rapids and waterfalls and some stretches are very narrow. This interrupts navigation and makes it cost-ineffective. As previously mentioned, the Guaviare is navigable to tugboats from the city of San José del Guaviare to its mouth at the Orinoco, at a distance of 620 kilometers. San José is the northern entranceway into the Colombian Amazon. It is linked to Villavicencio and Bogotá by the Marginal de la Selva road. A bridge crosses over the Guaviare River and the road goes toward the west. One hundred kilometers of this road have to be built so it will reach San Vicente del Caguán, at the Andean foothills. There is
also a road that goes south of San José del Guaviare and connects the city to the port of Calamar, on the upper Vaupés, which is a tributary of the Negro River.

San Vicente del Caguán is located on the northern Amazonian foothills. From there southward there is an almost continuous belt of roads and cities close to the Andes that extends over 3,300 kilometers until it reaches the city of Santa Cruz de la Sierra, in Bolivia. This belt connects the sources of the main tributaries of the Caquetá River, like the Caguán and the Orteguaza, to the main river. The upper section of the Caquetá and that of its tributaries are navigable to small boats all the way to the Araracuara rapids.

The Marginal de la Selva continues past the upper Caquetá to the upper Putumayo, which it crosses on the Santa Ana village. It reaches the border with Ecuador at the San Miguel River, a large tributary of the Putumayo. Another part of the road leads into the city of Puerto Asís, which is the most important boarding location for the Colombian tugboats that navigate the Putumayo. Puerto Asís is the southernmost part of the road system known as Troncal del Caribe. It connects Colombian ports in the Caribbean to Colombian ports in the Pacific Ocean, to the Orinoco River basin and to the Amazon. The Troncal del Caribe crosses the Andes. It goes from the city of Pitalito, on the upper Madalena River, to Mocoa, where it meets the Marginal de la Selva and goes on to Puerto Asís.

The Putumayo is a river that serves four nations, all of which make bad use of it. Colombia, Ecuador, Peru and Brazil navigate its waters haphazardly. There is no development plan for the river, its services or for the conservation of the basin. There are many projects, but none have been put into practice. Nevertheless, the Putumayo offers the possibility for fast navigation from Puerto Asís to the Amazonas, for 1,928 kilometers. During high tides (from March to August) it is navigable to vessels with a draft of up to 6 feet. Vessels with an 8-foot draft can go as far as the mouth of the San Miguel River, and vessels with a 12-foot draft can go as far as Tarapacá. During low tides, it is navigable to barges with a 4-foot draft all the way to the mouth of the San Miguel, and to barges with a draft of 2.5 feet can go as far as Puerto Asís.

Two thousand, six hundred and sixty four kilometers of the Colombian Amazon basin are navigable to tugboats and motorboats with a carrying capacity of over 100 tons. This is true if we add the 116 kilometers of the Amazonas River that are located in Colombia to the navigable stretches of the Guaviare and the Putumayo. In addition to the previously mentioned river sections, there are another 1,200 kilometers which are navigable to small boats carrying up to 20 or 30 tons of cargo. The most important stretch is a section of the Orteguaza and the Caguán Rivers which, together with the Caquetá, make up a navigable network with over 1,000 kilometers. Colombian Amazon rivers are navigable for a total of 3,864 kilometers.
In the Equatorial Amazon, only short stretches of two rivers are adequate for the navigation of tugboats and barges: an 85-kilometer section of the Putumayo River, from the mouth of the San Miguel River to the Guepí River, and a 225-kilometer stretch of the Napo River, from Francisco de Orellana to the mouth of the Aguarico River. By resorting to the free navigation of shared rivers, Ecuador attempts to turn these waterways into its own connection with the Amazonas and with the Atlantic. This is why the port of El Carmen de Putumayo, located at the confluence of the San Miguel and the Putumayo, was adapted to receive double-hulled tugboats with a carrying capacity of 600 tons and a 3-foot draft. A floating pier was built where 70-meter-long vessels can dock. Other improvements are being implemented in relation to storage and unloading. The port of El Carmen is currently connected with Quito and with the port of Esmeraldas, in the Pacific. It serves as a link between oceans.

On the Napo River, the port of Francisco Orellana, also called Coca, is the highest spot that can be reached by tugboats and barges with a 4-foot draft during high tides. Due to the fact that navigation on the lower Napo, in Peru, has been blocked for over half a century, the port of Coca has not been cared for and docking conditions are not good. Currently hydraulic engineering work is being carried out to improve arrival conditions for larger vessels.

Other rivers whose sources are in Ecuador, like the Aguarico, the Coca, the Tigre, the Pastaza and the Morona-Santiago, are only navigable to canoes or outboard motorboats. This is due both to the fact that there are rapids and to the fact the river has a low flow rate. This problem is solved by the excellent network of roads that go across the territory. This is especially true in terms of the Marginal de la Selva, which is completely interconnected all the way from the San Miguel international bridge, at the border with Colombia, to the village of Zumba, at the border with Peru. Due to conflicts involving Ecuador and Peru, the section of the Marginal de la Selva from Zumba to San Ignacio, across the border between the two countries, was not built. These villages are 44 kilometers apart. When this small section is built, the Marginal will meet another road which has already been built and goes through Jaén and Santa María de Nieva to Sarameriza.

The Peruvian Amazon is, next to the Brazilian Amazon, the part of the basin that has the best river connections. This is due to the fact that all of the rivers that form the Amazonas are located there, and the country shares many of its large tributaries. The confluence of the Ucayali, the Huallaga and the Marañón creates an amazing body of water that is navigable to sea ships all the way to the Atlantic Ocean, 3,665 kilometers away. The Marañón is navigable after the Pongo de Manseriche (Manseriche Strait) is crossed. The river is known as Marañón until it meets the Ucayali, 790 kilometers downstream. In this section it meets the Huallaga, its largest tributary, 390 kilometers downstream of the Manseriche. From the strait to the border with Brazil, a total of 1,355 kilometers of the river are navigable to vessels with a 4-foot draft all year round. They can
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continue 890 kilometers upstream on the Ucayali to the port of Pucallpa, and another 250 kilometers on the Huallaga to the port of Yurimaguas. During high tides, these same routes are navigable to vessels with a draft of up to 7 feet.

These 2,355 kilometers that are navigable all year round are not the main course for river connections in the Amazon plain in Peru. Cargo and passengers are transported along the Iquitos-Pucallpa route and, increasingly, along the Iquitos-Yurimaguas route, to and from the coast, the Andes and the Amazon. The Lima-Tingo María-Pucallpa road, which extends 860 kilometers, is the most important connection to link these Amazonian waterways to the Andes and to the Pacific Ocean. It also links the Pacific Ocean to the Atlantic Ocean. Since 1944, the year it was inaugurated, this road has replaced the inefficient route involving sea and river transportation according to which vessels left the port of Callao, went through the Panamá Canal and went up the Amazonas to the port of Iquitos.

Lately, there have been problems with the port of Pucallpa due to the sedimentation in the Ucayali. There have been serious problems making it difficult for vessels to dock at the pier. The port of Yurimaguas, on the Huallaga River, has taken over much of the service related to loading and unloading vessels. However, the road that links this port to the rest of the country is not good and there is no other alternative for a connection across the Andes. Another route is being implemented in the north. On the right bank of the Marañón, downstream of the Pongo de Manseriche, the port of Sarameriza was established. The location of this port makes it possible for there to be a direct connection with the north of Peru, up the Marañón to Abra de Porculla, where it is possible to cross the Andes and get to the port of Paita, in the Pacific Ocean. The road from Sarameriza and Santa María de Nieva, upstream of the Marañón, is being built. When the work is finished, the roads will extend 675 kilometers, linking the Pacific Ocean to the Atlantic Ocean. This means that there will not be the need to go up the Cerro Pasco, which is difficult. The Abra de Porculla, the lowest passage from Peru into the Amazonas, is only 2,144 meters high. This makes it very easy to cross the Andes Mountains. Also, the use of the port of Sarameriza by the Equatorial economy will guarantee that the peace agreement between Ecuador and Peru will be respected. In order for this to take place, the only thing left to do is to build a section of the Carretera Marginal de la Selva, linking Zumba to the Marañón River. The use of the port of Sarameriza by the two countries will boost the capacity of this port.

The navigation of the Napo River partially complements the Peruvian axis. This river is navigable all year round to vessels with a 3-foot draft all the way to the port of Pantoja downstream from the mouths of the Yasuní and the Aguarico Rivers. During the rainy season much heavier vessels can go upstream, with drafts of up to 12 feet. Two hundred and seventy kilometers from its mouth, the Curaray River meets the Napo, which increases its volume. From there onward the influence of Iquitos is strongly felt, and the population density increases. Motorboats of all sizes transport all sorts of products, especially wood to the veneer industry in Iquitos. In Puerto Arica there is a 75-kilometer-
long road that connects the city to the Putumayo River at the Flor de Agosto village. This road is increasingly being used for the purpose of transportation from Iquitos to the Putumayo. This avoids going down the Amazonas and upstream of the mouth of the Putumayo all the way to the binational territory (Colombia-Peru) at the mouth of the Yaguas River. There are transportation lines for cargo and passengers that take daily trips from Iquitos to Santa Clotilde and back, and several times a week there are trips to the Curaray.

The right bank of the Putumayo, between the Yaguas River and the Guepí River, is located in Peru. This section is 1,315 kilometers long and is navigable all year round to tugboats with a three-foot draft that can carry up to 600 tons. Due to the low demand on the part of the few villages located on the banks of the river and on the banks of some of its important tributaries, like the Algodón, local traffic involves basically small boats that can carry from 10 to 50 tons. Guepí is 1,750 kilometers away from the mouth of the Putumayo on the Amazonas.

The navigation center in the Peruvian Amazon is Iquitos. In the beginning of the 19th century, Booth Line, a North-American company, built a floating dock there that was used for exporting products during the rubber era.

“Booth Line was the only regular international line that went from New York to Manaus and Iquitos. This happened both during World War I and during World War II and took place for 75 years until 1970, using barges that could carry 2,500 tons. For the last few years, however, there were only trips from Manaus to Iquitos if there was enough cargo to be transported. If there wasn’t, cargo was kept in Manaus until there was enough of it to make the trip profitable. This resulted in damage to the cargo and losses for importers and exporters because of the time lost. When a wheat mill was established in Iquitos, there was the need for transportation so large amounts of wheat could be imported from Houston.”... “Currently this waterway is used for the transportation of the heavy cargo necessary for the development of the exploitation of petroleum and gas in the Lower Jungle. It is also used for the transportation of massive cargo like cement, sugar and the wood that is exported (in the form of veneers and boards) to other countries from Iquitos” (Torres, 2001).

In the south of the Peruvian Amazon, where the country borders Bolivia and Brazil, navigation is restricted to the Madre de Dios River and some of its tributaries. Small commercial boats and mining dredges navigate over short distances on the stretches where there are no rapids or waterfalls. Puerto Maldonado is becoming an axis of regional connection due to the recent construction of a road that links the port of Ilo, in the Pacific, to Iñapari, at the border with Brazil. On the other side of the border is Assís Brasil, in the State of Acre, and the road goes on through Rio Branco and Porto Velho to where the navigation of the lower Madeira starts. The road extends 810 kilometers from Iñapari to Porto Velho.
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“There are over 6,000 kilometers of navigable waterways on the rivers of the Amazon Region in Peru. This allowed for the development of commercial river transportation, which is responsible for the transportation of 90% of the passengers and cargo. This is the most important means of transportation in the region. The costs of river transportation are relatively high since there are no organized and permanent lines that link riverbank towns. This would make the integration and socio-economic development of populations in the Amazon region easier.” (Torres, 2001)

River connections within the Amazonian territory in Bolivia are much more complicated. The entire region is located in the upper Madeira basin. This includes the Beni-Madre de Dios and the Guaporé-Mamoré, as well as their tributaries. Because the Madeira is not navigable from Porto Velho to Guayaramerín, it is necessary for these tributaries to be connected to the Amazonas. During the rubber era, navigation on these rivers was the only means of communication, but it is currently not as important because only short stretches of the river are navigable due to the existence of rapids and waterfalls. The airplane is the most common means of transportation to more remote regions. However, roads are being constructed that lead increasingly further into the region. A road is being constructed linking La Paz, Yucuma, Trinidad and Santa Cruz. It links the stretches of the Beni and Mamoré Rivers which are navigable to small boats. In Yucuma, which is close to San Borja, there are waterways which are navigable during the summer that link the city to Guayaramerín, on the lower Guaporé, and to Puerto Heath, on the upper Madre de Dios.

One thousand, four hundred and sixty kilometers of the Mamoré and of its tributary, the Ichilo, are navigable. This stretch goes from Guayaramerín to Puerto Grether, which is very close to Santa Cruz de la Sierra. Eight hundred and fifty three kilometers of the Beni River are navigable, from Cachuela Esperanza to the San Buenaventura port. From this port, it is easy to get to La Paz. There is a road that goes through Yucuma and Coroico. Three hundred and fifteen kilometers of the Orthon River can be navigated, from Humaitá to Puerto Rico. The Madre de Dios can be navigated for 249 kilometers, from Sena to Puerto Heath, at the border with Peru. A total of 2,877 kilometers are navigable to small boats in the Amazon basin in Bolivia.

5. AIRWAY TRANSPORTATION AND WATERWAYS

Since World War II, airway transportation has played a very important role in the economy and in the management of the Amazon basin. From 1941 to 1945, the United States built a great quantity of small landing strips. These landing strips were strategically located and were used to transport rubber. This was indispensable to the maintenance of war efforts. Also, if the Nazis invaded the continent, this is where combat planes would land. Rivers were used to transport the rubber produced in the forest to these landing strips, from where it was sent straight to North America. Many of these landing strips
turned into villages and cities, where the model river-airport continued to control the economic and political life for many years. In some places, it still does. The harder the navigation of a given river, the more important the airport. Likewise, the farther away it is from administrative centers, the more the village needs an airport to deal with national, regional and local bureaucracies.

The previous information explains the fact that there are ports and airports on the banks of large rivers. There are villages along the riverbanks and behind them there are landing strips, normally bigger than the village itself. Daily life is related to the river, but the weekly or monthly arrival of the airplane is the great attraction and the cosmopolitan touch that links this water-related world to the metropolises. The whole village turns to the landing strip to receive or send products, travel to different cities or return to the village and to update themselves with the news. When the plane takes off again, everyone goes back to their boats or outboard motorboats, and the village goes back to its regular tranquility. At these places, even to this day, the river controls life and the airport is the touch of modernity that links the last corner of the forest to the world of economy.

Amazonian airlines tend to link small villages to regional or national urban centers. However, they do not link villages to one another. Due to this, traveling from one small town to another may require various stops, which makes airway transportation very expensive. Likewise, national borders tend to be an obstacle to international transportation within the basin. In general, when someone wants to go from an Amazonian city in one country to an Amazonian city in another country, this person has to fly to the capital of the first and, from there, he or she has to fly to the capital of the latter. After that, they have to find an airline in that country that will fly them to the Amazonian destination they want to reach. Ships from other countries cannot cross borders, and the same happens with airlines.

6. ENVIRONMENTAL RISKS RELATED TO TRANSPORTATION AND TO THE CONSTRUCTION OF WATERWAYS

6.1. The erosion of riverbanks

The great amount of sediments carried by the rivers that flow on tertiary and quaternary plains form the oversteepened slopes that are typical of white water rivers. These slopes get steeper and steeper every year. During low tides, they become very unstable because rivers erode their lower part. This occurs because of currents and because of the natural waves caused by the wind. In addition, the infiltration of rainwater through the upper part of the clay structures damages clay soils. They become fragmented and gullies are formed. Attacked from above and from below, slopes irremediably collapse, causing a great deal
of damage when there are villages or farms on them. They also cause damage to the vegetation on the riverbanks. This increases the amount of forest debris carried by river waters.

The greater the variation of the level of rivers, the steeper the slope and, consequently, the greater the possibility that gorge falls will occur. In regards to the Amazonas River itself, there have been famous catastrophes in its mid-course (the Solimões), where the difference in river levels reaches 16 to 20 meters. This forms gorges as high as that. It is not rare for small villages to disappear overnight, nor is it rare for small boats to be swallowed by gorge falls when they navigate too close to the riverbank. On the lower Amazonas, where the difference in volume is between 10 and 16 meters at the mouth of the Negro River and between 5 and 7 meters on the lower section of the river, this phenomenon is milder. Studies carried out by Sternberg (1998) on Careiro Island show that a different phenomenon occurs in these areas: landslides. Landslides, which can occur in the form of slides or slumps, are not as impressive as gorge falls, but they can cause greater damage. This is due to the fact the lower Amazonas is more densely populated and the infrastructure there is better developed.

Gorge falls enhance the effect of the waves caused by vessels. When a tugboat or a ship gets too close to the riverbanks, the noise coming from the back of the ship indicates that there has been a series of mudslides. Larger vessels create higher waves and, consequently, greater the damage. Since there is now a tendency to use increasingly larger and faster ships, and there has also been a significant increase in river traffic, the excavation of riverbanks will increase as well.

The erosion caused by vessels increases the amount of sand and clay and the number of tree trunks on riverbeds. This makes navigation even more difficult. Even though this is mostly due to deforestation at the basins and to the inappropriate use of fertile lowlands, increased navigation causes greater damage to the banks and constantly removes riverbed mass. This causes a decrease in depth and endangers the safety of vessels. Therefore, there has been a decrease in the navigation of smaller tributaries and in the use of ports. This occurs because there is a decrease in depth which makes it impossible for vessels to dock. It also occurs because rivers dry up.

6.2. Fuel spills and wastewater and garbage discharged from boats

Another problem that resulted from the increase in the navigation of Amazonian rivers is the increase in the number of fuel spills and in the amount of wastewater and garbage discharged from boats.
Data is not available regarding the amount of fuel spilled in Amazonian waters despite the fact that this information is very important. There has been a notable increase in the transportation of fuel, however. The growth of the cities has caused an increase in the consumption of diesel oil, gas and fuel oils. This is true both in relation to power plants and to cars, planes, motorboats and ships. Almost all of the heavy transportation takes place by waterway. Transportation conditions are generally precarious, which constantly causes spills. They are due to accidents, to the fact that the cargo is handled improperly or to the fact that fuel is excessively exposed to sunlight. The latter causes the liberation of gases and liquid due to the dilatation of the fuel. If we add this to the oil spilled by the engines of old boats and by inefficient outboard motors, we will have an idea of the amount of fuel that is spilled into the waters of the Amazonas.

Another phenomenon which is not properly analyzed is the increase in the amount of garbage and wastewater discharged from vessels, especially passenger and tourist boats. This phenomenon is currently secondary when compared to the increasing amount of debris cities dispose of into the rivers. However, it may be catastrophic if there is a great increase in tourism in the Amazon, which is expected.

6.3. **Excessive stress involving aquatic fauna**

A permanent complaint on the part of biologists is the fact that there has been a great increase in the stress aquatic fauna is subjected to. This is due to the increase in tourism. Reproduction sanctuaries in brooks and lagoons are constantly invaded by visitors. Whether they mean to or not, these visitors are causing great damage to basic ecosystems. Endangered species include the manatee, the turtle and the *pirarucu* fish. These animals are permanently injured by the propellers of motorboats. This accelerates extinction.

Likewise, vessels are very fast and remove the layers of eggs that lie buried in the riverbed. This exposes them to predators. They also stir the water in a way that kills small fish. This happens because their gills are filled with mud or because oxygen levels in the water are reduced to critical levels. Most of these sanctuaries should never be visited by motorboat. Only rowboats should be allowed in these places.

6.4. **The construction of dams**

The construction of dams across Amazonian rivers is the most controversial of the technical transformations. This is due to the fact that they undoubtedly affect ecosystems and the Indians and settlers who live in the areas that are flooded. People who are in favor of the construction of dams highlight the benefits they bring about. Among these benefits is the production of cheap energy which is cleaner than any other kind of production that has been massively used so far. There is also the role played by dams in the control of the
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high and low tides of the rivers. They can also be turned into huge pools for fish, and they can be used as systems to improve the navigability of rivers where there are waterfalls and rapids by flooding their riverbeds.

However, many people oppose the construction of dams. They highlight the fact that there are various other aspects which are negative. Poor countries fall into debt because of its high costs. Unknown ecosystems where there may be many useful plants and animals will be flooded, as will areas that are used for agriculture. Communities whose ancestors lived on those lands and who believe that the region is sacred will be driven out of the area. Diseases like malaria and schistosomosis will increase. This is due to the fact that this great amount of pooled water is the perfect breeding site for the vectors for these illnesses, snails and mosquitoes (Junk; Mello. 1987).

Although much has been said about the use of dams with the objective of improving navigation in Amazonian rivers, it is not possible to reach a conclusion based on the examples we have. Tucuruí, which was planned from the start to have a system of floodgates and ports of call that would allow vessels and migrating fish to pass, never received the necessary investments to complete the initial project. Other available examples regarding navigation with the help of dams are the cases of navigation limited to a pooled lake. This is what happens in Balbina, which is close to Manaus, in the State of Amazonas, and in Jamarí, in Rondônia. Navigation in these cases is only local. It is worth questioning whether the seven hydroelectric power plant dams designed for the Tocantins River will actually improve navigation conditions or whether navigation will simply be used as an excuse to the local population until the works that will provide the rest of the country and large mining companies with energy are finished.
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ATLANTIC OCEAN

PACIFIC OCEAN

LEGEND

- Rivers and related waterways
- International boundaries
- Countries and the Amazon States
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