

Summary: contradictions in the Amazon

Balbina Dam and the Rio Negro Bridge

Micro Study - Study Tour 'Booming Brazil'

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Autors:

Allard Horstman (s0149373)

Joey Willemsen (s0154776)

Bart Leferink (s0137162)

Sander Dekens (s0138819)

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INTRODUCTION

Brazil is a growing economy, which develops rapidly; it is on its way becoming more and more important in the world economy. Because of that, the country has taken several initiatives to improve the economy and the overall quality of life. This can be seen through the whole country, also in the Amazonas.

The Amazon is one of the most species-rich regions on earth. The Amazonas state however has to cope with major human expansion, (urban) development takes place on a large scale and the state has turned into a major industrial centre. These developments are reflected in several initiatives which have been taken the last years. For example, in Manaus, which is capital of the Amazonas state, a large bridge over the Rio Negro is in construction to boost the socio-economical situation of the region and to connect Manaus with Iranduba, another main city of the state. Also, twenty years ago, a large hydro-electric dam has been built in the Uatumã river, to generate electricity and to show the world how powerful Brazil as a nation can be.

These two projects in particular have been the subject of some discussions about whether they are sustainable or not. Some people have their concerns about whether the projects will destroy the rain forest, while others think economic growth is more important than the environment. This is a very interesting discussion for research in our study tour; it is interesting to find out whether these projects are sustainable or not.

In order to find out whether or not these projects are sustainable, we first have to define the concept of sustainability. This is done in the next chapter. After that, we can have a look at the projects (the Rio Negro bridge and the Balbina Dam), which is subject of the third and fourth chapter. In these chapters, we present our research methods and findings for both projects. It was not possible to find out all details about the projects yet. For this reason, we made a list of questions interesting to ask when we visit the projects during the study tour.

RIO NEGRO BRIDGE

In this section we will discuss the impact of the Rio Negro Bridge on its surrounding area in relation to sustainability. The main question for this project is:

To what extent is the impact of the bridge on the surrounding area sustainable?

In order to answer this question, we think of the area (around the project) as a system with certain functions and actors. In this system changes are made (i.e. a bridge is built). First we describe this system, after which we describe the changes that are made, by describing key aspects of the bridge, like location, materials used and costs. After that, we describe how these changes influence the system. At last, we discuss to what extent these changes are sustainable. We end the section with some questions we'd like to address during the study tour, because literature research will not suffice.

1 SYSTEM OF MANAUS, THE RIO NEGRO AND THE AREA

Figure 1 depicts the boundaries of the research area. The bridge connects the city of Manaus with the cities Iranduba and Manacapuru by road. It could influence the development of these cities, the water transport to these cities, and could influence the whole city of Manaus.

1.1 Geography

The geography of the research area is very different from the Dutch geography: Manaus is a metropolis in the middle of the Amazon with more than 2 million inhabitants in the metropolitan area (Wikipedia, 2010). The city is very isolated; the closest city with a similar size, Belem, is more than 1,000 kilometres away as the crow flies. The fastest distance by car is more than 3,000 kilometres, with a travel time of 40 hours (Google Maps, 2010).



Figure 1 System border (Source: Google Maps, 2010)

1.1.1 Rivers and Flora & Fauna

Manaus is located the place where the Rio Negro flows into the second largest river in the world: the Amazon River. At the height of Manaus both rivers are more than 2 kilometres wide. Both rivers have many sandbanks and other minor difficulties. Rio Negro means Black River, but the colour of the river is not really black. The dark colour comes from humic acid from incomplete breakdown of phenol-containing vegetation from sandy clearings (Wikipedia, 2010). According to (Ricardo) the Rio Negro is extremely acidic and poor in nutrients.

Yet, several (both larger and smaller) species have their habitat in the river. However these species are characterized by a small number of representatives. In order for the fish to survive they have to obtain a large part of their food from organic matter which can be found on the banks of the rivers. Further, the Rio Negro supports a large fishing industry and has numerous turtle beaches.

The Amazon rainforests are the world's most species-rich and have great biodiversity: more than one third of all species in the world live in the Amazonian rainforest. New species are discovered almost on a daily basis.

1.1.2 Region

Cities in the research area are Manaus, Manacapuru and Iranduba. Manaus grows rapidly: in 1950 the number of inhabitants was 279,000, in 2009 it was 1,739,000. The biggest expansion is in the north of the city (Wikipedia, 2010). The harbour is located on the bank of the river (Wikipedia, 2010). Manaus is a city dealing with urban sprawl. This means that the city expands very rapidly, creating problems like long transport distances to work, high car dependency and higher infrastructure costs per person.

Iranduba is a small town on the other side of the Rio Negro. The number of inhabitants is 40,436 (2005). The distance to Manaus is 25 kilometres. Manacapuru is located a little further, about 95 kilometres from Manaus and 70 kilometres from Iranduba. The city has 85,000 inhabitants (Wikipedia, 2010).

1.2 Economy

As the capital of the Amazonas state, Manaus plays an important role in the Amazonian economy. Manaus is a commercial city. This is reflected in for example the Manaus Free Trade Centre, which is a large commercial and industrial centre. The centre is important for the cities' economy, as many large companies produce electronic devices here (Russo).

Rubber used to be the main industry of Manaus. However nowadays timber, Brazil-nuts, petroleum refining (oil is brought to the city by barge), soap manufacturing and the production of chemicals are important for the city. Other local industries include brewing, shipbuilding and the manufacture of electronics equipment. (About.com, 2010).

Tourism is very important for the city. Because of its location in the rain forests, Manaus is known for its ecotourism. The rainforest and the wildlife are major attractions of the area, many tourists take boat tours to the Meeting of the Rivers (where the Rio Negro and the Solimoes River meet) or take jungle tours.

The Rio Negro forms the link of Manaus with the rest of the world. The harbour of Manaus, also called the Port of Manaus is the main transport hub of the region: both import and export take place by boats over the river. The river is more and more considered to be productive and supporting a large fishing industry (Ariau Amazon Towers Hotel, sd).

1.3 Transport

Transport in the region is very characteristic. The city of Manaus is very isolated. Within the city, the main transport is by car and public transport. Because of its geography, the main transport in the region is by ferry. Long distance transport is mainly by air and water.

1.3.1 City transport

In Manaus are about 400,000 vehicles. Traffic congestions are recurrent but not restricted to peak hours. The use of bicycles in the city is very small. But the public transport represents a fundamental role in the city. Manaus has a



Figure 2 Ferry dock of Manaus (left), Ferries to Manaus (right)

great structure of bus lines (300). Daily about 700,000 to 800,000 people go by bus. Also a monorail will be built in the city with a length of 20 kilometres.

1.3.2 Regional transport

Because of the few roads in the Amazon region, inland waterways are very common. Transport is mainly by ferries. These ferries are called 'balsas' in Brazil (see figure 2). All transport to the other bank of the rivers was done by these balsas. Even the main road BR 319 (from the state Rondônia to Manaus) crosses the Amazon by ferry. Other ways of regional transport is the bus.

1.3.3 National and international transport

Transport from Manaus to other metropolis cities in Brazil is mainly done by air and water. Manaus has one of the most modern and best quality airports in the world. The annual number of passengers is about 1.4 million, and it is the third Brazilian cargo handling airport.

National transport by road is limited. Only few roads lead to Manaus, the BR 319 (from Pôrto Velho, Rondônia) and the BR 174 (to Boa Vista, Roraima). Because of the few roads and the long distances, and the strategic location at the Rio Negro, Manaus has a very large harbour. This is the third largest export port of Brazil, and serves the states of Amazonas, Pará, Roraima, Rondônia and Acre.

1.4 Welfare

Manaus deals with one of the highest crime rate of Brazil. Drugs, prostitution and rapes are specific problems of Manaus. Also, the city deals with a high social inequality. Neighbourhoods close to the centre are generally wealthier and more remote neighbourhoods tend to be poorer, and more lacking of infrastructure and urban housing. In 2006 the housing deficit in the city was about 68,000 housing units. This means that about 300,000 people do not have access to formal housing. The rapid economic growth is a reason of the large inequality.

2 KEY ASPECTS OF THE BRIDGE

2.1 Location & dimensions

The bridge is located in the south of Manaus, where it is in the neighbourhoods of Compensa (73,000 inhabitants) and Santo Agostinho (18,000 inhabitants). It connects Manaus with Iranduba where it lies on the so-called 'Tip of Ouvidor'. In the middle of the river, a 158 meter high mast is located on the 'Isle of Chameleon'. Figure 3 gives a satellite view of the location of the bridge.

With a total length of approximately 3,600 meters the bridge over the Rio Negro is the second largest river bridge in the world. It has a width of 20.70 meters with four lanes of traffic (two lanes for each direction) and a pedestrian lane on both sides. The bridge will have 74 pillars and the average spanning between the pillars is about 55 meters. The largest span is in the middle of the bridge, where a large mast supports a span of 400 meters (200 meters on both sides) with steel cables. The bridge is quite high: in the dry season the bridge is at 70 meters high, relative to the water level and 55 meters high in the wet season. It is estimated that the bridge is made of 14,500 tons of steel and 138,000 cubic meters of concrete. This equals the construction of 25 buildings with 20 floors.



Figure 3 impression of the bridge (Skyscrapercity, 2010)

The bridge (the crossing of the river) itself costs about 450 million US dollar, however the project comprises not just this, because the bridge also has to be connected to the local road system. In Manaus the bridge will connect to the 'Shipyard Brazil Rio Negro'. On the other side, the Iranduba side of the river, connection of the bridge with local roads requires an extension of 11 km, costing about 62 million US dollar.

2.2 Driving factors

At first, a bridge over the Rio Negro to Manaus is an old aspiration of the population of the municipalities of Iranduba and Manacapuru. A problem in the current system is a long travel time between these cities. The

current travel time from bank to bank by ferry is 30 to 40 minutes. A bridge will reduce the travel time to five minutes. This will significantly improve logistics of the municipalities. The agricultural and industrial production will be improved. The bridge provides also tourism and urban development for both Manaus and the cities on the other side of the bridge (Amazonas.am.gov.br, 2010).

In a broader context, the Government wants development in Brazil with solutions for citizens and respect for nature, says the judiciary of Brazil (Portal Amazonia, 2009). President Lula says that the construction of the bridge is one of the initiatives of "Sustainable Amazon Plan". "The bridge will provide a new and practical option for growth in Manaus and will open thousands of jobs and enterprises," said Amazonas governor Eduardo Braga (Portal Amazonia, 2009).

2.3 Public opinion

Brazil is just as the Netherlands a democratic country. This means that people are free to demonstrate and object to new constructions. Generally, in Brazil people have their opinion heard if they are disagreeing. In the northern regions of Brazil the Government has traditionally a fairly strong position. The people do not demonstrate against or criticize the government as quick as in The Netherlands for example. This means that the Government gets things done earlier than in the rest of Brazil (Sena, 2010).

The Rio Negro Bridge was an old aspiration of the population of the municipalities of Iranduba and Manacapuru. This means the public opinion about the bridge in these cities will be good. However, to create the bridge 300 houses will be demolished in the neighbourhood of Compensa (Manaus). It seems that there was hardly any resistance against this slopery. Permission for the work was given after the study on the neighbourhood impact (Portal Amazonia, 2010). On the Internet hardly any information can be found about public opinion around the bridge.

There is some political discussion about the bridge: former PMDB (a Brazilian political party) senator Gilberto Mestrinho says: "This work, the bridge will connect anything with anything. I think three or four new ferries and a decent port will improve the crossing." (Portal Amazonia, 2009).

3 EFFECTS OF THE BRIDGE ON THE SYSTEM

The realization and use of the bridge over the Rio Negro will influence the system. In this section we distinguish short-term and long-term impacts. Short-term impacts can be observed within a few years (i.e. 3 years). Long-term impacts (mainly prognoses, because no factual data is available yet, the bridge is still under construction) will impact the system after several years.

3.1 Short-term developments

3.1.1 Geography

The geography is not just changed by a new road on the map. About 300 houses are demolished in Manaus, and a new connection to the main road network is made. In Manaus the bridge connects to the Estrado da Estanave (see figure 4).

Besides this, we do not expect any short-term developments on geography-subjects like climate or flora and fauna.

3.1.2 Transport

The bridge creates the link between the municipalities of Iranduba and Manacapuru with Manaus by road. Travel time between these cities will be reduced by 30 minutes to just five minutes. It is also possible to walk and cycle on the bridge (Amazonas.am.gov.br, 2010). There won't be a toll charge on the bridge, so everyone can use it (Blog da Floresta, 2010). The absence of tolls will result in a strong decrease of ferries between Manaus and the Iranduba region. But the bridge won't affect the ferries between other banks, like between Manaus and the BR174. We think more people will move from the region to Manaus. Because of the shorter travel time, the attraction to Manaus will be bigger and the amount of traffic will increase.

Short-term developments in city transport can be a different traffic distribution. The driving direction to the bridge can get much busier. This effect is hard to estimate, because it is the first bridge across the river.

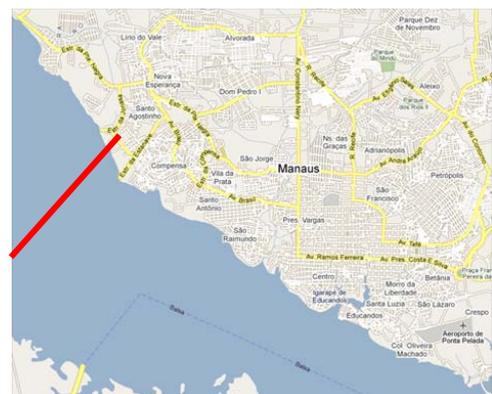


Figure 4 Location of the bridge in a road map (Google Maps, 2010)

Now only few people move regularly from the Iranduba region to Manaus or otherwise. This amount of people will grow steadily.

The impact of the bridge on national transport will be marginal. The bridge connects Manaus to Iranduba and Manacaparu. After these cities is the deep forest of the Amazon located, and no single road. As said, the bridge doesn't connect Manaus to the BR174.

3.1.3 Economy

Short-term developments to the regional economy can mainly be found in the cities of Iranduba and Manacaparu. The bridge will stimulate the economy of these cities, because the travel time to Manaus is much shorter. Industries can easier deliver their products in Manaus and otherwise. The market for the cities will be bigger (Amazonas.am.gov.br, 2010). For the people it will be easier to look for work in Manaus. Also during the construction of the bridge, about 1700 people are provided of a job. 500 of them are managers, the rest are i.e. masons and carpenters (Jusbrasil, 2009).

The economy of Iranduba and Manacaparu will not only grow because of a shorter delivery time and a greater market. Tourists will visit the bridge, especially short after it's finished. Also the cities of Iranduba and Manacaparu can expect more tourists in the next few years, as said by the Amazonas government (Amazonas.am.gov.br, 2010).

The bridge will not have a big short time influence on the economy of the city of Manaus itself. The main benefit is for the cities on the other side of the bank.

3.1.4 Welfare

The short-term impact of the bridge on the welfare of the people in the research area will be marginal. Welfare is a thing that grows steadily. Impacts on welfare are often observable after several years. Fact is that people from Iranduba and Manacaparu can travel easier to Manaus. People from these cities can go easier to schools or offices in Manaus. The chances of these people will grow.

3.2 Long term developments

3.2.1 Geography

Because of the bridge both Manaus and Iranduba will expand in terms of inhabitants. Expansion will also occur in terms of size: according to (Aitchison, 2009) the bridge will relieve urban sprawl Manaus is currently dealing with, by creating a new industrial zone in Iranduba. This industrial zone, probably devoted to the metallurgy sector, influences both flora and fauna in the neighborhood as metallurgy is considered a heavy industry, often blamed for pollution.

3.2.2 Transport

In short term, benefits in transport in the area are in the reduced average travel time. In long term also, but when both Manaus and Iranduba significantly expand in the region of the bridge these benefits will decrease, because the amount of traffic also grows significantly. Therefore the bridge will be utilized by its maximum traffic capacity. This decreases the travel time, however travel time will still be much shorter than without the bridge.

Other changes in the transport system are similar to the short term changes. The bridge provides a link between both sides of the river and lays a foundation for further development of the region.

3.2.3 Economy

A main benefit of the bridge is urban development (Amazonas.am.gov.br, 2010). The bridge will provide more traffic in the bridge area, this means a better accessibility of the harbour and the ground will get more expensive. The area could grow into a top location for offices or other commerce. When this happens the bridge indirectly generates more jobs. Besides that, the bridge also provides a lot of publicity for Manaus. Not only in Brazil, but around the world companies will know the city because of the bridge. This could result into economic advantages.

We think most economical benefits we discussed in the 'short term developments' section are similar in the long run, probably larger. This is reflected for example in the expansion of the metallurgy sector. Expansion of the metallurgy sector in the region creates jobs, which benefits the regional and national economy.

3.2.4 Welfare

The development of the region has several positive influences. However in the past, rapid growth of the economy has enforced the large inequity Manaus deals with. It is uncertain how the bridge influences the future situation in the long term.

The future situation of Iranduba and Manacapuru will be much brighter. People of these cities get more chances to commute to Manaus, or visit that city for other purposes. We don't think the inequality will get larger in cities of Iranduba and Manacapuru. The bridge will stimulate local business and the cities will feel more connected to Manaus. Tourism will be bigger in the whole area.

4 CONCLUSIONS

4.1 Sustainability

In this section we try to find out to what extent the impacts described above are sustainable. Note that this (and the findings above) conclusion is based on the information that was available to us on the internet. Some questions are yet to be answered and have to be asked out during the study tour, for these see 'Remaining Questions'.

4.1.1 People

The bridge is an old aspiration of the population of Iranduba and Manacapuru. Realization of the bridge will enlarge future chances for these people. They can travel easier to Manaus for work, study or other purposes. Looking at Manaus, the bridge won't have much influence on the people there. 300 houses will be demolished; however we don't know how the organization deals with that. As far as we know, there is hardly any criticism on the bridge.

In terms of people, we think the Rio Negro Bridge is not sustainable in the short term, as 300 people have to be moved. In the long run, the bridge might be sustainable, as the bridge indirectly creates a future for a lot of people. Especially perspectives for the people from Iranduba and Manacapuru will increase.

4.1.2 Planet

On short-term, the bridge won't have big effects on flora and fauna. During the construction much concrete is used. We could not find any information about sustainable constructing of the bridge. On the long term, the bridge could have a negative impact on the environment. Traffic and metallurgy industry could cause exhaust fumes and carbon dioxide emissions. The exact impact is actually unknown, but we think the bridge will have little negative impact on the planet component.

4.1.3 Profit

In despite of the high costs, the bridge will stimulate the economy of especially Iranduba and Manacapuru. The travel time will decrease to 5 minutes from bank to bank. The business market for these cities will get bigger. Also the economy of Manaus will profit from the bridge. Urban development and international publicity are main benefits. The bridge also provides lots of jobs during construction. Considering this, we think the Rio Negro Bridge is a sustainable investment, in terms of profit. It brings large economical benefits to the region.

4.1.4 Altogether

The definition for sustainability, the bridge does meet "the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland, 1987). It meets the needs of both the present and the future, as the population of Iranduba and Manacapuru will get better chances and the economy of these cities will grow, as well as the economy of Manaus. By this a foundation for a sustainable future is made for the region. The environment will probably suffer slightly from the bridge, but the economic and social advantages overcompensate that.

4.2 Remaining questions

We set up these questions, aiming to get an answer during our visit to the Rio Negro Bridge project in Brazil. The company that we are going to visit is CIAMA (<http://www.ciama.am.gov.br/>). This is a public development company of the state of Amazonas. The questions are subdivided in terms of sustainability.

4.2.1 People

- Can you tell us something about the composition of the inhabitants of Manaus, and especially of the neighborhoods Compensa and Santo Agostinho?
- How does the project organization deal with the 300 demolished houses?
 - o Who were the people affected, according to the composition of these inhabitants?
 - o Were the inhabitants consulted in the process?
 - o Are these inhabitants compensated, and to what extent?
 - o Where did the people move?
- It seems there was hardly any criticism on the project from the people from Manaus and Iranduba. Is this right? Don't people prefer investments in poor neighborhoods instead of a bridge?
- Does the bridge, according to official prognoses, influence inequity? Positively or negatively?

4.2.2 Planet

- What is the impact on the environment during the construction of the bridge? Is the bridge built sustainably?

4.2.3 Profit

- The costs of the bridge are more than 450 million US\$. What benefits are expected?
- The bridge reduces travel time with more than half an hour. But on the main roads in Manaus traffic jams are common. What is the use of a bridge if people get stuck in a traffic jam after the bridge? Are there any investments to reduce traffic jams in Manaus?

BALBINA DAM

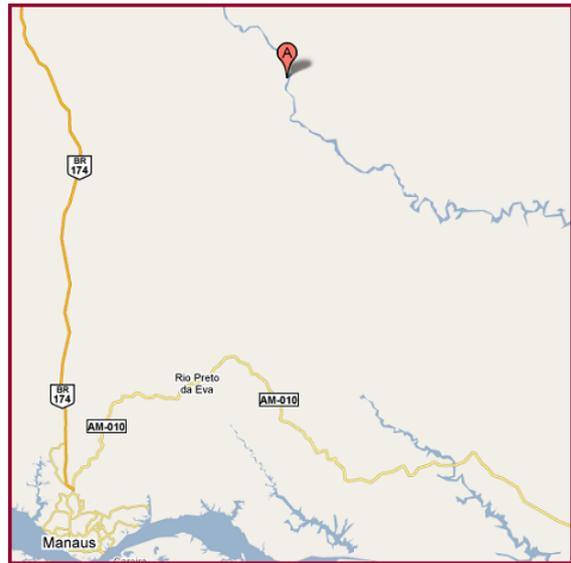
This part of this study is about the Balbina Dam: a large hydroelectric dam in the Amazonas. To find out whether the influence of this project on the area is sustainable or not, we did the same as for the Rio Negro bridge. Our main question here was:

To what extent is the impact of the Balbina dam on the surrounding area sustainable?

First, we describe the area as a system, second we describe the project itself. Then we describe the changes the project imposes on the system. After that, we discuss to what extent these changes are sustainable. We end the section with some questions we'd like to address during the study tour, because literature research will not suffice.

5 SYSTEM OF THE UATUMÃ RIVER AND THE SURROUNDING

Before the Balbina Dam was built, the system and the surroundings of the Uatumã river were quite different from the current situation. The Balbina Dam is situated approximately 150 kilometers northeast of Manaus, in the municipality of Presidente Figueiredo. The location is in the Brazilian part of the Amazon rainforest. The dam is located in the Uatumã river, which is a tributary of the Amazon and Rio Negro rivers. The dam influenced different aspects in and around the Uatumã river. In the figure below, the borders of the research area of the Balbina Dam are shown.



5.1 Geography and climate

The local relief of the area is slightly undulated and the land is extremely poor, not favorable for agriculture. The area around the Uatumã river is the wettest region on earth and is subject to marked annual seasonality of temperature and precipitation. Some characteristics are shown in the table below.

Table 1: mean rainfall, temperatures and evapotranspirations 1978 - 1984 (Walker, Miyai, & Amaral de Melo, 1999)

	Mean monthly minimum	Mean monthly maximum	Mean annual
Rainfall (mm)	107 (August)	353 (April)	2294
Temperature (°C)	20.9 (March)	37 (November)	
Evapotranspiration (mm)			1200-1500

5.1.1 Uatumã river

The river responds to this seasonality with a time lag of several weeks. During the wet seasons, the water levels of the Uatumã river can rise 7.5 to 12 meters. Information related to the river is shown below.

Table 2: hydrological information Uatumã river (Walker, Miyai, & Amaral de Melo, 1999)

	Minimum	Maximum	Mean
Discharge (m ³ /s)	197 (November)	1127 (June)	570
Flow (m/s)	-	1.1 (June)	-
Depth (m)	-	10 (June)	-
Solid suspended matter (mg/l)	-	13-16	-

The minimum in November and maximum in June shows the time lag compared to the minimum rainfall in August and maximum rainfall in April. The solid suspended matter of 13-16 mg/l means 1.5 – 5.5 tons of solid matter per hour which means that there was a lot of sedimentation and erosion in the river (Walker, Miyai, & Amaral de Melo, 1999).

5.1.2 Manaus

The most important city in the research area is Manaus because the Balbina Dam should provide electricity for Manaus. In 1970, Manaus had 622,733 inhabitants, but the amount of inhabitants was growing rapidly. By 1990, the population had grown to 1,025,979 inhabitants (Wikipedia (EN)).

In the 1970's, Manaus had many power plants that burnt oil. But due to the oil crisis of 1973, the government had to look for other energy sources.

5.1.3 Fauna

The Uatumã river is known for the peacock bass fishing during the month of September to December. The Uatumã River is one of the hotbeds of peacock activity in Brazil (Larsen, 2010).

In the Amazon there are several million animal species. One fifth of the world's bird species live in the Amazon in only one fiftieth of its land surface. (New Internationalist, 1991).



5.1.4 Flora

The Uatumã river is a nutrient poor, acid blackwater river. However, the Ca^{2+} levels are higher than other blackwater rivers in the Amazon. These somewhat better nutrient conditions of the Uatumã river and its tributaries allowed for the growth, accumulation and dispersal of aquatic macrophytes which are absent in the Rio Negro and most of the Amazon blackwater tributaries (Walker, Miyai, & Amaral de Melo, 1999).



As mentioned before, the Uatumã river runs through the Amazon. The Amazon makes up one third of the world's remaining tropical rainforest and contains 30 per cent of all known plant and animal species. (New Internationalist, 1991).

5.2 People

In the influenced area of the Balbina Dam, the territory of one indian tribe, Waimiri Atroari, is located. In 1985 there were nine settlements. The economic activities of the settlements are based on hunting, fishing, agriculture, and gathering wild fruits. Men are responsible for hunting. Fishing and gathering fruit is a undertaken by both sexes and often the whole family may go out fishing or gather fruits. Women are the ones who harvest the crops. (Instituto Socioambiental, n.d.) These settlements were located near the National Indian Foundation (FUNAI) Posts. The Indians faced a lot of setbacks from the moment the FUNAI workers visited the villages.

First of all fatal epidemics followed after FUNAI workers visited the Indian villages. Entire villages were eliminated and the residual Indians started to expel the invaders. The sudden change of behavior reinforced the prejudices of the Indians as 'bad', 'wild' and 'animals' and therefore the Waimiri-Atroari Attraction Front (FAWA) captured the Indian tribe with the purpose of recreating their society to redeem them from their past and change them into "civilized Indians" (Baines, 1994).

Secondly, the population of the Waimiri-Atroari decreased from 6,000 to 3000 around 1975 because of expeditions of settlers and explorers. The president at that time created a reserve for the Indians, with a size of approximately 1,1 million ha, which originally was 8 million ha.

After that the population size decreased even further to 1000 because of the construction of a new road (BR-174) and the violations. (Cummings, 1995).



When the planning for the Balbina Dam started in 1981, only less than 600 Waimiri-Atroari Indians remained and in 1983, due to greater influx of disease, it even dropped to 350 (Cummings, 1995). Just before the flooding of the Balbina reservoir, an area of approximately 2.440.000 hectares was declared to be occupied by the Indians of the Waimiri-Atroari (Baines, 1994).

5.3 Economy

As the capital of the Amazonas state, Manaus plays an important role in the Amazonian economy. Manaus is a commercial city. The centre is important for the cities' economy, as many large companies produce electronic devices here (Russo).

Rubber used to be the main industry of Manaus. However nowadays timber, Brazil-nuts, petroleum refining (oil is brought to the city by barge), soap manufacturing and the production of chemicals are important for the city. (About.com, 2010).

Also, tourism is very important for the city. Because of its location in the rain forests, Manaus attracts a lot of tourists and is known for its ecotourism.

The Rio Negro forms the link of Manaus with the rest of the world. The harbour of Manaus, also called the Port of Manaus, is the main transport hub of the region: both import and export take place by boats over the river. (Ariau Amazon Towers Hotel).

As mentioned before, the economic activities of the Waimiri-Atroari are based on hunting, fishing, agriculture, and gathering wild fruits.

5.4 Transport

There is a highway from Manaus to the municipality of Presidente Figueiredo: the BR-174. The highway runs all the way to the border of Venezuela and crosses the area of the Amerindian tribe Waimiri-Atroari. The highway is in this area closed at night. Another paved road to the Balbina Dam is the AM-240. (Férias, 2010)

6 KEY ASPECTS OF THE DAM

6.1 Driving factors for the project

The Balbina Dam was already initiated in the early 1970s. The construction of the dam started in 1985, after the governmental decision to build it. The owner of the dam is Eletronorte, the Brazilian state electric utility for the Amazon region. This company, now known as Eletrobras Amazonas Energia, is a subsidiary of Eletrobras, the biggest company of the electric power sector in Latin America. It was a public company that had an energy monopoly in the northern part of Brazil, but it is now privatized. However, still 52% of the shares are owned by the federal government (Eletrobras, 2010).

The official explanation of the government to build the dam was that it was needed to foresee in the growing demand for power in Manaus. The power demand was approximately 220 MW a year (1987) and was expected to be 420 MW a year in 1996 (Fearnside, 1989). Furthermore, the oil prices (in the 1970s) were at a very high level, so the government was looking for other, cheaper, ways to generate energy.

However, besides the official explanation, there were other reasons for building the dam. The other reason was a political one and came directly from the Brazilian president's office (Fearnside, 1989). At that time, the military political party was in power, both at national and Amazonas level. They wanted to *“shake off the image of a country dominated by forest and Indians”* (Cummings, 1995).

So, the dam was probably not only built for the need of energy, but also to fulfill the wishes of the economic and political elite, who wanted to show that the government invests in the Amazonas region. At the end of this research, this hypothesis is tested.

6.2 Location & dimensions

The Balbina Dam is situated in the Amazon rainforest, approximately 150 kilometers northeast of Manaus. The municipality in which it is located is called Presidente Figueiredo, a municipality with an area of 25,422 km² and a population of 26,282 (IBGE, 2009). The dam is located in the Uatumã river, a tributary of the Amazon. An Amerindian tribe lives in the neighborhood of the dam: the Waimiri-Atroari. More about the location can be found in the latter chapter.

The dam has a height of 33 m, is 2,920 m long (Wikipedia, 2010) and consists of five generators that can generate a maximum of 50 MW each, which was intended to meet the total demand of Manaus and her surroundings (Cummings, 1995). The dam is made of concrete (Pires de Camargo et al., 1984) and had cost \$700 million and several delays in 1988, while the cost estimation of the dam was only \$383 million

(Fearnside, 1989). However, in 1988, they discovered a technical error in the dam which would cause the dam not to function. Solving this technical error cost an additional \$ 700 million (Cummings, 1995).

7 EFFECTS OF THE DAM ON THE SYSTEM

The Balbina Dam affects the systems that is described before. In this chapter, the effects on the systems are described. Many research is already done on these effects, and these reports are used to describe these effects.

7.1 Short-term changes

The Balbina Dam was closed on the 1st of October, 1987. Directly after this closure, the effects on the Uatumã river were visible: water was no longer running through the river at that moment. The great fish population in the river died because of the water shortage. These effects affected the people downstream the river immediately, because they are dependent on the water and fish in the river.

Upstream, before the dam, the water level began to rise. The people living there had to move. The rise of the water level caused animal deaths and trees set under water.

7.2 Long-term changes

7.2.1 Effect on Uatumã River

The water quality in the Uatumã river, downstream the dam and in the lake, became very bad. Reasons for this are the decay of the plants and trees in the area and the geography. The amount of oxygen in the water became very low and the water became acidic due to the decay. This is even aggravated by the standstill of the water.

7.2.2 Effect on Geography and Climate

Because of the flat geography, the dam flooded a total of 2,360 km² of rainforest. The ratio of energy generation and the size of the flooded area is one of the worst of Brazilian hydroelectric power plants (Kemenes, Forsberg, & Melack, 2008).

Because there was a lot of political pressure to build the dam quickly, the decision makers chose that the trees in the flooded area would be drowned instead of cutting them. This decision led to a great emission of greenhouse gases. Millions of tons of methane emission from dead trees were emitted ((O)eco, 2009).

The greenhouse gas emission from the dam have proven to be ten times higher than those of thermoelectric installations, considered the most polluting fossil fuel (Kemenes, Forsberg, & Melack, 2008).



7.2.3 Effect on Manaus

The Balbina Dam is built to supply energy for Manaus, but has little effect on Manaus's energy supply. The energy capacity of the dam is 250 MW, but when the generators were finally running, only an average of 112 MW was generated. They expected a 420 MW energy demand for Manaus in 1996, but the dam can only provide about 25% of this demand, and the demand is still growing every year (Fearnside, 1989).

7.2.4 Effect on Fauna

The effect of flooding the area on the fauna in the rainforest is very big. The rich amount of animal species that lived in the area are drowned.

7.2.5 Effect on Flora

As said before, the effect on the flora, the plant and tree species, are very big. The fauna in the area of Balbina is all drowned.

7.2.6 Effect on People

The effect of the development of the Balbina Dam was enormous. Since the valley was wide and shallow, the dam flooded a huge area including significant parts of the demarcated reserve of the Waimiri-Atroari.

The shallow reservoir has since been shown to emit huge amounts of methane and nitrous oxide, both very powerful greenhouse gases. (Cunningham, 2008)

The population of the Waimiri-Atroari Indians have been reduced between 1974 and 1987 from approximately 3,000 individuals to 374 individuals. Especially the new diseases to the population, caused by the contact with Brazilian society, and the flooding by the Balbina Dam caused this large decrease in population size and had a negative impact on their villages and agricultural activities. The Waimiri-Atroari were becoming dependent on mining activities, resulting in the breakdown of their traditional productive and economic systems. (United Nations Environment Programme, n.d.)

The Indians which were encountered during the construction were slaughtered. As a revenge, the Indians killed construction workers and government Indian agency workers. Eventually the Brazilian government and the electricity company Eletronorte were forced to negotiate with the Indians. (Brazilmax, 2004)

To 'compromise' the Indians, the Waimiri-Atroari Programme was established which was financed by Eletronorte, the energy generation company for the North of Brazil. The aim was to achieving more equitable economic and cultural relations between the Waimiri Atroari community and the Brazilian society, to guarantee the Waimiri-Atroari Indians exclusive exploration rights over their territory, to improve the Waimiri-Atroari's general living conditions and to increase the understanding of the socio-political environment in Brazil. (United Nations Environment Programme, n.d.)

Due to the program, some improvements are made (United Nations Environment Programme, n.d.)

- Official registration and recognition of Waimiri Atroari land. However, 311 km² of it was flooded by the Balbina Dam. (de Oliveira, 2009)
- A 7.5% per annum average growth in the Waimiri-Atroari population over 10 years.
- 100% vaccination coverage, zero level of tuberculosis, interrupted transmission of malaria
- Establishment of 14 "schools" within the Waimiri-Atroari territory with indigenous teachers, built and conceptualized by the Indians.
- 30% literacy rate, with reading and writing taught in the native language and Portuguese.
- Establishment of small seedling nurseries and agro forestry systems.
- Aquaculture projects with river turtles and fish.
- Surveillance posts to protect a group of Indians (the Pirititis) who have not yet come into contact with Brazilian Society.

So the living conditions of the Indians are improved but their way of life has changed a lot. Right now the Indians have got an official registration and recognition of their lands which actually means that the Indians are kept as 'prisoners' inside their area and other people are kept out.

7.2.7 Effect on Economy

The effect on the economy is high. Eletronorte made a initial cost estimate of \$383 million. However, the costs increased to \$700 million (Fearnside, 1989) and even another \$700 million was needed to solve a technical fault in the dam. Besides that, the maintenance costs are very high (Cumplings, 1995).

The effect on the economy is more visible when it is compared to the energy capacity of the dam. For the Balbina Dam, the ratio of costs and energy capacity is \$ 3000/kW. This ratio is very high compared with other dams in the Brazil. The costs of Balbina are even higher, because this calculation concerns energy capacity; the real energy generated is only the half of this capacity (Fearnside, 1989).

Another economic effect is the loss of forest. Because the trees are drowned instead of cut, potential economic benefits of logging are lost. These trees also could have been used to generate energy from biomass. Other losses are the rubber, rosewood and pharmaceutical plant species (Fearnside, 1989).

8 CONCLUSIONS

In the sections above, we presented some information about (expected) influences the dam has had, both on short term as long term. Just like for the bridge we try to find out to what extent these influences are sustainable, with the definition we described in the second chapter of this report. Note that this (and the findings above) conclusion is based on the information that could be found on the internet. Some things are yet unknown and have to be found out during the study tour.

8.1 Sustainability

As described before, the effects of the Balbina Dam on the system are large. Although a hydroelectric power plant seems a sustainable energy at first sight, without using fossil fuels, the reality in Balbina is different. Many aspects are not taken into consideration when deciding to build the dam, including the effect on the livelihood of the Waimiri-Atroari Indians, the environmental effects on the flora and the fauna in the rainforest and the economical situation (respectively People, Planet, Profit).

Especially the environment is not taken into account before the construction. Eletronorte, the company that built the dam and that is responsible for the energy in the Amazonas, only looked at the economic benefits and the political consequences. An environmental impact assessment (EIA) made by an independent party before the decision of Balbina would probably have shown that building Balbina was not the right decision. Besides making an EIA, more participation of the local inhabitants and experts would have helped in the decision making process.

We conclude that by the construction of the Balbina Dam, the needs of the present were much more important than the ability of the future generations to meet their own needs. The dam is in our opinion not sustainable on all the three aspects People, Planet and Profit.

8.2 Remaining Questions

Also for this project, our insight was not complete enough after the literature research. During the study tour we will ask the following questions in order to complement our research. Unfortunately, the energy company is the only actor we can ask questions to. In the final report, we will handle this biased information critically.

- Were stakeholders with little power, like the local inhabitants of Balbina, involved in the decision making process?
- The people in the flooded area had no other option than to move. Was this relocation of the native inhabitants planned or assisted?
- What compensation did the native inhabitants get for the impact on their livelihood?
- What is the effect of the dam on 1. the water quality, 2. the water quantity and 3. the fish habitat? How can these effects be justified?
- The dam cost \$ 700 million, although the power capacity of the dam is relatively low. Can the dam economically be justified?

- What alternatives would have been there for the Balbina dam? E.g. a dam in a more hilly area (which leads to a smaller flooded area) or a coal power plant?
- What possibilities (e.g. improving the dam) are there nowadays for trying to compensate the loss for the Indians, the environment and the economy?
- When taking the decision of constructing the dam at this moment, with the knowledge of today, what would the energy company decide?

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