

BELO MONTE AND THE LIVELIHOODS OF LOCAL COMMUNITIES



A research on the indirect impacts of the hydroelectric dam Belo Monte on the income, alimentation, and environment of fishermen families and indigenous communities of the Middle region of the Xingu River

M. de Boer
Forestry and Nature Conservation
Velp
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DAMS AND THE LIVELIHOODS OF LOCAL COMMUNITIES

A research on the indirect impacts of the hydroelectric dam Belo Monte on the income, alimentation, and environment of fishermen families and Indigenous communities of the Middle region of the Xingu River

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Menno de Boer

910821001

Forestry and Nature conservation

Major Tropical Forestry

University of applied sciences Van Hall Larenstein (VHL)

Velp, the Netherlands

Supervisor: Ir. Erika van Duijl (VHL)

External supervisor: Dr. Prof. Juarez Carlos Brito Pezzuti (UFPA)

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Pictures front page: Belo Monte construction site; indigenous girl in Muratu; house of riverine family; Cacique of Muratu in fishing boat. (Source: Menno de Boer)

Key words: Riverine communities, Xingu River, Hydroelectric dam Belo Monte.



PREFACE

The controversy of the Belo Monte hydroelectric dam is a typical example of the conflict between indigenous and non-indigenous people, who live using a natural resource on very small scale, and huge political movements that force them into change. These conflicts interest me, and it was one of the most interesting periods of my life to be in the middle of this reality.

It's only now, after spending three months in the Middle Xingu region and two months of literature studies and data analysis that I start to understand the huge impact of a dam being built in a precious and fragile ecosystem, in the middle of the livelihood of local people.

This document is the final product of my bachelor study Forestry and Nature Conservation, major Tropical Forestry at the University of Applied Sciences Van Hall Larenstein in Velp, the Netherlands.

Doing the research in Brazil and writing this document was a great experience for me, in which I learned plenty. I met many very cooperative and inspiring people. Some of them contributed in a special way to my research.

I would like to thank my supervisor from the Universidade Federal do Pará (UFPA) Dr. Prof. Juarez Carlos Brito Pezzuti, and his wife Daniëla Felix for always providing me with support. Not only did they give me the opportunity to conduct my thesis under their supervision, but also they provided me with the appropriate guidance and feedback when I needed it.

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In addition, I would like to thank NGO ISA for providing me with various services. The opportunity to work in their office in Altamira was a huge convenience. Moreover, the opportunity they gave me to join them on two trips to Muratu, was essential for this research.

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ABSTRACT

With the construction of a hydroelectric dam, especially in a fragile region like the Amazon rainforest, many aspects of the environment are affected. (Santos, Barbosa, & Hernandez, 2009) People living in the Amazon, in the vicinity of these construction site, are often very dependent on natural resources, and in particular the river in which this dam is being constructed.

This research focusses on the impact of the construction of the hydroelectric dam complex Belo Monte in the Xingu River, on the income, alimentation and environment of local fishermen families and indigenous communities of the Middle Xingu region (figure 2.1).

The research question of this research is: *“What are the consequences of the changes caused by the hydroelectric dam Belo Monte for the income, diet, and environment of the fishermen families in the middle Xingu River and the indigenous communities living along the Middle Xingu River?”*

This question was answered by answering the following sub questions:

- To what extend did hydroelectric dam complex Belo Monte affect the sources of income and alimentation of the two target groups until now?
- What are the alternatives of the two target groups, for adapting to the changes in the sources of income and alimentation?
- What are the implications for the alimentation and income of the two target groups in the different alternatives, defined in sub question two?
- What are the implications for the environment of the indigenous communities when the exploitation of these alternatives is intensified?

The methods applied include interviews with fishermen, conducted in Altamira, and interviews conducted with the indigenous people of Muratu.

The income of both groups has been affected negatively until May 2014. This is caused by the negative influences of the dam on fishing, hunting, and agriculture. The indigenous people of the Middle Xingu region are now more dependent on jobs, rather than self-sustaining. The alimentation of both groups changed as well. Both depend more on the city for their alimentation in May 2014, than they did before the construction of the dam.

The indigenous communities will practice agriculture, hunt more, collect more NTFPs and have jobs, in order to adapt to the loss of income from (ornamental) fishing. They will be more dependent on outside sources for their income and alimentation. The health value of their alimentation will not be lower than it currently is, but it will be different from their traditional alimentation.

The fishermen families do not know what their future sources of income and alimentation will be. The communication toward them about their options is bad; they do not know if it is possible to continue fishing or not. The health value of the diet of the fishermen families of the Middle Xingu will be lower. Their alimentation will consist of less fish, which is not compensated with other products. The environment of the indigenous communities will be affected by their actions, conducted to adapt to the changes. The increased hunting pressure will cause the number of animals of many hunted species to decrease. This causes a general decline in biodiversity in the fragments of the indigenous areas.

Recommendations are given to the indigenous communities of the Volta Grande, the fishermen families of the Middle Xingu, the association of fishermen, Norte Energia S.A., and FUNAI. Moreover, possibilities for further research are elaborated on.

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ACRONYMS AND ABBREVIATIONS

\$R	Brazilian Real (Brazilian currency)
°C	Degrees Celsius
BNDES	Banco Nacional de Desenvolvimento e Econômico e Social
FUNAI	Fundação Nacional do Índio
Ha	Hectares
HBM	Hydroelectric dam complex Belo Monte
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
ISA	Instituto Socioambiental
km ²	Square-kilometres
m	Meter
m ³	Cubic meter
MW	Megawatts
NGO	Non-governmental organization
NTFP	Non-timber forest product
RESEX	Reserva Extrativista
T	Tons
TI	Terra Indígena
UFPA	Universidade Federal do Pará
VHL	Van Hall Larenstein

1. INTRODUCTION

For their high potential in generating electric power, and they are said to have low environmental impacts, 48 hydroelectric power plants are planned throughout Brazil. Of these dams, 30 are planned to be built in the Amazon region. (The Economist, 2013)

However, with the construction of a hydroelectric dam, many aspects of the environment change; forests are cut, rivers are blocked, land is inundated, water flows change, and rivers dry up. (La Rovere & Mendes, 2000) This has a huge influence on the livelihoods of people living in the direct vicinity of a dam, especially those largely dependent on water resources. (Magalhães & Hernandez, 2009)

One of these dams is the hydroelectric dam complex Belo Monte (further referred to as HBM), which is being constructed in the middle part of the Xingu River near Altamira, Pará, Brazil (figure 1.1). This dam will have the potential to supply 18 million households with electricity. (Leite, et al., Capítulo 1 - Obra, 2014)

The subject of this research is the influence of the changes caused by HBM on fishermen families of Altamira, and on indigenous communities along Volta Grande (Big Bend) of the Xingu River. It takes a closer look at the impact on the income and alimentation, the plans of the groups to adapt to the changes, and the impact of these adaptations to their lives and environments.

This report is written in collaboration with NGO Instituto Socioambiental (ISA). This organization established a village organization (Associação da aldeia Muratu) and is conducting a research and monitoring project in Muratu, an indigenous village in one of the impacted areas, on the impact of the dam.

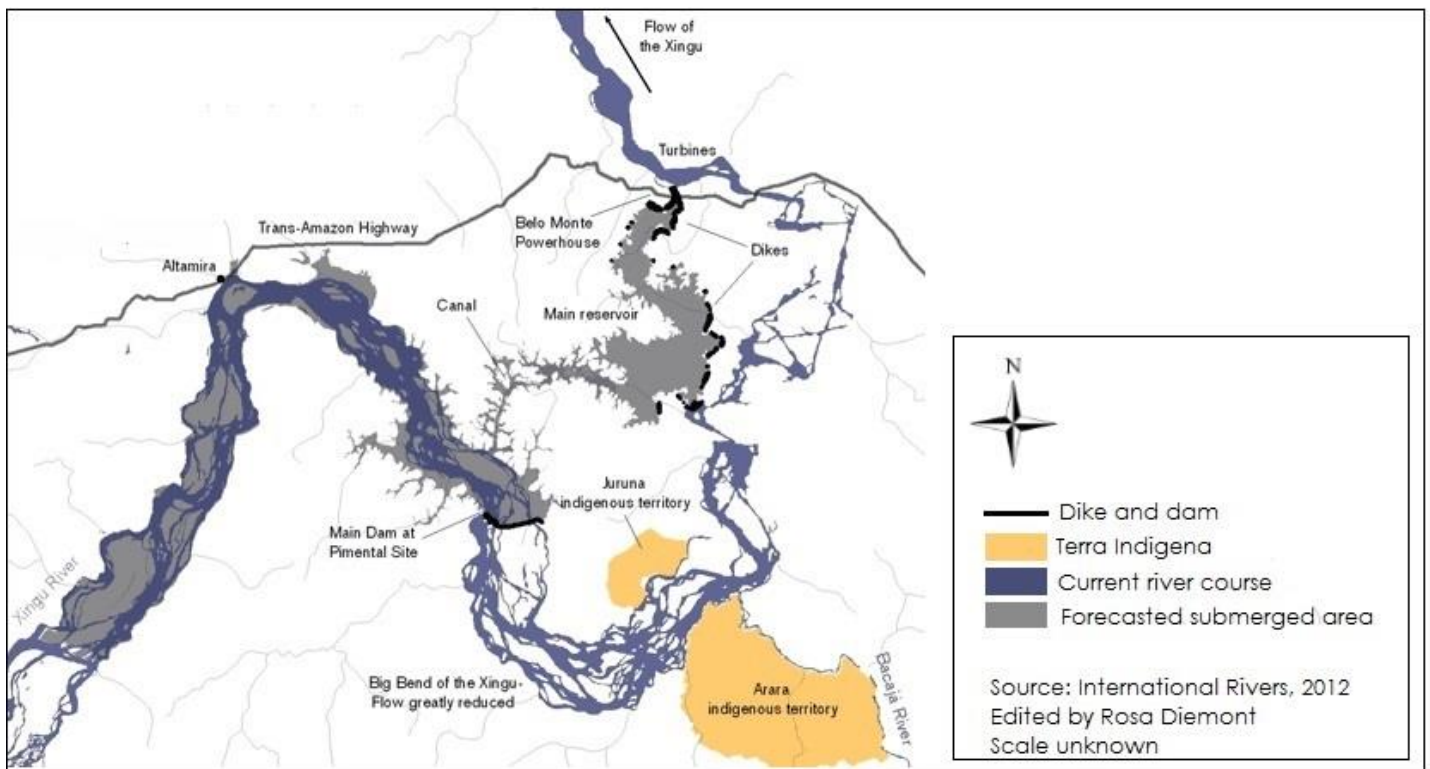


Figure 1.1 - Schematic map of the Middle Xingu region and the dam complex

Problem description

Many people in rural areas, especially in developing countries, are directly dependent on natural resources. People living in the Amazon region, both indigenous and non-indigenous riverbank dwellers, depend heavily on fish for their alimentation. Fish is a very important addition to the starchy cassava, which makes up another large part of their diet. (Dorea, 2002) Another aspect of the dependency on aquatic fauna as a resource is the commercial value.

In the case of HBM, significant changes will occur in the river: Upstream the main (Pimental) dam, a lake will be formed, in front of Altamira. On the other hand, downstream the main dam, the water flow in the Volta Grande do Xingu will be reduced to 20% of its original state, which is the “sanitary outflow”, because 80% of the water is diverted into two man-made canals, leading to the main turbines of the complex (figure 1.1). (Magalhães & Hernandez, 2009) (Leite, et al., Capítulo 2 - Ambiente, 2014)

These changes affect the amount of fish, and the accessibility of the river. In the area of the Middle Xingu, fishermen families and indigenous people also depend on the river for alimentation and income. Not only because of fishing, but also for agriculture, hunting, and non-timber forest product (NTFP) gathering. (Carneiro, 2014) Since many properties of the river will change, it is likely that their sources of income and alimentation are affected.

Information about the severity of the impact of the environmental changes, caused by HBM, on the livelihoods of people is lacking. Since the start of the construction of the dam, what has happened to the income and alimentation of people dependent on the river? In addition, what will happen to their income and when the dam is finished? Is there a difference in impact on riverbank dwellers and on indigenous peoples? What are their plans for adapting to these changes?

These questions were unanswered, even though the dam is almost finished.

This research discusses the impact of HBM on the income and alimentation of two research subjects, the indigenous communities living along the Volta Grande, and the fishermen families in the Middle Xingu region. Furthermore, a prediction is made about the impact on income, environment and alimentation of their adaptations to these changes.

Goal of the research

The goal of this research is to increase the understanding of the impact of the changes caused by HBM on the income, alimentation, and environment of the indigenous communities in the Volta Grande and fishermen¹ families of the Middle Xingu River. Both these groups² depend heavily on the river for their income and alimentation.

Main research question

What are the consequences of the changes caused by the hydroelectric dam complex Belo Monte for the income, diet, and environment of the fishermen families in the middle Xingu River and the indigenous communities living along the middle Xingu River?

¹ There are two types of fishermen in this area: fishermen catching ornamental fish, and fishermen catching fish for consumption. This research focusses on the latter.

² The characteristics of the two research groups are described in chapter three, the local situation.

Sub questions

- To what extent did hydroelectric dam complex Belo Monte affect the sources of income and alimentation of the two target groups until now?
- What are the alternatives of the two target groups, for adapting to the changes in the sources of income and alimentation?
- What are the implications for the alimentation and income of the two target groups in the different alternatives, defined in sub question two?
- What are the implications for the environment of the indigenous communities when the exploitation of these alternatives is intensified?

Justification

When rural communities are asked to indicate their most important forest uses, they mostly start by describing the river and its resources. This is in contrast to what most people consider when thinking of NTFPs.

Fish is one of the most important NTFPs in the Amazon region. (Ros-Tonen & Wiersum , 2003) In the case of the Middle Xingu region, thousands of people depend on this forest product. Moreover, all of their sources of income and alimentation, like agriculture, hunting, and forest fruit gathering, are in one way or another related to the river. HBM has a huge influence on the ecosystem, on which fishermen of the Middle Xingu region and indigenous people of the Volta Grande are dependent for their livelihoods.

The case between Norte Energia S.A., the main contractor responsible for the construction, and fishermen (indigenous and non-indigenous) is still going on. (Silva, 2014) People have the opinion that they deserve compensation, for their loss of income and loss of land.

With this research, the true impact on the income and alimentation of fishermen of the Middle Xingu region and indigenous people of the Volta Grande is clear. This report will add to discussion between Norte Energia S.A. and the local people.

In addition, it is unclear what people will do, in order to adapt to the changes. It is likely that these adaptations have an impact of their livelihoods and surroundings. This is then, an indirect impact of HBM. In this case, Norte Energia S.A. should be aware of this.

The relevant results are translated into Portuguese, and presented to the association of fishermen³, and NGO ISA, in order to make it accessible for fishermen.

Contents of this report

In the first part of this report, the local situation in which the research took place is described. In this chapter, background information is given about the climate, the research target group, and HBM. Secondly, the methods applied to gather the data, and to analyse the data are explained. In the following part, the results, discussion and conclusion are given. Finally, recommendations are given to various bodies.

³ The association of fishermen represent the fishermen, arrange licencing, and are responsible for the retirement fund of fishermen. Each fishing region in Brazil has its own association of fishermen (Colônia de Pescadores).

2. THE LOCAL SITUATION

The climate of the region, the Xingu River, the two target groups, and HBM are described in this chapter.

Climate and seasonality

The climate in the Middle Xingu Region is predominantly humid tropical without a dry season, according to Köppen. The mean air temperature is 26°C. The average annual rainfall is around 2300mm with the 'dry' season during August and September. The average precipitation in this period is around 35mm. (Cunha & Ferreira, 2012)

From the conversations with people from Muratu and Altamira, the following information about seasonalities was obtained. There are two seasons in this region, which are called summer and winter by the local population. The summer season is between June until December. During this season, the water level of the river is low, and there are fewer rains. In December, the winter season starts, and precipitation peaks. (El Dorado Weather, 2014)

Several aspects explain the differences in income and alimentation, between the summer and winter. The various sources provide different quantities and qualities of products in the different seasons. For the families in Muratu, fishing is easier in the summer, because the water is low, and the fish are more concentrated. This makes it easier to obtain alimentation. However, the income from ornamental fish is higher in the winter for most people in Muratu, because the price is higher. Hunting is easier in the winter, because the animals are more concentrated. This is caused by high water, which makes their terrain smaller. However, some of the villagers state that hunting in summer also has its advantages, because animals have less water sources, which makes them easier to locate near the relatively small river. Most important NTFPs for the families in Muratu, Brazil nut (*Bertholletia excelsa*), Açaí (*Euterpe oleracea*) and Cupuaçu (*Theobroma grandiflorum*), mainly provide fruits in the winter.

In Altamira, it is not allowed to fish in the winter months, from the 15th of December until the 15th of February. During this time, people who are registered with the association of fishermen receive insurance money. Fishing in the remaining winter months is more difficult for people in Altamira, because the fish are looking for fruits in the flooded forests along the river.

The Xingu River

The study area of this research is the Middle Xingu region. The Xingu River flows along an 1800 km stretch, from Mato Grosso into Pará, where it enters the Amazon River (figure 2.1). This river has a system of stable processes of erosion and sedimentation. Numerous geological events caused the formation of rapids and waterfalls. These features cause great biodiversity, and influence the distribution patterns of aquatic fauna. Over 600 species of aquatic fauna live in the Xingu River, most of them fruit eaters. (Camargo, Giarrizzo, & Isaac, 2004, volume 10) The Volta Grande, the area from Altamira until the waterfalls of Belo Monte, is considered one of the most

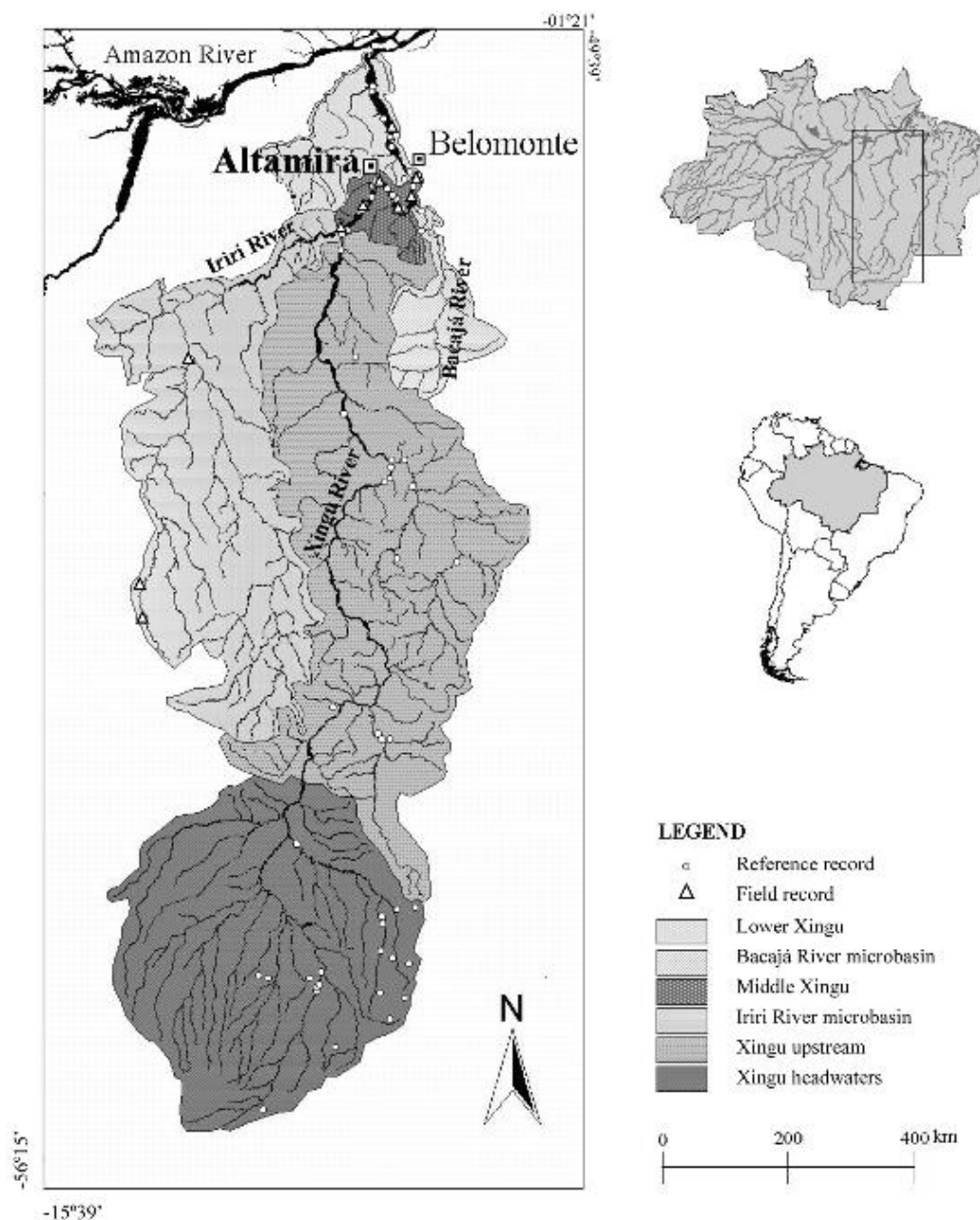


Figure 2.1 - Map of the middle Xingu region, and its location. (Camargo, Giarrizzo, & Isaac, 2004, volume 10)

important areas in the lower Amazon basin, because of its flora, fauna and indigenous and riverbank communities. (Cunha & Ferreira, 2012)

The inundation period of the Xingu River occurs from December to June. The flow rate of the Xingu at its peak is around 20000 m³/s. The water level reduces during the period from July to November. During this period, the flow rate can drop to 400 m³/s. (Cunha & Ferreira, 2012), (Leite, et al., Capítulo 2 - Ambiente, 2014) The effect is that the river has a very wide catchment area during the high waters, and a very concentrated catchment area during low water levels.

The hydroelectric dam complex Belo Monte

The complex is being built in the Middle Xingu region, near the city of Altamira in Pará, Brazil (figure 2.1). The Norte Energia S.A. consortium is responsible for the construction. (Leite, et al., Capítulo 1 - Obra, 2014) Brazil's economic growth is the main reason for the construction of HBM in the Xingu River. This rapid surge of the economy provoked a demand for stable sources of energy. This is fuelled even more by the growing iron and aluminium industry, which has especially been expanding during the last two decades in the eastern Amazon region. (Wohl, 2012) It is the third largest dam in installed power generating capacity, with its 11,233 megawatts. (Eletrobras, 2009) However, this will not be reached due to insufficient current. For this to be reached, more dams would have to be built upstream. (Jaichand & Sampaio, 2013) The dam is financed by the BNDES⁴. The total costs for construction and compensation are estimated to be around R\$ 30 billion. (Leite, et al., Capítulo 1 - Obra, 2014)

The plan for this hydroelectric dam originates from the seventies of the 20th century (Eletrobras, 2009), and has been a controversial project ever since; *“One of the world's most controversial dam projects, the Belo Monte Dam will devastate an area of over 1500km² of rainforest and results in the forced displacement of as many as 40,000 people”*. (BankTrack, 2014) There have been many protests since the first viability studies were conducted in 1975. Indigenous communities who would be affected greatly (especially in the original plans, where their territories would be partly flooded) were supported by national and international NGOs. (Jaichand & Sampaio, 2013) *“Originally, five huge dams were planned for the Xingu Basin, which would have flooded 18,000 km² of the rainforest and generated over 20,000 MW of electricity. The upstream dams would have stored water for Belo Monte (then called Kararaô), making it more effective in generating electricity. They would have also flooded indigenous reserves and protected areas.”* (International Rivers, 2012) These plans were discarded, and new plans were made, mainly due to protest from indigenous tribes. (Rainforest Foundation, 2009)

HBM consists of a series of dams, dikes, reservoirs and canals. There are two main dams, one near the village Belo Monte which contains the main powerhouse, and one near Altamira, the Pimental dam (figure 1.1). The first dam has an artificial reservoir on land, of 440km², and the second dam creates a reservoir in the original stream of the Xingu River of 6140km². The second (main) reservoir is used for regulation of the water flow during the dry season, to make sure energy generation is maintained. The canals will divert the water from the larger reservoir, away

⁴ Banco Nacional de Desenvolvimento e Econômico e Social, the Brazilian national development bank.

from the Volta Grande into the first reservoir. This means that the Volta Grande will only receive 20% of its original water. (Fearnside, 2006)

Future changes in the river

There will be consequences for the river and its ecosystem, both upstream and downstream the dam. Upstream, the water quality will deteriorate, because the flooding will cause the anaerobic decomposition of the submerged vegetation. Furthermore, the natural fluctuations will be stopped. This will affect the aquatic flora and fauna drastically. Originally, there are many frugivorous fish species, who feed on the fruits of the seasonally inundated trees, which only submerge in during the winter months. Since the fluctuation will disappear, these species of aquatic fauna will suffer. (Cunha & Ferreira, 2012)

Downstream in the Volta Grande, the effect will be different. The diversion of the water from this bend will have a large impact. Not only will the water table be only 20% of its original state, but the hydrological cycle will be reduced as well. This will result in changes in the reproductive cycle of many plant and animal species, since these have become synchronized with the fluctuations in water levels. (Cunha & Ferreira, 2012) Many species may go extinct locally due to these changes. With the building of the Tucuruí dam in the Tocantins River, the number of species downstream of the dam decreased with more than 50%. (La Rovere & Mendes, 2000)

The indigenous communities of the Volta Grande

There are two indigenous groups, living in TIs⁵: Juruna people living in TI Paquiçamba and Arara people living in TI Arara da Volta Grande (figure 1.1). These two indigenous tribes, their lifestyle, traditions, and cultural history are identical. (Carneiro, 2014) Since this research was carried out only among the Juruna tribe, this group will be described here.

The part of the research about the indigenous communities was conducted in the village of Muratu, in TI Paquiçamba (figure 1.1). The families of Muratu belong to the Juruna tribe, which has settlements in two states in Brazil, one in the north of Mato Grosso, and one in Pará (both along the Xingu River). There is one leader in the village. This leader is called the Cacique⁶. The TI of Paquiçamba currently occupies an area of 4,384 ha. This will be increased to 15,733 ha. (Fundação Nacional do Índio, 2014) The population of Paquiçamba was 84 in 2008. (Instituto Socioambiental, 2014)

The history

The name Juruna comes from the traditional language, and means “black face” (Yuru means face, and Una means black). This refers to the facial tattoos, which were used until the mid-1900s. The Jurunas call themselves Yudjá; river master. Around 1840, the population of Jurunas was estimated to be around 2000, situated in nine “aldeias”⁷. This number decreased dramatically around 1880, to around 200 Jurunas. There were approximately 150 around 1900 and 52 in 1916. This dramatic decline was caused by the rubber industry, which started to grow in

⁵ TI stands for Terra Indígena. This is Portuguese for Indigenous Territory. These are areas throughout Brazil, reserved for indigenous peoples, where they can live in their traditional lifestyle. (Fundação Nacional do Índio, 2014)

⁶ A cacique is the chieftain of an indigenous village in Brazil.

⁷ Aldeia literally means village, but in this region and context, the word is used to indicate indigenous villages only.

the second half of the 19th century. Rubber tappers killed the indigenous people in order to reach the rubber. (Vieira, Silva, Lima, Carvalho Jr., & Pimental, 2009)

The livelihood

The Jurunas in TI Paquçamba speak Portuguese primarily. Additionally, some still speak their original language. In other areas, the Jurunas still mainly speak the original Juruna language. (Povos Indigenas No Brazil, 2014) The Juruna people in Muratu are Catholic, but there are still some traces of their original beliefs. (Juruna, Informal conversation, 2014)

The life of the Jurunas is traditionally based on the Xingu River. They depend for a large part of their diet on fish (figure 2.2). The other aspects of their traditional livelihoods are based on the river as well. They collect NTFPs, hunt and practice agriculture. The Xingu River influences all these sources.



Figure 2.2 – Indigenous people of Muratu, fishing in the Xingu River (Diemont, 2014)

They collect ornamental fish “Acari”⁸, to gain an income. These fish are sold to local traders in Altamira, from where they are distributed to national and international customers.

Slash and burn agriculture is practiced on fields around the villages, until recently mainly for alimentation. Every family is allocated around 0.5 ha. On these plots, they grow both annual and biannual crops. The annual crops are, among others: maize (*Zea mays*), cassava (*Manihot esculenta*), pineapple (*Ananas comosus*), and okra (*Abelmoschus esculentus*). These are intercropped with trees like avocado (*Persea americana*), cocoa (*Theobroma cacao*), and various citrus fruits. After two years of use, the agricultural plots are left for two years, after which the families return and use them again. The information about agriculture by indigenous communities in the Volta Grande is based on the interviews with the Cacique of Muratu.

Furthermore, the families hunt, for their alimentation mainly. Some indigenous people also sell bush meat (however, this is illegal (IBAMA, 2014)). Among the hunted species hunted are Caititu

⁸ A detailed description of the changes in the ornamental fish, and the fishermen who catch them, is given in the thesis report of R. Diemont (Diemont, 2014).

(*Pecari tajacu*), Paca (*Cuniculus paca*), Tatu (of the Dasypodidae family), and Capivara (*Hydrochoerus hydrochaeris*). The information about hunting in indigenous communities of the Volta Grande is based on interviews with two hunting specialists of Muratu.

Support

The Jurunas of Muratu are being compensated for the changes in the river. This has been done in different forms. A road has been constructed, in order to ensure a connexion with the city once the river is closed. Furthermore, they have received money for building new houses. These houses have been constructed, and the families are living in them. The compensation included the construction of a new school building. There are different positions available in the village for a community service job. The government pays for these. These positions include teacher, health agent, football teacher, etc. (Juruna, Informal conversation, 2014)

Apart from the government support, which is mainly by financial means, they receive support from FUNAI⁹ and ISA. Among other activities, the FUNAI establish the TIs, and protect the people living in them. They make sure that strangers cannot enter the park (amongst other for protection against diseases). (Fundação Nacional do Índio, 2014) ISA is involved in several research and development projects which are conducted in the TIs, mainly in Muratu. (Instituto Socioambiental, 2014)

Fishermen families the Middle Xingu region

The sources of alimentation and income of fishermen families of the middle Xingu region are mainly based on the Xingu river as well. These fishermen and their families, live in the municipality of Altamira and consists of around a thousand fishermen with their family, as stated by the association of fishermen of Altamira.

For fishing in the Middle Xingu, a licence is required. However, not all fishermen have licences. There are many fishermen who fish on a very small scale, illegally. The president of the association of fishermen estimates that there are around the same number of illegal fishermen as legal fishermen.

Rural and urban fishermen

The second target group of this research, the fishermen families of Altamira, can be divided into two sub-groups: The fishermen living inside the city of Altamira, and the fishermen living on the riverbanks of the Xingu River, outside the city. The main difference is that the fishermen from the city are less self-sustaining, and depend more on the city for their alimentation, while the rural fishermen oftentimes have a piece of land, which they use for agriculture, hunting, or gathering forest products, and are thus less dependent on the city for their alimentation. This information is based on observations of the researcher.

⁹ FUNAI (Fundação Nacional do Índio) is the body of the Brazilian Government responsible for the establishment and execution of Indigenous policies. Its goal is to protect and promote the rights of indigenous peoples. The organization does this, amongst others, by delimitation and registration of TIs. (Fundação Nacional do Índio, 2014)

History of the settlers

Originally, indigenous communities occupied the area of the middle Xingu only. The settlers arrived, attracted by the money to be found in rubber tapping. Later gold mining was the main activity which stimulated the local economy in the twentieth century. Furthermore, the commercialization of jaguar (and other cats) skins, keeping of cattle on the riverbanks, and the cultivation of black pepper and cocoa were economic activities of the settlers. More recently, the trade in ornamental fish became a large source of income for these people. During all this time they practiced small-scale subsistence agriculture and fishing as sources of alimentation. (Macedo, 2014)

Current lifestyle

The fishermen from the city mostly live near the ports, in the Favelas¹⁰. They use various types of small boats called 'Voadeiras', and canoes. Fishing is done during fishing trips, which take four to eight days on average. After the trips, they stay at home for a few days, after which they leave again. They work closely together with the fish traders in Altamira. The fishermen buy ice in order to preserve the fish. They buy the ice and take it with them on their fishing trip, but they do not yet pay. When they sell the fish that they catch, first, the price of the ice is subtracted from the price of the fish. The surplus is the income of the fishermen.

Apart from the fish for consumer purposes, there are fish that are caught for ornamental purposes. This research does not focus on these types of fish, or the fishermen who catch them. The alimentation of the urban fishermen families is largely derived from the city. They do use part of their yield for own consumption, but the majority is sold, and other products (rice, cassava, etc.) are bought in the city.

The rural fishermen living in the Middle Xingu region have more sources of alimentation and are largely self-sustaining. Their lifestyle is similar to the indigenous lifestyle. The information about the alimentation of fishermen families in the Middle Xingu is based on observations and conversations with fishermen.

These fishermen families will be impacted heavily by the changes in the Xingu River. Since many fish species will disappear, fishing practices will change. Furthermore, navigation will be harder, as the main dam is built on the route from many fishing locations to the city of Altamira.

Government support

People who live in the favelas near the river, where the main reservoir will be located, get compensation for the loss of their house. Many urban fishermen living in these areas are eligible for this. They can choose from four types of compensation; a newly build house in a new residential area, money to build a new house, a newly build house in another area, or a piece of land where they can build a new house. (Silva, 2014) People living in the Volta Grande do Xingu have not yet received compensation, because their houses/agricultural lands are not being flooded. This is despite the fact that many of them expect that they will have to move, because their sources of income and alimentation, like fishing, agriculture, and NTFP gathering disappear.

¹⁰ Favela is the Brazilian term for slump. The poorer part of the population of most Brazilian cities live in these types of areas. In Altamira, the favelas are mostly located near the main fishermen's port, "Porto Carrosa".

On top of this, they do not have governmental bodies, or NGO, which are involved in their problems. The only organization supporting them is the association of fishermen.

3. METHODOLOGY

Two types of interviews have been conducted with the two research target groups. Secondly, planned specialist interviews were done in several occasions. Moreover, incidentally opportunistic interviews were conducted with specialists. Apart from interviews, observations were made.

The research target groups and study area

The study area of the research is the middle Xingu region. This region extends from the Iriri-Xingu confluence, to the village of Belo Monte (figure 2.1 and 3.1). (Camargo, Júnior, & Estupiñan, 2012)

The first research target group, the indigenous communities, were all interviewed in Muratu. This group has been chosen as research subject, because they live in the Volta Grande, and are representative for all indigenous communities living in the Volta Grande. Furthermore, they were most easily accessible. The schedule of other researchers had to be taken into account for the trips to the indigenous village Muratu, because of licence issues. This caused that a limited amount of time was spent interviewing indigenous families. Two one-week-trips (16th of April 2014, and 6th of June 2014) were organized to this village.

The fishermen of the Middle Xingu have been selected as a target group of this research, because they are heavily dependent on the river for their income and alimentation, and are likely to be affected by the changes in the environment.

Fishermen in Altamira live in the suburbs, or favelas of the city, and on the riverbanks of the Xingu River outside the city. It was impossible to select the research subjects consciously; they were reached in an opportunistic fashion. This caused that the amount of data gathered about the various groups is not evenly distributed. The best place to encounter fishermen during weekdays is the association of fishermen. Most interviews (62%) were conducted here. On Fridays, when most fishermen return from their fishing trips, it is possible to find them in the fish stores, where they sell the fish. Most of the remaining interviews have been conducted here.

Considering the available time, and the possibilities for contacting the target group, it was not possible to conduct the preferred number of interviews. The fishermen who fish illegally are not researched, because it was almost impossible to identify and reach them. It is not possible to see who is fishing illegally and who is not. Moreover, the fishermen fishing illegally do not visit the association of fishermen.

The research period

The planning phase of the research started in March 2014, until the first of April 2014. The field research phase was carried out from the second of April 2014 until the 22nd of June 2014. The final report was finished on the 28th of August 2014.

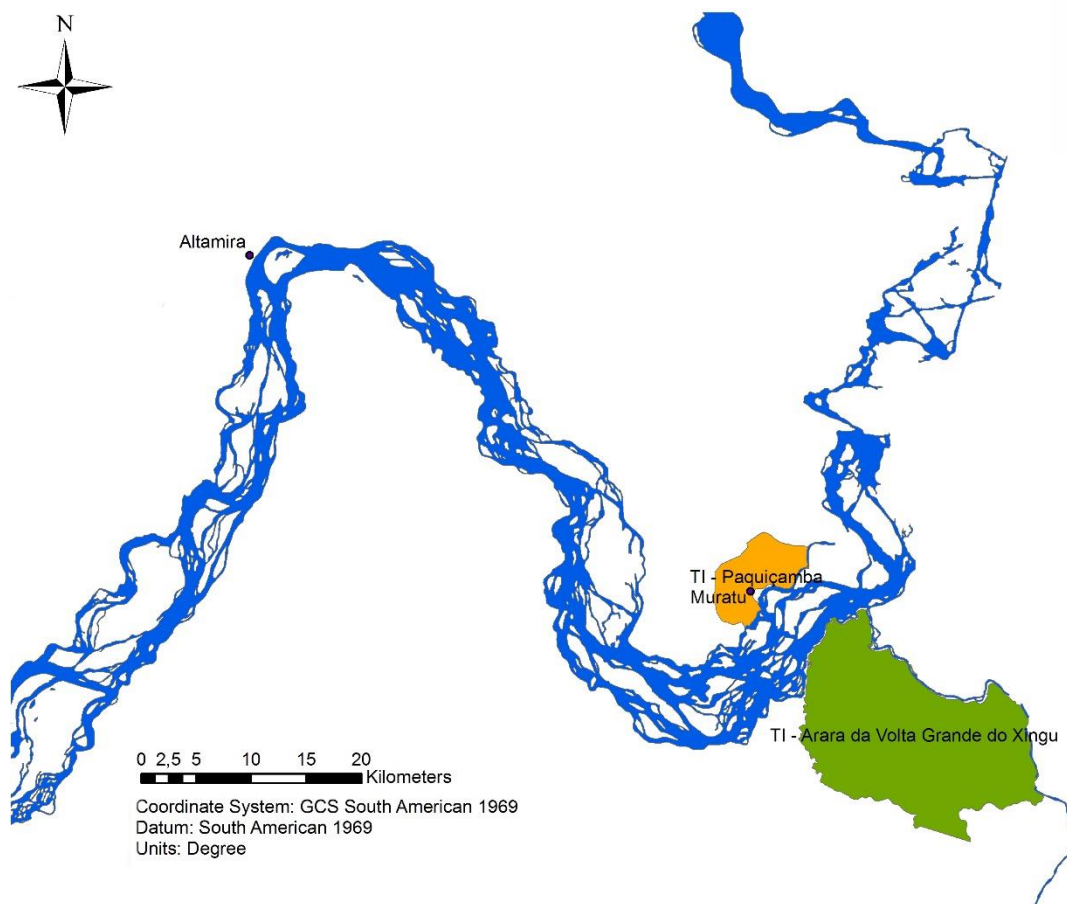


Figure 3.1 - The study area: Middle Xingu region. (Source unknown)

The sample size

The population of the indigenous communities of the Volta Grande is around 200 persons. The family size is on average five, this means that there are 40 families. According to the president of the association of fishermen, the population of fishermen *families* which are registered with the association of fishermen, is around a thousand and this number varies always. This number only represents the fishermen which are registered with the association of fishermen. There are around twice this number of fishermen in the region.

Preliminary interviews

In order to structure the main interviews, it was necessary to have a basic understanding of the lives and livelihood of the two research target groups. To ensure this, as a preparation, open interviews were held with local specialists

A PhD student in Anthropology was interviewed about the history of Altamira, and the historical sources of income and alimentation. A PhD student (Aquatic Ecology and Fisheries, and originally from Altamira), was interviewed about the possible alternative sources of income and alimentation of the target group in Altamira.

Data Gathering

A learning period was required before the interviews reached their full potential. After a few weeks into the research period, the interviews were conducted in a fully satisfactory manner. Furthermore, cultural differences impeded the research. Especially in the indigenous village, the cultural difference between the interviewer and interviewee was large. Luckily, the first interviews were conducted in the presence of a translator. The questions had to be designed with much care in order to make sure that the interviewees understood them. This required a relatively large period of trial and error.

INTERVIEW ONE – CHANGES IN INCOME AND ALIMENTATION

These semi-structured individual interviews (appendix I) have been conducted with the research target group from Muratu, and from Altamira. The goal of this interview was to determine the changes that have occurred in the alimentation and income, due to the dam, until now. It covered the sources of income, the income, and the sources of alimentation. These subjects were treated for the time before the construction started, for May 2014, and their expected income after the dam is finished. Furthermore, a distinction was made between the summer and winter. Lastly, information about the costs of food during the three periods was gathered during the interviews.

Initially, a pebble distribution method was used to find the distribution of sources of income and alimentation. People were also asked to give numbers to the various sources, but this proved to be too complex. Eventually this method was discarded. Figure 3.2 shows one of the initial interviews, where this method was still applied.



Figure 3.2 – Interview with a fisherman Altamira (Diemont, 2014)

The cards (appendix II) initially applied for this method display the various sources of income and alimentation, and were useful for structuring the interview parts about the several sources of income and alimentation.

INTERVIEW TWO – THE OPTIONS AND THE CONSEQUENCES

The second interview (appendix III Muratu, appendix IV Altamira) has also been conducted with the research target groups. This qualitative interview was originally designed as a focus group discussion, but since it was very rare to encounter more than one person of either of the target groups, this was only applied once, with two fishermen from Altamira.

The subject of this interview were the options that the interviewees consider as a future source for their income and alimentation, and the impact on their income and alimentation. Furthermore, in Muratu, the effect of the plans on the direct environment were a subject too. First, the interviewees were asked to present their plan for future income and alimentation. Secondly, they were given several options for sources of income and alimentation (such as a job in the city, a new fishing technique), which they had to evaluate.

Furthermore, the interviewees were asked to make a prediction of the impact of their preferred alternative source of income, on their income and alimentation (and in the case of Muratu, also on their environment).

SPECIALIST INTERVIEWS – CHANGES IN THE SOURCES

These interviews were held in Muratu and Altamira. They were used to confirm what was said in the two main interviews, and to gather more in-depth information about the causes and consequences, and the reasons behind the statements made during the two main interviews.

In Muratu, three individuals were interviewed about the changes in agriculture (appendix V), hunting (appendix VI), and NTFP gathering (appendix VII).

In Altamira, the president of the association was interviewed about the changes in fishing, and the alternatives of fishermen (appendix VIII).

SPECIALIST INTERVIEWS – ALTERNATIVE SOURCES OF INCOME

These specialist interviews include two interviews. One interview, which was opportunistically held with a former fisherman who now has multiple other sources of income. He was interviewed about his reasons for using new sources, and the outcomes of the utilization of the new sources. Furthermore, he was asked what he thinks about the options of fishermen in general.

The second, open interview was held with the lawyer who represents the fishermen. He could explain more about the problems of the fishermen. Moreover, he gave insight in the main parties like Norte Energia S.A., the ministry of fisheries and aquaculture, and the roles of these players. Next to an interview, he introduced me to these players during stakeholder meetings in May 2014. (Silva, 2014)

FIELD TRIPS

Two field trips were conducted opportunistically; both in Muratu, with the Cacique of the village to his agricultural plot, and on a fishing trip. The goals of these trips were to have a better understanding of their practices, to describe how HBM influences these sources until now and in the future, and to determine how the sources would affect the environment when the use by the target groups would be intensified.

OPPORTUNISTIC OBSERVATIONS AND CONVERSATIONS

In both research locations (Altamira and Muratu), opportunistic observations were done and conversations were held. The observations were about; fishing practices, alimentation patterns (in Muratu), fishermen's problems etc. Conversations were held with fish storeowners, fishermen in the streets, researchers, and local residents. These conversations contributed to my understanding of the livelihoods, problems and options of the two research target groups.

Data Analysis

The data gathered in Muratu, and among the fishermen in Altamira, are used to describe the consequences for the two target groups; the fishermen families of the middle Xingu region, and the indigenous communities of the Volta Grande.

DATA ANALYSIS – CHANGES IN INCOME AND ALIMENTATION

The number of sources of income and alimentation in the three periods were compared in Altamira and Muratu. Two-tailed t-tests were conducted, to compare the average incomes from before the construction started, to the income in May 2014.

The indicated reasons for the changes in sources of income, sources of alimentation, and income were categorized per source in Microsoft Excel, each category was given a letter. The letters were counted in order to construct frequency tables with the various given reasons.

Lastly, the costs of food were compared to the income of the interviewee, in order to measure the share of income used to buy food in the three periods. The average was taken of the share of cost of food, and t-tests were conducted to measure if the difference between the period 'before the construction' and May 2014 are statistically significant.

DATA ANALYSIS – THE OPTIONS FOR ALTERNATIVES OF MURATU

The plans for the intensification of the use of various sources of the families of Muratu were categorized in 'new source', 'stop dependency', 'increase dependency', 'decrease dependency', 'no change', and 'never depended'. People indicated what would happen to the level of dependency on the sources of income and alimentation. This was put into a table. Of the various actions, for example 'stop using fishing as a source of income' the number of families planning this were counted. The share of families was calculated, dividing the number of families planning one action by the total number of respondents (n=7).

Furthermore, the reasons given by the interviewees for these changes in dependency in the future are explained. Since people in Muratu have a clear plan of what they are going to do in order to have an income and alimentation, no other alternatives for income or alimentation are discussed.

DATA ANALYSIS – THE OPTIONS FOR THE ALTERNATIVES OF ALTAMIRA

The first results used are gathered during interview one, where the target groups expressed their plans.

Secondly, the data from the second interview are used. In this interview, it was asked if the interviewees think that they can continue fishing, and the various options were evaluated. The interviewees had to indicate if they consider the several options viable as a source of income and/or alimentation, and give reasons for their statement. Every interviewee indicated his or her preferred option. All the options are given in a graph, showing what share of the respondents considered every option as most viable.

The reasons why they consider the stated option the best are displayed in frequency tables, indicating the percentage of the research target group who support the various opinions. Moreover, the reasons for disapproving various options are given in other frequency tables.

DATA ANALYSIS – THE IMPLICATION FOR THE INCOME

The respondents in Muratu all have a clear idea of their future income and source of income. They know what their sources of income and alimentation will be. These data have been compared to their current sources of income and alimentation, and current income. Conclusions were drawn about the impact of the use of their future sources of income, and on their income.

Some of the respondents in Altamira had an idea of their future source of income. These cases were put into a table, indicating the future source of income and expected income.

DATA ANALYSIS – THE IMPLICATIONS FOR THE ALIMENTATION

The families in Muratu indicated (in interview two) what would happen to their source of alimentation, and how they expect the composition of these sources will be when the dam is finished. This composition is compared to the current composition. Moreover, the respondents were asked if and how the alimentation and the health value of their alimentation will change in the future. These changes have been listed, and conclusions were drawn based on this.

Both the data gathered with interview one and interview two were used to draw conclusions about the future alimentation of the fishermen families of Altamira. The data of the first interview in Altamira was used to examine the expectation of the families concerning the usage of the various sources of alimentation, when the dam is finished.

The second interview in Altamira, gave an insight in the expected changes in alimentation, when the new sources of alimentation are taken into use. During the interview, the respondents had to indicate their preferred option for obtaining an income and alimentation (sub question two). The expected quality and quantity of this nourishment had to be indicated as well.

The results about the implication of the usage of alternative options for the alimentation were supplemented with literature. Literature was gathered about the changes in health value.

DATA ANALYSIS – THE IMPLICATIONS FOR THE ENVIRONMENT

The statements about the plans of natural resource utilization of the families of Muratu is used to describe the implications for the environment. In addition, the interviewees stated how they think the environment will be impacted by their new behaviour.

These impacts have not been quantified for all aspects (only for the increased agriculture), which makes it impossible to quantify the changes of the environment. For these aspects, qualitative changes have been described, from which conclusions were drawn.

The agriculture, hunting and NTFP-gathering specialists in Muratu indicated how the changes will affect the environment. These data are used to describe the implications of the new behaviour on the environment.

Some aspects, like the change in agricultural ground used have been described in a quantitative manner, which made it possible to measure the future impacted area. The plot size increment was multiplied by the number of families planning to do this, and compared to the total area of TI Paquiçamba, in order to estimate the magnitude of the impact of the changes.

4. RESULTS

The construction of HBM significantly changed the income, alimentation and environment of the fishermen in the middle Xingu and the indigenous communities of Altamira. In this chapter, the results from the research are presented per subject.

Result 1: Changes in income until May 2014

The income decreased for the fishermen in Altamira. The income of the indigenous communities in the Volta Grande did not change. They started using different sources for their income.

Muratu

The average number of sources of income in Muratu is 2.4 (n=9). Before the building activities started, this was not different. Other sources of income are being used in May 2014 than before the construction. Figure 4.1 shows what share of the respondents use the various sources, before the construction of the dam and in May 2014.

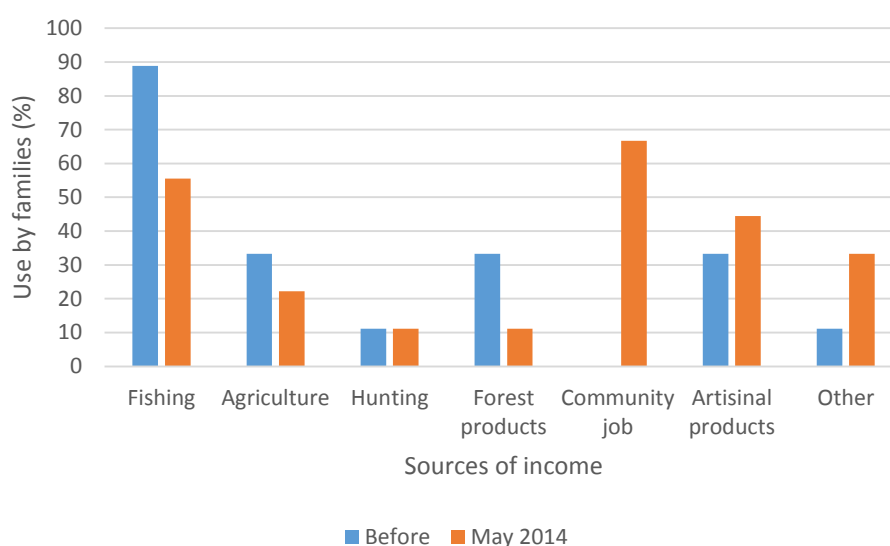


Figure 4.1 – Sources of income in Muratu (n=9)

Eight out of nine families state that, before the building activities started, their income consisted mainly of ornamental fishing. This is around 90% of the interviewees. Currently, only 63% of the families derive income from fishing. Fishing for subsistence is still done by everyone. The reasons given for these changes are that ornamental fish are now impossible to sell, because the quality of these fish has decreased too much. The interviewees state that the dam causes this, because it decreased the water quality and increased the current (66%).

66% of the interviewed families now (partly) generate their income with a community service job. They expect that they will keep these jobs in the future.

The 'other' sources of income include a position at FUNAI, a local village store, and the rental of a boat.

The average income of the families of Muratu decreased both in summer and in winter. Figure 4.2 displays the average monthly income of the families in Muratu before the building of the dam started and in 2014, in summer and in winter.

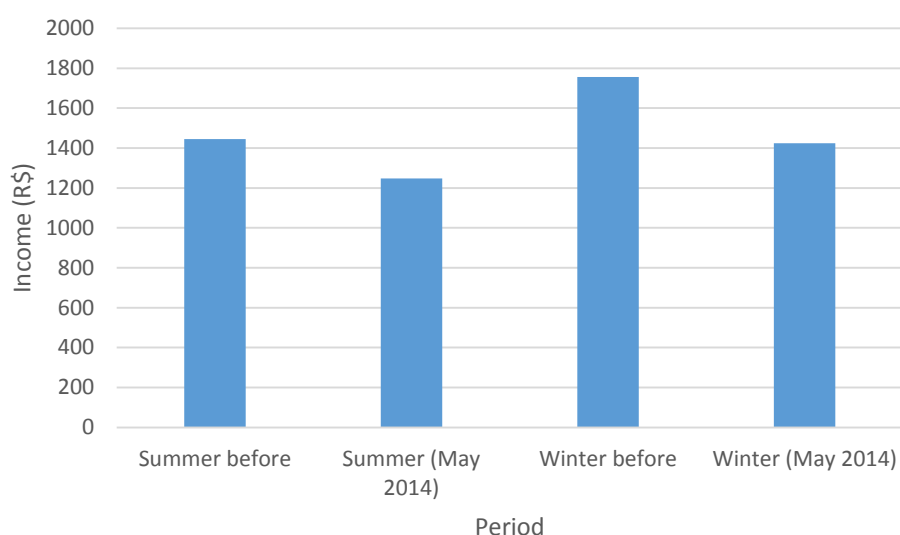


Figure 4.2 – Income in Muratu (n=9)

However, this change is not significant. H_0 (Two-tailed t-test): “*There is no significant difference between the income of the indigenous communities of the Volta Grande, before the construction of the dam started and the income in May 2014*” is accepted; the income in May 2014 is not significantly different than the income before the construction started ($p=0.27$).

The main reason for the changes in income are mainly caused by the lack of income from ornamental fish. However, the same share of families now have one family member with a job, which generates extra income. Table 4.1 displays the reasons for the changes in income in Muratu, and the share of the respondents who expressed this.

Table 4.1 - Reasons changes income Muratu (n=9, multi-response)

Reasons	Frequency
Lost the income from ornamental fish.	67%
One of the family members started a job.	67%
NTFPs are available to a lesser extent.	33%
It is more difficult to catch ornamental fish.	11%
Hunting is more difficult.	11%
Income from fishing did not change yet.	11%
One of the family members started making artisanal products.	11%
One of the family members has an alternative source of income.	11%

The quality of the ornamental fish decreased. The interviewees indicated that the fish are redder, and the tails of the fish break off more easily than before. For this reason, they are not bought anymore by the traders, and some families of Muratu stopped fishing these fish.

Some families now partly derive their income from a community service job. These jobs include health worker, teacher, school coordinator, sports coach etc.

NTFPs are harder to find, and it is not profitable anymore to sell these products. One of the given reasons is that due to the fact that animals flee into the forest from the construction site, more animals are feeding on the forest fruits, gathered by the community.

Some state that they can still sell the ornamental fish, but that it is more difficult, and that the income from these fish is lower than before.

Persons selling game state that their income from hunting is lower than before the dam.

Altamira

The income of the research group in Altamira is mainly derived from fishing, but there are other minor sources of income. Figure 4.3 shows the sources of income and the percentage of the families of the target group in Altamira, which use them.

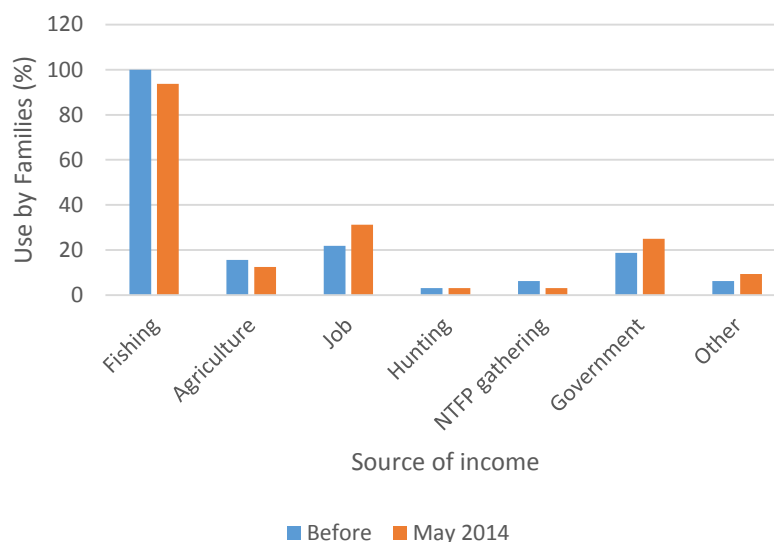


Figure 4.3 - Sources of income in Altamira (n=32)

Before the building activities of the dam started, the average number of sources of income per family was 1.4; this number is still the same. All of the families of the target group used to derive an income from fish before the dam. This number decreased a little bit until now. People who stopped (6%), did this because they have other sources of income, which are more profitable.

The other sources of income used by the target group are agriculture, a job, hunting, NTFP gathering, catering, and government. Furthermore, there are other sources of income, which are not put into categories; these include woodcutting and catering activities.

The share of people practicing agriculture decreased as well. The reason given for this is that the water of the river is warmer, which caused the harvest to fail.

Some families in the target group derive (part of) their income from a job in the city. The number of families in the target group who did this has grown since the building activities started. They did this to augment the income. In some cases (6%), the man took an extra job, and in other cases (6%), the partner took a job.

The number of families who derive part of their income from forest products has decreased as well. The families who stopped selling NTFPs (3%) expressed that some of the valuable products, like Açai (*Euterpe oleracea*), have suffered from the changes in the water quality or quantity, caused by the dam. For this reason, they only use the fruits for supplementing their alimentation, instead of for augmenting their income.

More families receive part of their income from the government. There are some families where one of the members has reached the retirement age, others have gotten children and receive child support.

Apart from these changes, there have been families who started exploiting other sources of income, like selling products (e.g. bananas, fishing nets) in Altamira (3%).

The income in both the summer and winter time has decreased, stated in May 2014. Figure 4.4 shows the average income of fishermen families in Altamira in summer and winter, before the construction and in May 2014.

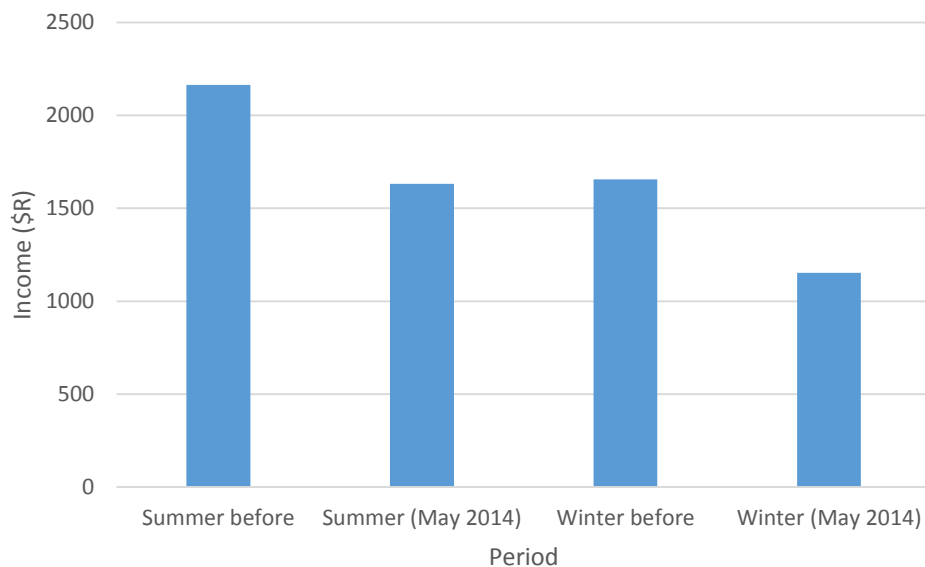


Figure 4.4 – Income Altamira (n=32)

H_0 (Two-tailed t-test): “There is no significant difference between the income of the fishermen families of Altamira, before the construction of the dam started and the income in May 2014” is rejected, and H_1 is accepted, the income in May 2014 is significantly 27% lower than the income before the construction started ($p=0.04$).

The main expressed reason for the decreasing income is that fishing is impacted negatively by the construction of HBM. The reasons given for the decreasing income from fishing are the displayed in table 4.2.

Table 4.2 – Reasons changes income from fishing Altamira (n=27, multi-response)

Reasons	Frequency
The dam, because of the bombs used, the lights, the dirty water, and sounds of the machines, affects the fish.	31%
The costs of fishing are higher.	19%
There has been a change in the currents.	9%
There are more fishermen.	9%
The water temperature increased.	3%
The fish are smaller on average.	3%

Fishing is affected by the various aspect of the construction site, such as bombs, lights, water pollution, and noise of machines. This is confirmed by the president of the association of fishermen.

He added that the illumination used for construction at the dam, has an effect until the Iriri River. (figure 2.1) The lights cause the fish to move away, which makes it more difficult to catch them. Furthermore, the explosions used for construction of the dam scare the fish away. The explosions start every day at six o'clock in the morning. The fishermen have to finish fishing before this time, in order to catch fish. The water in the Volta Grande is polluted due to the construction activities. For this reason, there is 70% less fish in this region.

The higher costs of fishing reduces the income. The price of gasoline, ice and alimentation has increased due to the increased population of Altamira.

The increased or decreased currents and changing water levels have affected some fishing spots. The president of the fishing association added that these spots occupy 10% of the total fishing area.

The influx in number of fishermen causes that the fishing locations have to be divided with other fishermen, and fish is more scarce.

The water temperature is higher, which causes some fish to die, and makes fishing is more difficult.

The president of the fishing association stated that the transport to and from some fishing locations is more difficult, because one has to navigate past the dam. This increases the gasoline costs, and lowers the income. Furthermore, some locations are unreachable with a smaller boat, so big boats are used; this increased the costs as well.

It is also stated by some of the interviewees that the income did not yet change; there are less fish in the river, but at the same time, the price of fish increased. This caused the income of these respondents to stay the same. (3%)

The reasons given for the changing income from the other sources are given in table 4.3:

Table 4.3 – Reasons for changes in income of other sources (n=32)

Reasons	Frequency
Some of the respondents took an extra job to augment their income.	6%
Some of the partners of the respondents took a job to augment the income.	6%
NTFPs are now only gathered for alimentation, not for commercial purposes.	3%
Forest fruits are available to a lesser extent, so the income from these products went down.	3%
Agricultural harvest failed.	3%

Result 2: Changes in sources of alimentation until now

The alimentation use of the two target groups changed. The reasons for this and the expressed severity of the changes are explained in this paragraph.

Muratu

One of the families (11%) stopped using hunting as a source of alimentation in May 2014, because they lack the time to hunt. The rest of the families still make use of the five sources of alimentation. However, not necessarily in the same amounts as before the construction started.

The families in Muratu have different sources of alimentation. All of the interviewed families have at least four sources of alimentation. The used food sources in Muratu are the following:

- Fishing
- Agriculture
- Hunting
- NTFPs
- The city (shops)

Fishing for subsistence changed according to all the interviewees. The changes, which occurred until now in this resource, are presented in table 4.4.

Table 4.4 – Fishing changes Muratu (n=8, multi-response)

Changes	Frequency
Fishing is more difficult now; it takes longer to catch the same amount of fish.	75%
Some fish species are harder to find.	25%
There are more fishermen, who fish illegally in the waters of Muratu.	25%
More time is spent on solving problems and having meetings to arrange things. This makes that there is less time to fish.	12,5%

Agriculture did not yet undergo changes influenced by the dam. However, people state that hunting did change already; it is now more difficult to hunt the same amount of meat as before. There are different changes indicated, which explain why hunting is more difficult (table 4.5).

Table 4.5 – Hunting changes Muratu (n=8, multi-response)

Changes	Frequency
The animals are harder to find, and further from the village.	37,5%
There are other hunters in their area.	25%
Hunting is not possible anymore.	12,5%

Animals are harder to find because of the lights and the bombs used at the building site. The game flees from these disturbances. Due to the influx in hunters, there are now less animals in the TI.

Since for some families most time is spent on the community service jobs, there is no time to hunt.

On top of this, one hunting specialist of the village expressed that there are more snakes in the forest, because animals are displaced from the construction site into their territories.

A part of the community noted changes in the availability of some NTFPs too. All families use NTFPs to supplement their diet. The different noted changes are displayed in table 4.6.

Table 4.6 – NTFP changes in Muratu (n=8, multi-response)

Change	Frequency
There are less fruits available.	37,5%
There are no changes so far in this source of food (and income).	37,5%

The diminishing supply of NTFPs is an effect of the deforestation around the area of Paquiçamba. Mainly the birds, like the Green-winged Macaw (*Ara chloropterus*), flee from the building site into the area of TI Paquiçamba, and eat fruits of the Brazil nut (*Bertholletia excelsa*).

The families obtain a large part of their food from shops in Altamira. This food source changed for people in Muratu, because the city is harder to reach, due to the dam. Furthermore the prices in the city have augmented.

The costs of food

The families in Muratu used to spend around 260 R\$ per month (18% of the income on average) on food, before the building activities started. This increased to around 420 R\$ monthly (30% of the income on average) in May 2014. H_0 (two-tailed t-test): “*There is no significant difference between the share of income spent on food by the indigenous communities before the construction started, and the share of income spent on food in May 2014*” was rejected and H_1 was accepted ($p=0.04$). This is an increase of 160% over the last 4 years. The given causes for this are described in table 4.7.

Table 4.7 – Cost of food Muratu (n=8, multi-response)

Causes	Frequency
People have to buy more food, because the other sources are less available.	75%
The costs of food in Altamira increased.	50%

The increase of the price of food is explained by the population growth in Altamira, which is an effect of HBM.

Altamira

Until now, very few families changed the utilization levels of the food sources. One of the families stopped using agriculture as a food source already, because the yield failed, due to the changed water quality and quantity. Another family started using the city as a food source since the building activities started, because the other sources were not sufficient anymore. Figure 4.5 presents the used sources of alimentation by the fishermen in Altamira, before the construction started and in May 2014.

All families of the target group are currently dependent on the city (stores, street sellers etc.) as a food source. Before the building activities started, 97% of the families were (at least partly) dependent on this food source. No other changes have yet occurred in the exploitation of the various sources by this research group.

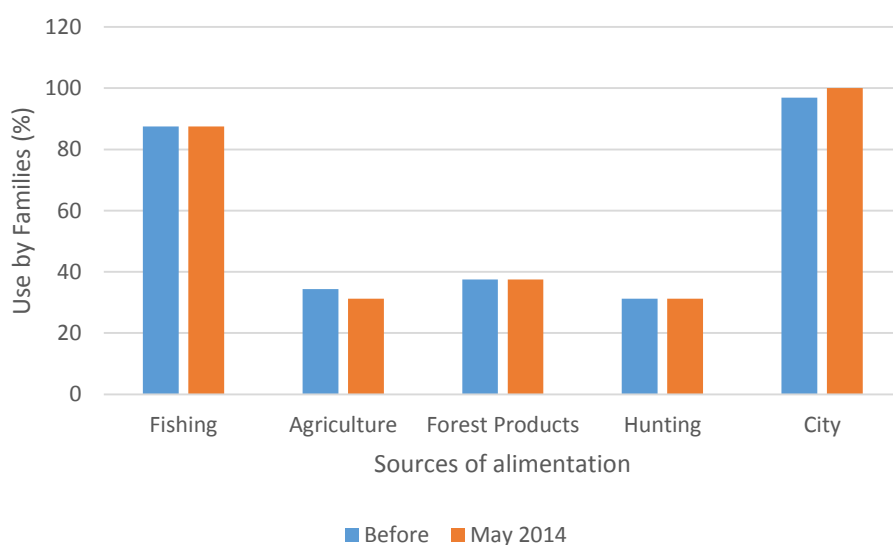


Figure 4.5 – Sources of Alimentation Altamira (n=32)

The costs of food

The cost of food for the fishermen of Altamira has increased from 33% before the construction started, to 51% in May 2014 of the income on average. H_0 (two-tailed t-test): “*There is no significant difference between the share of income spent on food by the fishermen of the Middle Xingu region before the construction started, and the share of income spent on food in May 2014*” was rejected and H_1 was accepted ($p=0.01$).

The main reason given for this is that the population of Altamira increased, from around a 100.000 to 150.000, which caused the prices to increase a lot. Furthermore, the income of the fishermen families decreased, which causes the share of income spent on food to increase.

Result 3: The alternative sources of income and alimentation

Muratu

All the families in Muratu state that they expect that fishing will hardly be possible after a few years after the dam is finished. The general plan is that they will extract their income from agriculture and community jobs.

The families of Muratu all have a plan for gathering income and alimentation after the dam has been finished. Some of the families adjust the intensity of the utilization of some of the sources of income (table 4.8) and alimentation (table 4.9).

Table 4.8 – Future income source utilization Muratu (n=9)

Source of income	New source (%)	Stop dependency (%)	Increase dependency (%)	No change (%)	Never depended (%)
Fishing	0,0	77,8	0,0	0,0	22,2
Job in the city	0,0	0,0	0,0	0,0	100,0
Job in the village	0,0	0,0	0,0	77,8	22,2
Agriculture	66,7	0,0	11,1	0,0	22,2
Hunting	0,0	11,1	0,0	0,0	88,9
NTFP gathering	11,1	0,0	33,3	0,0	55,6
Artisanal products	0,0	11,1	0,0	33,3	55,6
Other	0,0	11,1	0,0	11,1	77,8

All families plan to stop using fishing (ornamental fish) as a source of income. The main given reason for this is that the ornamental fish are ill, and that the traders do not want to buy the fish anymore.

More than half of the families are going to use agriculture as a new source of income. There is a project, PBA¹¹ being implemented, which (among others) promotes agriculture, in order to compensate for the lack of income from fishing. Most families plan to triple their land size, from two linhas¹² to six linhas.

The family, who used hunting as a source of income, will stop with this in the future, because it is very difficult to sell with the currently strong regulations by IBAMA¹³.

The families who already use NTFP gathering as a source of income (one-third), will intensify this and one family will start selling NTFPs. The arguments are that Açaí (*Euterpe oleracea*) in specific is a good source of income, and they will invest in an Açaí-making machine. Furthermore, NTFPs in general are a viable source of income. One family (11%) stops creating Artisanal products, because of lack of time, due to a community service job.

¹¹ Plano Básico Ambiental is the plan for compensation by Norte Energia S.A. In this part of a project being implemented They would provide a plan for the production of crops, tools, and planting material. However, until now, nothing has happened.

¹² One linha is 50m x 50m, meaning 0.25ha.

¹³ IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) is the Brazilian institute responsible for the implementation of the national environmental policy. It carries out various activities for the preservation and conservation of natural heritage, and exercises control and supervision over the utilization of natural resources. (IBAMA, 2014)

The families will depend less on fishing for their alimentation. They will compensate for this by practicing more agriculture, hunting more, and buying more in the city.

Table 4.9 – Future alimentation source utilization Muratu (n=9)

Source of alimentation	Stop dependency (%)	Increase dependency (%)	Decrease dependency (%)	No change (%)	Never depended (%)
Fishing	22,2	0,0	66,7	0,0	11,1
Agriculture	0,0	77,8	0,0	11,1	11,1
Hunting	0,0	44,4	11,1	33,3	11,1
NTFP gathering	11,1	22,2	0,0	55,6	11,1
City	0,0	77,8	11,1	11,1	0,0

Around one fifth of the families state that they will not use fishing as a source of alimentation anymore once the dam is finished. Moreover, a little more than half of the families state that they will decrease the dependency on this resource for alimentation. The reason given for this is that they expect that there will be (almost) no fish available in the river, and that they will have to depend on other resources. Around three-fourth express that they will increase the utilization of agriculture as a source of alimentation. They think this is a good option in order to compensate for the lack of alimentation from fishing. Almost half of the families will compensate for the decreased dependency on fishing, by hunting for alimentation more. Furthermore, they will hunt further from the village, in order to find animals. One family (11%) expressed that they will decrease the hunting pressure, because they do not need to hunt in order to have enough alimentation, and it is easier and better to keep animals near the house. Furthermore, they expressed that it is better to preserve the forest animals, when it is possible to keep them. Three-fourth will depend more on the city as a food source, because the other sources will be insufficient.

Altamira

Most people (59%, n=32) did not have an idea of how to earn an income or obtain alimentation in the future. They expressed that fishing will not be possible in the future. Most people do not have the reasons why fishing will not be possible, but most of them also say that fishing is impossible for the next five years. Some (6%, n=32) say that the water will be dirty, and that fruits (alimentation for aquatic fauna) are lacking.

Most people (in interview 2, n=15) wish to continue fishing, if it were possible. However, many express that this is not possible, and that they will have to change their occupation in order to have an income.

None of the respondents thinks it is a possibility to continue fishing in the same way that they do now. The alternative options named by the target group and the interviewer are presented in figure 5.6. This figure shows what share of the respondents consider each of the options the best option for earning an income or gathering alimentation. The questions were asked multi-response, and two of the respondents expressed that two options were equally good.

Changing fishing practice

Roughly 27% of the people consider to change the fishing practice in order earn money and have alimentation. They say it is possible to learn a new practice, and continue fishing in the area that will become a lake. One of the interviewees (7%) explained that they would need to buy new materials, such as a bigger boat and other nets. Furthermore, they need money in order to bridge the time that their practice is not optimal, and they do not yet make enough money to survive. The fish, which will stay in the lake, are, possibly amongst others: Pirarara (*Phractocephalus hemiliopterus*), Pescada (*Plagioscion* sp.), Surubim (*Pseudoplatystoma* sp.) and Fidagu (Scientific name unknown). The interviewees who consider this the best option think that it is fair to ask for compensation in order to buy this equipment from Norte Energia S.A., since the dam causes the changes. Figure 4.6 presents the preferred options of the fishermen in Altamira.

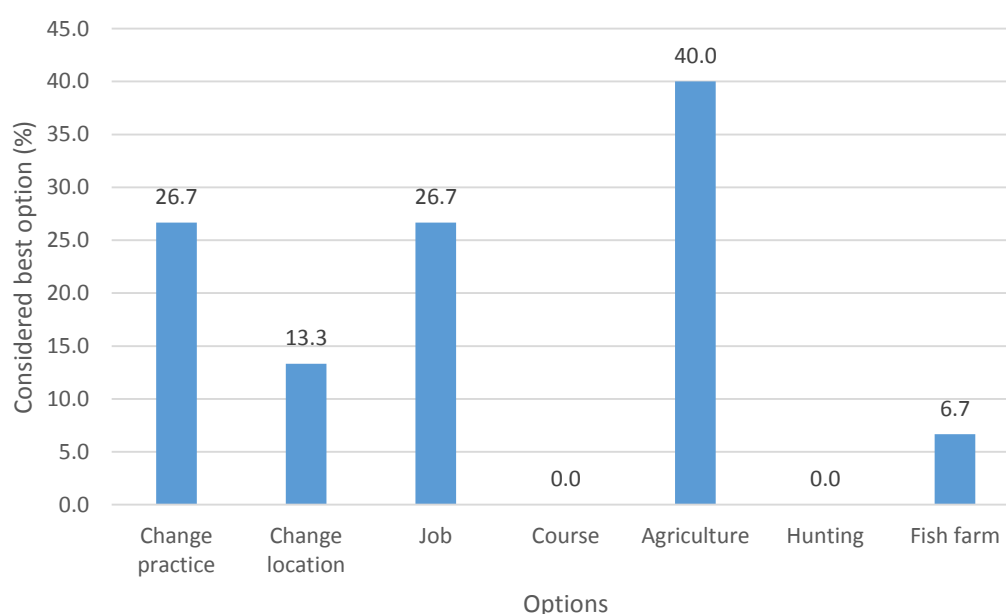


Figure 4.6 – Preferred options in Altamira (n=15)

The main argument given why fishing with other practices is not possible in the future is that the fishing equipment is too expensive, and that there are no fish in the lake in any case. Table 4.10 presents the reasons given discarding this option.

Table 4.10 – Reasons for discarding changing fishing practice (n=15, multi-response)

Reason	Frequency
The required new fishing equipment required is too expensive.	13%
The lake is too deep.	13%
Others expressed that there will be no fish in the lake.	13%
It is illegal to fish in this region.	7%
It would take too long to learn.	7%

The investment is too high, so even if there are fish, it is not possible to start. Some state that the lake is too deep, which means that the fish are out of reach. Others state that, for the next five to ten years, it will be impossible to fish. It would take too long to learn the new practice, which makes it impossible, because money is required to bridge the time where no income is earned.

Change fishing location

Some people (20%) express that this that they think fishing in another location is a good option; the rest thinks it is not. Around 13% of the respondents consider this option the best of the given options. Some plan to move to the Amazon River region, to fish there. It is stated that it is necessary to make an investment in new equipment (boat, nets), and that compensation is required in order to do this. Some said that if necessary, they would move to other areas. One of these fishermen fishes in the Volta Grande currently, and says it is not possible to continue fishing in this location once the dam is finished. For this reason, he will try to fish upstream, in the lake, with other methods. The arguments opposing this option are the following presented in table 4.11:

Table 4.11 – Reasons for discarding fishing in another location (n=15, multi-response)

Arguments	Frequency
In many areas, fishing is prohibited.	53%
The boats they currently use to fish are too small.	20%

In many areas outside the Middle Xingu region, fishing is prohibited; for example TIs and RESEXes¹⁴. Some people fish in these areas illegally, but many do not dare to do this. The small boats are too small to reach the areas where fishing will be possible in the future. They do not have money to buy a bigger/better boat to reach these areas.

A job in the city

A job in the city is considered a possibility by approximately 50% of the interviewees. Around 27% of the people express that this is their preferred choice in the future. The reason given for this option are that selling in the street is a very low demanding source of income, with low investment. Two of the interviewees are already employed, and will start living from this source of income. The given reasons opposing this option are given in table 4.12.

Table 4.12 – Reasons for discarding a job in the city (n=15, multi-response)

Reasons	Frequency
It is not possible, because they are not educated.	27%
Retirement will be lost.	13%
It is impossible because they are too old.	13%
Due to personal reasons, this is not possible.	7%

They are not educated to do anything other than fishing. They will not be hired. Some expressed that they applied for jobs, but they were not hired because of this. Another stated reason is that they will lose their retirement that they accumulated with fishing. They need to keep this profession in order to receive retirement money when the required age (65) is reached. The president of the association of fishermen confirmed this. Some of the respondents expressed that they are too old to take a job, and that they do not have a chance to be hired.

¹⁴ RESEX stands for 'Reserva Extrativista', or Extractive Reserve in English. These are areas, which are located throughout Brazil, where a set number of traditional inhabitants are allowed to explore the forest. The main objective is to preserve the culture and means of life, and to ensure the ecological sustainability. (IBAMA, 2014)

A course

One of the interviewees explained that there are free courses in the university for fishermen, which they can conduct to learn a new type of job, and get a new source of income. However, none of the respondents thinks this is the best option. The reasons given by the respondents against this option are displayed in table 4.13.

Table 4.13 – Reasons for discarding doing a course (n=15, multi-response)

Reasons	Frequency
A job in general is unwanted.	47%
A course is too expensive.	40%
Some fishermen cannot read.	27%

Some of the respondents do not want a job in general, so a course is not necessary. It is not a possibility to earn an income. Some express that they need money to do this, and they do not have enough money. Another argument given is illiteracy, which makes a course impossible.

Agriculture

Approximately 53% of the families consider this option possible, and 40% thinks that it is the best option. One of the main given constraints by the families that consider it is that they need money to invest for this option. They think that Norte Energia S.A. is responsible for the compensation, and should provide money for buying land. One of the interviewees stated that it is said that this is not an option for everyone. Only people who already have experience with agriculture will be able to live of agriculture. Arguments given opposing this option are given in table 4.14.

Table 4.14 – Reasons for discarding agriculture (n=15, multi-response)

Reasons	Frequency
There is no arable land left to buy.	13%
Some respondents are too old to start with agriculture.	7%

Hunting

None of the respondents considers hunting an option for income. One person (7%) says that, in case there are still animals, he considers hunting, in order to supplement his diet. The reasons given against this possibility are expressed in table 4.15:

Table 4.15 – Reasons for discarding hunting (n=15, multi-response)

Reasons	Frequency
Hunting is not allowed by IBAMA.	47%
Many fishermen never hunted, and it is not common to hunt.	27%
All the animals will be removed	13%

They express that they cannot start hunting now, because they do not have experience in this. The island will be flooded in the main reservoir, and animals will be removed. This means that there will be no animals to hunt.

Other suggested options

It was suggested by some respondents (13%) that a fish farm (aquaculture) could be a solution for the lack of income. They stated that there are projects, which are developing the fish tanks (aquaculture) in the Xingu River, where some local species could be grown. One person (7%) does not agree with this, because it would cost too much money to start this. The rest of the respondents did not consider it.

One of the interviewees, who is conducting a research in order to set up a fish farm, expressed that the investment is 50.000 R\$. He plans to get credit in order to invest. Some of the local fish species are suitable for aquaculture.

Result 4. The implications for the income

The income will change in the future for both target groups. Both the composition and the income value will change for Muratu. For the fishermen of Altamira, the future income is unknown.

Muratu

The interviewees who are able to make a prediction of their income (66%) expect that their income in both summer and winter in the future will be higher than it is in May 2014. Figure 4.7 presents the average income in Muratu in May 2014, compared to the income when the dam is finished.

The families of Muratu mostly have a clear idea of their future possibilities, and have plans for the use of their future sources of income. The number of sources of income in Muratu will not change. Both in May 2014 and in the future they exploit on average 2.4 sources per family.

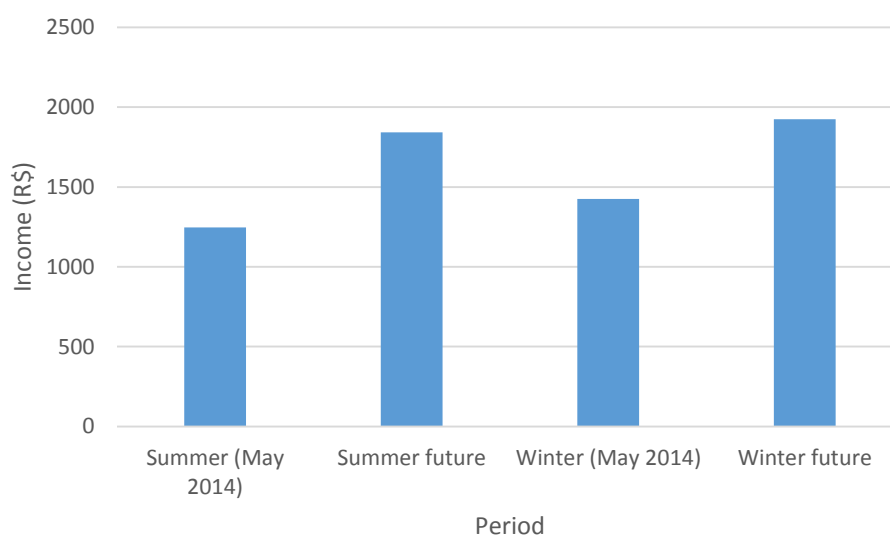


Figure 4.7 – Income comparison future Muratu (n=9)

More than 20% of the interviewees expect that their income will rise. Around 10% expects that their income will not change at all, and 33% expects their income to decrease.

Around 20% of the interviewees expect that their income in the next three to five years, after the dam has been finished, will be higher. The reason they give for this is that the (ornamental) fish will be more concentrated in the river, due to the lower water table. This will make it very easy to catch these fish, and will cause a higher income. They expect that after this period, their income will decrease again, because the before named advantage will be gone. The changes in income are caused by the changes in the sources of income (table 4.16).

Table 4.16 – Reasons for expected income change (n=9, multi-response)

Causes for changes in income	Frequency
Expected income from agriculture.	66%
Fishing will not be a source of income anymore.	55%
Income from other sources of income (such as village shop, rental of boat) change.	22%

Altamira

Most people who took part in the first interview do not know what to do in order to have income or alimentation. Some of the people (19%) do have a plan, and they have an idea about their future income (table 4.17).

Table 4.17 – Expected income Altamira

Respondent ID	Future source of income	Income (R\$)
7	Respondent and partner are both employed.	4800
12	He will sell fish, and the respondents partner has a job.	2500
14	He will practice agriculture, and make fishing nets.	5000
19	He plans to have a job in the city.	700
29	He is a boat-driver and will do this full time when the dam is finished.	1800
30	He will start a job in the mines, after finishing a course, and his partner has a job.	1250

The interviewee planning to practice aquaculture (interview two) in the future expects his income to be around 5000 R\$.

The expressed minimum income that is required is on average 1355 \$ per month. The interviewees state that they need this money, in order to buy food, clothes, medicine, and pay the rent and the school fees.

Result 5: The implications for the alimentation

Muratu

In Muratu, one of the families state that they will stop using fishing as a source of alimentation in the future. They will eat more fruits. They express that fish will disappear from the Volta Grande, and fishing will not be possible at all. For this reason, fishing will not be a source of alimentation anymore; the fish that they eat, they will have to buy. The same number of families as in May 2014 will use the other sources.

The families are already planting fruit trees in the village, which do not yet supply fruits. Furthermore, they plan to keep more chickens, pigs and other animals as a food source in the village.

The interviewees of interview two gave an indication of the expectations about their future alimentation, and about the quantities and qualities of the various facets thereof (table 4.18).

Table 4.18 – Expected alimentation changes in Muratu (n=7, multi-response).

Changes	Frequency
The family will eat more fruits.	100%
The family will eat less fish.	86%
The family will eat more meat.	71%
The family will eat more vegetables.	57%
The family will eat more fish.	14%
The family will eat less meat.	14%

All families state that they will eat more fruits in the future. The main given reason for this is that they recently planted fruit trees, which will carry fruits only after a few years. Almost 90% of the families expect to eat less fish in the future. This is because fishing will hardly be possible, which means they will have to buy the fish that they want to eat. Since they have to buy it in the city, which is several hours away from the TIs, they will not eat a lot of fish. All families stating this, express that this means their diet will be less healthy than it is in May 2014. The second reason is not related to the dam, and was expressed by 14% of the families. They state that their children are growing up, which means they need more food, and they can buy less of the more expensive foods, like fish.

Around one-third of the families will eat more meat in the future, for multiple reasons. Some express that they will hunt more, because they can fish less. This means that more meat will be available in the village. Other say that they will keep animals near the house, in order to be able to eat more meat.

More than half of the families are going to eat more vegetables. The stated reasons are that they will plant more vegetables (in home gardens and on agricultural fields). Furthermore, 14% say that they can afford more, due to higher income, which means that they will eat more of everything.

Very few people state that they will eat more fish. They say this, because they will have a high income, and they can afford to eat more of everything, including fish.

Some state they will eat less meat. This is because their children are growing up, which means they cannot afford the same amount of meat per person as they do in May 2014.

Altamira

The share of interviews expecting to be using fishing, agriculture, forest products and hunting as a source of alimentation decreased. The interviewees in interview one (n=32) indicated which sources of income they expect to use in the future, in comparison the sources of alimentation used in May 2014 (figure 4.8).

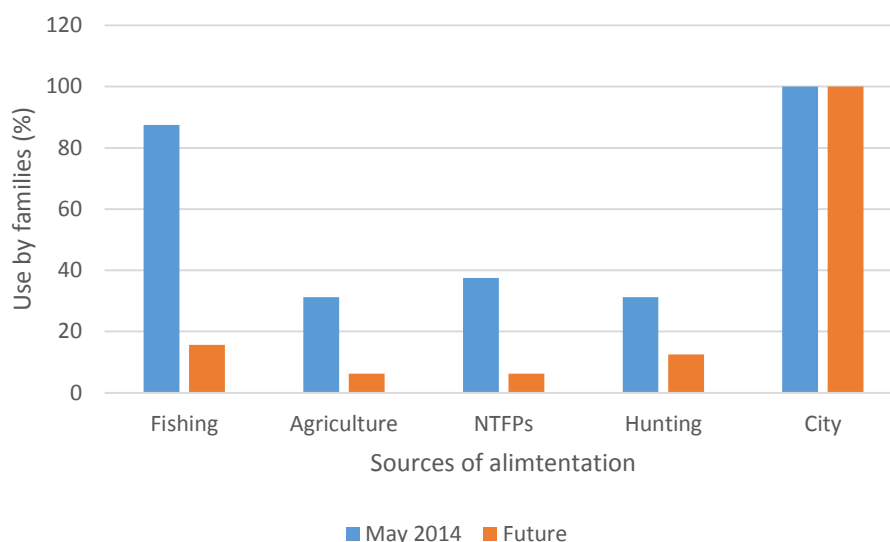


Figure 4.8 – Future use of sources of alimentation in Altamira (n=32)

Most of the families, who use agriculture, hunting, and NTFPs as a source of alimentation, are rural fishermen, riverbank dwellers. All the interviewees express that they are already dependent on the city for their alimentation, and they think that this dependency will stay.

The interviewees of interview two do not know precisely what their sources of either income or alimentation will be, but they gave an indication of the expected quantity and quality of their alimentation (table 4.19).

Table 4.19 – Expected alimentation changes in Altamira (n=15, multi-response)

Alimentation change	Frequency
The family will eat less fish, which makes the diet less healthy.	33%
The family will eat less, and less healthy.	33%
The alimentation will be of higher quality, if it is possible to use the expected future source of income.	20%
The family will eat less products from their agricultural plot.	20%
The family will eat less NTFPs.	20%
The family will eat less hunted meat.	13%
The family will not notice any changes in their alimentation	13%
The family will have more and healthier food available, because their future source of income is better.	13%

The families, who express that they will eat less fish, gave various reasons. They expect that fishing will not be possible in the future, so they have to buy all the fish that they want to eat.

Currently, they sell the majority of the caught fish, and eat the rest themselves. Moreover, they expressed that, in the unlikely case that fishing is still possible, they would have to sell a bigger share of the catch in order to have sufficient income, causing them to eat less fish. To compensate for the lack of fish, more other products would be bought from the city, which is considered less healthy.

Some have an idea of what they want to do. For example, one family plans to have an agricultural plot outside the city. The interviewee expressed that if they obtain this (if, and when they get compensation), they will have a more healthy diet, than they currently have.

Some families expressed that they will eat less or no food from their agricultural plot. In some cases, this is because the islands of some interviewees will be flooded. In other cases, it is caused by the fact that the islands are located in the Volta Grande, which will receive 80% less water. They already notice a difference in production, and expect that they will barely be able to produce anything when the dam is finished.

The same counts for NTFPs. All the trees will be removed from the island in the area where the lake will be formed, which means that many NTFP producing species like Brazil nut (*Bertholletia excelsa*), Açaí (*Euterpe oleracea*), and Cupuaçu (*Theobroma grandiflorum*) will be removed. In the Volta Grande, it is expected that mainly the Açaí palms will suffer, because they require a very high water table, and are often partly submerged.

Many animals will be removed from the islands, and the mainland that will be submerged. Some families stated that they will eat less meat, because it will be difficult to encounter animals to hunt. Around 15% of the families think that they will have a better alimentation, because they are certain of their future source of income and alimentation, and know that their alimentation will be better in quantity and quality.

Result 6: The implications for the environment

The families of Muratu stated that they would increase the use of some resources to compensate for the diminishing supply of other resources. They will increase the size of their agricultural plot, increase hunting pressure, and collect more NTFPs. None of the respondents expects that NTFP gathering will influence the environment.

People will depend more on agriculture, and will triple the size of their agricultural fields (result three). On average, this means that the size of the agricultural plots will triple from half a hectare, to one and a half hectare per family. The agricultural expert from the village confirmed that this is the minimum size required for income from agricultural production.

Hunting pressure in Muratu will increase (result three). Both hunting specialists expect that all the families will hunt in the future. Moreover, they expect that all hunting families will hunt more frequently in the future, to compensate for the loss of other alimentation sources.

28% of the families expect that this increased hunting pressure will cause Caititu (*Pecari tajacu*) to go extinct in the TI, because it is the most hunted species. The experts confirm that it is possible that some animals go extinct. Furthermore, they state that many hunted species will suffer from the increased hunting pressure, and the abundance will decrease. Some people express that it is necessary to hunt further from the village than before. One expert states that they have to hunt relatively far from the village already, because there are no animals close to the village. Currently, the families hunt until 8km from Muratu. The maximum distance to hunt is around 15km.

5. DISCUSSION AND CONCLUSION

1: Changes in income

Indigenous communities

The dam affects the various sources of income, fishing, NTFP gathering, and hunting directly. The average number of sources of income among the indigenous communities of the Volta Grande did not change; however, the former sources of income are replaced by others. Most people have stopped collecting ornamental (commercial) fish, and have started working in a community service job. People are now more dependent on outside sources of income, rather than on the natural resources of the TIs. The income of the indigenous communities did not change significantly. The main reason for this is that before, their income was derived from the commercialization of ornamental fish “Acaris”, with which the families have problems now, due to the decreasing quality and quantity of the fish. This is a direct impact of the dam.

Altamira

The families of Altamira still depend on various sources of income. The number of sources did not change. All of them still depend on fishing as a source of income; however, some have additional sources of income, and some have lost sources of income, which means the composition of sources changed slightly.

The income in the winter, before the construction started was the same as the income in May 2014. However, the average income is significantly 27% lower in May 2014 than before the construction started. These changes in income were, directly or indirectly, caused by the construction of HBM. The dam its effects on the fish population, the local economy, and the population of Altamira causes the income of fishermen families to be lower.

Used methods

It was not possible to define the share of the various sources of income in the total income of the interviewees, because pebble distribution method did not work; there were miscommunications about the goal of the questions. However, by far the most important source of income for all fishermen families in Altamira is fishing, in May 2014.

During the interviews, the respondents were asked to compare their current income to their income from four years ago. This can often cause a bias, because respondents tend to be overly negative about developments. (Baarda, 2009) In this case, it is likely that the income change is not as severe as portrayed by the interviewees. In addition, they were asked about a detail in their past; their income. It was sometimes difficult for the respondents to remember what their income was. This may have caused some inaccuracies regarding the comparison between the income before the construction activities, and in May 2014.

Conclusion

The indigenous communities along the Volta Grande depend on different sources of income than before, in May 2014, while the fishermen families of Altamira depend on the same sources. The income decreased for the fishermen of the Middle Xingu, but not for the indigenous communities of the Volta Grande. HBM caused these changes in income, both directly and indirectly.

2. Changes in alimentation

Indigenous communities

Fishing, hunting and NTFP gathering are more difficult now, due to changes caused by the dam. They depend less on these sources for their alimentation. This causes the indigenous communities to be more dependent on the city; in May 2014, they spent significantly 160% more of what they used to spend before the construction activities started. This is partly because of the fact that they buy more (as they are less self-sustaining than before and family size increased over time), and partly because of the demographic and local-economic changes in Altamira, which has driven up the cost of living. This too, is an impact of HBM.

Altamira

The source of alimentation of the fishermen families of Altamira is mainly based on the city. Some of them have other sources of alimentation, but everyone is at least partly dependent on the city. The number of families using the various sources did not change until now, however, the dependency on the city did. The families now spent a significantly larger part (130%) of their income on food; due to the construction of the dam, the income of fishermen is much lower, which causes that they have to spend a larger share of their income on food.

Moreover, the other sources of alimentation, like agriculture and hunting, have suffered already from various impacts of the dam on water quality and quantity. These sources are mainly used by fishermen families living on the riverbanks of the Xingu River. These people used to depend less on the city for their alimentation than they do in May 2014.

Used Methods

It would have been interesting to quantify the usage of the various sources in the different periods. For example, what percentage of their diet is derived from fishing, and how was this before the construction started. In this way, a more detailed description could have been given about the influences of the dam. However, this was not possible, with the communication problems caused by the cultural difference between the interviewer and the interviewees.

However, the most important source of alimentation for indigenous families along the Volta Grande, and fishermen families of Altamira alike are fishing and the city, both before the construction of HBM and in May 2014.

Conclusion

Both indigenous communities along the Volta Grande and fishermen families in Altamira depend more on the city in May 2014 than they did before the construction started. This is caused by the decreasing supply of their traditional sources of alimentation, which are deteriorated by the construction of HBM. The intensity of usage of various sources has changed too for both groups.

3. Alternatives for the future

Indigenous communities

The indigenous families know what they want to do, and have a plan for obtaining their future income and alimentation. Where their lives are now mainly based on fishing of ornamental and

“Nós da Muratu não queremos esse negócio da lista de compra não, nós queremos viver independentes, do jeito que nós vivemos, não depender de ninguém. Aceitamos sim né, que eles nos deem alguma coisa, mais por enquanto, até nós ajeitarmos nossa roça, tiver tirando nosso sustento. Aí sim, nós vendemos os nossos legumes que nós produzimos, né, escoamos nossa produção e compramos o que nós quisermos, não ficamos dependendo da Norte Energia e nem da FUNAI dizer o que é bom para nós e o que não é. Nós é que sabemos o que é bom para nós ou não.” (Juruna, A Batalha de Belo Monte: Giliarde Juruna, 2013)

consumable fish, it will be based on agriculture and local jobs in the near future.

This statement, by the Cacique of Muratu, expresses that they accept help, but at the same time they want to be able to take their own decisions; they know what is good for them, and what is not. Others do not know this. They do not like that various institutions have an influence in their lifestyles; they want to be independent.

However, for these new sources, they are for a large part dependent on the Brazilian government; the state pays the income for the jobs and FUNAI (a government body) implements the agriculture promotion projects. This means that the new developments are unwanted to a certain extent, but the families do not have a choice. Their current source of income is taken away, through the construction of HBM.

The indigenous communities want to be mostly self-sustaining, and independent of external sources (Juruna, Informal conversation, 2014). Due to the new developments, it is going in another direction. Their lives will shift from a subsistence- farming and fishing based lifestyle, to a market economy, where they have to sell agricultural goods to buy their alimentation.

Nevertheless, they will also still depend on natural resources for the alimentation. They will collect more NTFPs than they do now, and hunt more. Moreover, they will depend on their agricultural production for alimentation.

Altamira

The communication from Norte Energia S.A towards the fishermen is bad; fishing is generally considered to be impossible when the dam is finished, but none of the respondents really knows why it is not possible. Some think it is not allowed to fish, others think it is not possible at all, and few think it could be possible using other methods.

However, fish will not disappear entirely. The composition will change; many species, mostly migratory, will disappear. Others, especially those adapted to lentic habitats will thrive in the

reservoirs. Among these are Tucunarés (*Chichla monoculus*), Oranas (*Hemiodopsis sp*), Pescadas (*Plagioscion sp*), Maparás (*Hypophtalmus sp*), and Piranhas (*Serrasalmus sp*). Apart from the Piranhas, these species are promising for mid- and large size markets. However, adaptations are required to the equipment and methods used. (Magalhães & Hernandez, 2009) These changes do not apply for the Volta Grande. The fishermen who fish here in May 2014, will most likely have to move their focus to the reservoir as well. The reservoir will be a very heavily used resource, once new techniques are being applied more widely.

Other alternatives are there as well; aquaculture is considered a viable alternative by the president of the association of fishermen, and there is at least one project being implemented (Lopes, 2014), but none of the respondents knew about this in May 2014.

The preferred alternative for most families is agriculture. However, many people will need either credit or compensation for this. Since one of the options for compensation is a piece of land, this would be ideal for most people. However, people are not aware that they have this option. Since most of them are illiterate and lack access to communication channels, they cannot verify what their options are. Norte Energia S.A. does not communicate this option to people when they present them the types of compensation, allegedly because it is the most expensive option for the company. (Silva, 2014)

Almost all arguments against the considered options were based on *lack of money* and *old age*. The families would need money to invest in agriculture, a shop, a new boat for a new fishing technique etcetera. They do not have this money, and are pessimistic towards the likelihood of compensation. The problem for the older fishermen (55+), is that they have less opportunities. They are mostly illiterate, and have never had a job before. It will be a very large change in their live if they have to do something else for an income than fishing.

Some arguments given for discarding the options are debatable. The fact that a fisherman is illiterate does not mean that courses are not possible; there are many jobs for which literacy is not required.

Conclusion

The situations of the two target groups are very different. Indigenous communities in the Volta Grande have more opportunities than the fishermen families in Altamira, and they have a plan. Due to the government support, they have more possibilities and less problems. However, they have a negative attitude about the future changes in their lifestyles.

The fishermen in Altamira have possibilities, but they are generally unknown. Moreover, for them it is ill defined what the possibilities are for fishing in the new situation, when the dam is finished. Many of the fishermen require money, in the form of compensation, to invest in a new source of income, such as agriculture. If there is no money available, their options will be very scarce. Next to this, the average age of fishermen in Altamira is higher than the average age of people living in Muratu, which makes the switch towards another job even harder.

4. Implications for the income

Indigenous communities

Not only did people of Muratu have an idea of their future sources of income, they could also make a prediction of their future income. The income of the indigenous communities will increase, due to several reasons. The main reason is that most families will derive part of their income from a community job. On top of this, they plan to increase agricultural production. Where they only produce enough for their subsistence now, they will produce more in the future, in order to sell their produce.

They will have an income, but it will be more based on outside support than it currently is, which is in essence unwanted by the community.

Altamira

Since the fishermen families of Altamira do not know what their source of income will be, it is impossible to predict how high it will be. There are a few possible explanations for their expressed uncertainty about their future income:

They were interviewed about their future, and their general view of their future is pessimistic. It is a possibility that they portray their future more negative than it actually is. This could have caused a bias. (Baarda, 2009)

Most fishermen in Altamira have been practicing fishing their whole lives, in many cases even multiple generations. They are not used to take decisions about their lives and lifestyles; it has always been the same. Now their situation changes drastically, and it is very difficult for them to adapt to these changes.

Conclusion

There is a very clear difference between the future income situation of the fishermen of Altamira and the indigenous communities of the Volta Grande. In the latter, they will have an income, which is higher than their current income. This is necessary, because their lifestyle is more market based. The fishermen families of Altamira, do not know what their source of income will be, and their future income is unpredictable.

5. Implications for the alimentation

Indigenous communities

The main change in the diet of the indigenous communities in the Volta Grande is that they will eat less fish. Furthermore, they will eat more meat, to compensate for the lower levels protein in their diet. In addition, fruits and vegetables will be more abundant in their alimentation. The reason for this is that they will hunt more, gather more NTFPs, and plant fruit trees and vegetables on their agricultural plots. Moreover, they planted fruit trees in the village, which are not yet mature, and they will keep animals near the houses.

A larger part of their alimentation will come from the city, and a greater part of their income will be used to buy alimentation.

A large share of the families expects that their alimentation will be less healthy than before, because fish is lacking. Fish is a healthy and important supplement to a diet, providing a wide variety of vitamins, minerals and high quality proteins (Food and Agriculture Organization of the United Nations, 2014). However, they do replace the reduction by eating more fruits and vegetables, and still receive ample animal protein.

Altamira

Fishermen families in Altamira will eat less fish. This is because in May 2014, they save a part of their catch, for their own alimentation. When fishing is not possible anymore, which the majority expects, they will not eat their own caught fish. The families will have to buy fish if they want to eat it, but since close to none of them knows what they will do, it is unknown if they will be able to buy fish.

The expectancy is that their diet will be less healthy when the construction is finished. Since the families do not have a new source of animal protein that they will broach, this is most likely true.

The alimentation of fishermen families living outside the city, along the Xingu River (and especially in the Volta Grande) will change drastically, because most of them cannot grow fruits and vegetables anymore. Furthermore, they cannot hunt, or gather forest products. This in combination with the fact that fishing will hardly be possible makes it almost impossible to live off the land. They will start depending more on the city for their alimentation, since they lose almost all their sources of alimentation

Conclusion

The alimentation of the indigenous communities of the Volta Grande will be different, but healthy. In essence, fish will be replaced by meat, and supplemented with fruits and vegetables. However, traditionally a large part of their alimentation consists of fish, and there are many aspects of their culture based on fishing. Their culture and traditions may suffer from this change in lifestyle, caused by the changed environment.

The health value of the diet of fishermen families of Altamira will suffer; they will eat less fish, and do not have the means to compensate for this. In addition, families living outside the city will depend much more on the city, because all their sources of alimentation will suffer greatly from the changes caused by HBM.

6. Implications for the environment

Indigenous families will practice more agriculture, increase hunting pressure, and gather more NTFPs. Hunting and agricultural will have a negative impact on the environment of the TIs.

Hunting will cause the number of individuals to decrease among all hunted species in the forest. Moreover, the hunting specialist in Muratu states that the Caititu (*Pecari tajacu*) will go extinct locally. Since this is the preferred species by most families in the TIs along the Volta Grande, it is possible that this happens. Local extinctions mainly happen in forest fractions (Rainforest Conservation Fund, 2014), like the TIs along the Volta Grande.

Even though the Jaguar (*Panthera onca*) and other large predator species are not hunted (only killed when encountered, out of self-defence), it might suffer from the increased hunting pressure; their prey is killed by the inhabitants of the TIs.

Other animal and plant species in the forest of the TIs might suffer from increased hunting pressure; in areas where the *Pecari tajacu* went locally extinct, certain frog species suffered, because they require pools made by these animals (Rainforest Conservation Fund, 2014). There may be many other influences, caused by the increased hunting pressure.

The area used for agriculture will increase. However, the influence is debatable. The total occupied area for agriculture in Paquiçamba is currently around 10 hectares, and will be around 30 hectares when all families start the agricultural production for commercial purposes. The whole area of Paquiçamba will be around 15 thousand ha after amplification, which means that the agriculture fields will only occupy around 0.2% of the total area, in relation to 0.07% in May 2014. Moreover the area of the TI of the Arara is much larger (Fundação Nacional do Índio, 2014), and there are almost as many people (111) (Instituto Socioambiental, 2014), meaning that the relative influence of increase in agricultural production is even lower.

Conclusion

The main environmental impact caused by the new activities of the indigenous communities along the Volta Grande of the Xingu River is the increased hunting pressure. This can cause the local extinction of some species, and will cause an overall decline in biodiversity in the TIs. The impact of the increased agricultural pressure is negligible, because it covers a very small area of the TIs in the Volta Grande.

General discussion methodology

When more interviews could have been conducted, a more significant share of the population could have been interviewed. The current share of respondents is not large enough to be representative. This applies for both groups.

In order to get a representative sample (confidence interval: 95%, and confidence level 10) of the indigenous communities, at least 28 of the estimated 40 families should have been interviewed.

For a representative sample (confidence interval: 95%, and confidence level 10) of the fishermen families of the Middle Xingu region, at least 88 of the 1000 fishermen families should have been consulted. This applies mainly for the results about income. The reasons about the changes in income are most likely very similar for both populations, because the groups are homogeneous.

Final conclusion

The income of the indigenous families, as well as the income of the fishermen families of Altamira has changed negatively until May 2014. The sources of alimentation that they use changed as well. Fishing, hunting, NTFP gathering have become more difficult, and provides lower yields than before the construction started. HBM and the construction thereof directly and indirectly causes this.

Indigenous families along the Volta Grande have a clear idea of what to do, and know what their income and alimentation sources will be, in contrast to the fishermen families of Altamira. These people have no idea about their future sources of income, and do not know what they will do or what their income will be. The income of the indigenous families will be based on jobs and agricultural production, and will be higher than it is in May 2014. The occurring changes make them more dependent on outside support.

The alimentation of the indigenous families will not decrease in quality, but in composition. Their traditional diet will change to a more market based diet. The diet of the fishermen of Altamira will decrease in health value.

The environment of the TIs in the Volta Grande will suffer directly and indirectly from the increased hunting pressure, which is a result of the diminishing fish supply. Even local extinction of some animal species is likely.

6. RECOMMENDATIONS

The indigenous communities of the Volta Grande

It is recommended to keep a sufficient number of farm animals in the village, to diminish the hunting pressure. It is better to preserve the animals in the forest, as a backup source of alimentation, to preserve the traditional way of life, and for biodiversity conservation purposes.

The fishermen families of Altamira

My recommendation for the fishermen families is that they make sure they know what the exact influence of the dam is on fishing, and the other sources of income and alimentation. They should focus on the possibilities of fishing in the main basin of the dam.

The Colônia das Pescadores

It is recommended to the association of fishermen that they create awareness with the fishermen of the middle Xingu. They should investigate the options for fishing in the future, and other options, and communicate clearly to all fishermen families what their options are. Communicate about the options of aquaculture in the region.

Courses should be designed, based on experience in other situations (Tucuruí), for adapting the fishing methods to the new situation. Fishing will be possible, but with new techniques.

Contacts should be made between the fishermen and medium to large scale fish traders. New markets should be tapped, because of the change in fish composition.

Norte Energia S.A.

The fishermen of Altamira should be compensated for their diminishing income, which is already occurring. They suffer of the changes in the environment, caused by the construction of HBM. Their income is lower than it was before the construction started, and they are more dependent on the city for their alimentation.

Compensation could also be, at least partly, in the form of education, to increase the chances of fishermen for getting a job. In addition, courses could be organized about new fishing techniques, which should be accessible by all fishermen.

It is important to communicate clearly about the expected influences of HBM on the natural resources in the region. Fishermen do not know what will happen to their source of income, and do not know how they will earn their living when the dam is finished.

FUNAI

The indigenous territories should be better protected. It is important that these forest fragments remain. Illegal hunting, fishing and NTFP gathering cause the sources to deplete, and have a serious negative effect on the indigenous communities living there.

Further research

Research should be conducted to the sustainable hunting levels in Muratu, and a hunting management plan should be created. This is important for the local biodiversity of TIs, and for the communities living in them.

Secondly, research can be conducted to ways of commercializing NTFPs for the indigenous people. The wish is there, to commercialize Brazil nut (*Bertholletia excelsa*) and Açaí (*Euterpe oleracea*). This would be a good opportunity for them to be less dependent on outside sources, such as government-paid jobs.

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APPENDICES

I Interview one

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
 - Age:
 - Gender:
 - Date of the interview:
 - Location interview:
-
1. Are you influenced by the dam, or will you be influenced by the dam, in any way?
 2. What activities are a source of alimentation for your family?
 3. What is the monthly income of your family?
 4. What are the sources of income of your family?
 5. What was the income of your family before the construction of HBM started?
 6. What do you think the income of your family will be when HBM is finished?
 7. How much of the income of your family was spent on alimentation, before the construction of HBM started?
 8. How much of the income of your family is currently spent on the alimentation?
 9. How much of the income of your family will be spent on alimentation once HBM is finished?
 10. What is your plan for the future? What do you think your sources of alimentation and income will be?

II Pebble distribution method card

One example of the pebble distribution method cards, applied for more clarity for both the interviewer and interviewee. In total eight cards were used (Cards designed by R. Diemont, 2014).



III Interview two - Muratu

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
 - Age:
 - Gender:
 - Date of the interview:
 - Location interview:
-
1. Are there sources of income and alimentation in the village, which are unused until now?
 2. What are the options of your family, for obtaining income and alimentation, once your current sources are not sufficient anymore?
 3. Rate the following options from (1) impossible to (5) preferred to use as a source of income or alimentation: - changing your fishing practice, -changing your fishing location, - a job in the city, -a course in the city, -practice more agriculture, -hunt more, -a job in the village, -collect more NTFPs, -create more artisanal products. Why did you make these choices?
 4. What do you think most people of the village will do, in order to obtain an income and alimentation?
 5. What do you think will be the influence of your new actions, on the forests in the TI?
 6. What do you think will happen to the animals living in the forest of the TI, once you are going to practice your new actions?
 7. Do you think your new actions will affect the river in any way?
 8. Do you expect that your new actions will influence the aquatic fauna in any way?
 9. What is the minimum income that you need to sustain your family?
 10. What do you think will be the influence of your new actions on your alimentation? Will this be positive or negative?
 11. Are you, your family, or the village being compensated in any way?
 12. Do you think you, your family, or the village have the right on compensation?
 13. Do you, your family, or the village need compensation?

IV Interview two – Altamira

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
 - Age:
 - Gender:
 - Date of the interview:
 - Location interview:
-
1. Can you continue fishing the way you do now, or are there changes occurring in your sources of income and alimentation?
 2. What are the options of your family, for obtaining income and alimentation, once your current sources are not sufficient anymore?
 3. Rate the following options from (1) impossible to (5) preferred to use as a source of income or alimentation: - changing your fishing practice, -changing your fishing location, - a job in the city, -a course in the city, -practice more agriculture, -hunt more. Why did you make these choices?
 4. What is the minimum income that you need to sustain your family?
 5. What do you think will be the influence of your new actions on your alimentation? Will this be positive or negative?
 6. Are you and your family being compensated in any way?
 7. Do you think you and your family have the right on compensation?
 8. Do you and your family need compensation?

V Specialist interview: Agriculture

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
- Age:
- Gender:
- Date of the interview:
- Location interview:

1. How does the agricultural system in Muratu work?
2. What types of crops are planted?
3. How many times per month do you work on your 'Roça'?
4. With how many people do you work on your Roça?
5. Does everybody in the village own a Roça?
6. Until what distance from the village are the roças located?
7. Do you think that this source of income will be affected in the future?
8. Do you think you will work more on the roças?
9. What size does the Roça need to be in order to get alimentation and income?
10. Do you think that all the families in the village will have more and/or bigger roças?
11. Do you think that the forests will suffer from this?
12. How long is the rotation?

VI Specialist interview: Hunting

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
- Age:
- Gender:
- Date of the interview:
- Location interview:

1. Is everybody in the village allowed to hunt?
2. What type of animals do you hunt?
3. How many animals are hunted by the village per month?
4. What type of animal do you kill the most?
5. How many times per month do you hunt?
6. How far into the bush do you go to hunt?
7. Did you note differences until now in this source?
8. Will hunted be affected in the future?
9. Do you think that people from the village will hunt more?
10. Do you think more people from the village will hunt?
11. Do you think people will hunt further from the village?
12. Do you think the composition of animals will change in the future?
13. Do you think the number of animals will change in the future?

VII Specialist interview: NTFP gathering

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
- Age:
- Gender:
- Date of the interview:
- Location interview:

1. Can everyone collect forest products?
2. Who collects forest products?
3. What types of forest products are collected?
4. What forest product do you collect the most?
5. How often do you collect NTFPs?
6. Until what distance from the village do you collect NTFPs?
7. Do you notice differences until now in this source of income and alimentation?
8. Will this source be affected more in the future?
9. Do you think people from the village are going to collect more NTFPs?
10. Do you think more people are going to collect NTFPs?
11. Do you think that people are going to collect NTFPs further from the village in the future?
12. Do you think this will affect the forest?

VIII Specialist interview: Fishing (Association of fishermen)

Most questions were supplemented with a range of explaining questions, like: Why? How? How many? By whom?

- Name:
- Age:
- Gender:
- Date of the interview:
- Location interview:

1. What has changed until now for the fishermen?
2. Is this all caused by the dam?
3. How will the dam affect fishermen in the future?
4. Are there people who are affected in other ways?
5. What happened to the income of the target group?
6. What will happen to the income of the target group?
7. What can fishermen do to keep an income?
8. What do you think of my solutions?