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Public policy implementation and basic sanitation issues associated with hydroelectric projects in the Brazilian Amazon: Altamira and the Belo Monte dam

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ABSTRACT

Located in the State of Pará, along the Xingú River, the Belo Monte Hydroelectric Complex is the largest, most recent project in the Amazon region and third largest in the world. The city of Altamira, located 52 km upstream from the Belo Monte dam, served as the main stage for its construction. Using surveys and interviews performed in 2016 as social and quantifiable tools, we determine basic sanitation practices in Altamira after the construction of Belo Monte and reveal issues that can impact the environment and public health of the population. Through analysis of national policies and the use of publicly available information, we identify discrepancies between Altamira's current reality and Brazil's existing national public policies, mainly Brazil's Water Resources Policy and the Federal Sanitation Law. Similar basic sanitation provision and waste disposal practices along the region lead us to believe that, if not addressed, the implementation gaps observed in Altamira are likely to emerge in future hydroelectric development projects currently envisioned throughout the Amazon Basin. As more dams in the Amazonian region are planned, identifying public policy implementation gaps that affect basic sanitation and water resources creates opportunities to anticipate problems that could impinge on the public health needs of residents where such large infrastructure projects will be implemented.

1. Introduction

Energy independence and reduction of emissions are objectives often pursued by many nations. In the global south, hydropower development has been touted as a strategy promising to provide these goals. Although a growing number of countries are removing a large number of dams each year, hydropower still provides some level of energy to a total of 159 countries (International Energy Agency, 2016). In regions with lower levels of socio-economic development, hydropower capacity has been increasing rapidly in the past six decades (Chen et al., 2016). Proliferation of dams is evident in the Amazon, Congo, and Mekong Basins, where proposed projects continue to emerge in order to harvest countries' hydroelectric potentials (Winemiller et al., 2016). In the Brazilian Amazon, which holds 42.2 percent of Brazil's hydroelectric potential (Ministério de Minas e Energia, 2015), hydroelectric projects are not new. Located in the State of Pará, along the Xingú River, the Belo Monte Hydroelectric Complex is the largest, most recent project in the Amazon region and third largest in the world.

The city of Altamira, located 52 km upstream from the Belo Monte dam, served as the main location for construction staging efforts. The population increase brought forth by the construction of the dam stressed the city's basic sanitation services through greater water demand, wastewater disposal, and solid waste generation. Belo Monte's environmental licensing required that dam developers provide a significant improvement on such services in Altamira, in part to meet the demands of the growing population stemming from the construction of the dam. Lack of compliance with this requirement created a mounting sanitation crisis. In 2016, Brazil's Federal Public Ministry deemed Altamira's risk of a sanitary collapse a critical issue that had been unresolved in the five years encompassing the construction of the dam (Ministerio Publico Federal, 2016; Conselho da Justiça Federal, 2017) and that remained unresolved.

Altamira's current situation does not coincide with the requirements established by national policies, mainly Brazil's Water Resources Policy and the Federal Sanitation Law. These policies were created to guide

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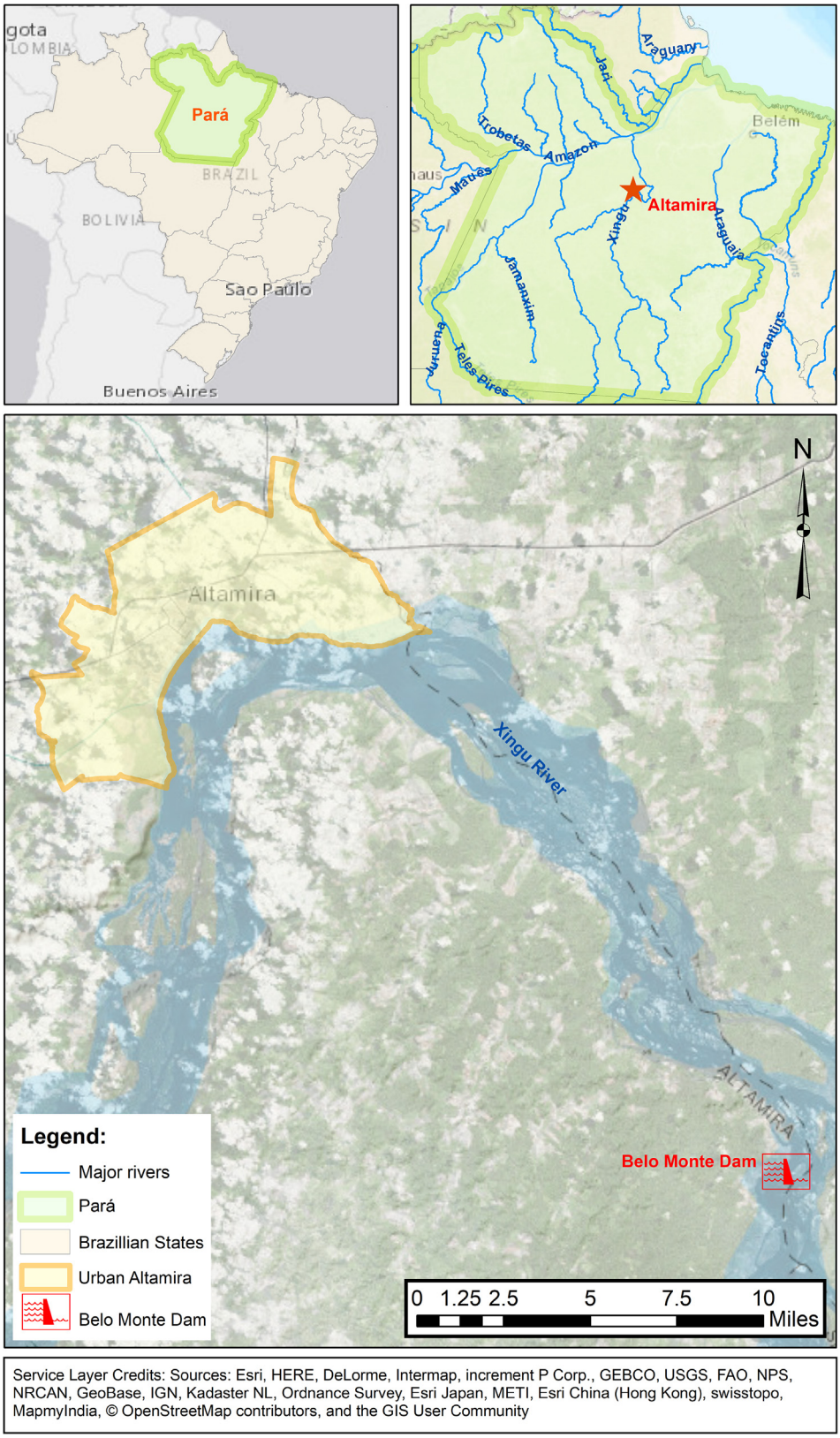

Fig. 1. Altamira and Belo Monte Study Region.

water management and basic sanitation in the country. They seek to ensure water quality, sustainable development, and social inclusion, while attempting to minimize environmental impacts related to the implementation and development of sanitation services. Using surveys and interviews performed in 2016 as social and quantifiable tools, we reveal sanitation practices in Altamira after the construction of Belo Monte. Through the use of publicly available information and analysis of Brazil's Water Resources Policy and the Federal Sanitation Law, we identify that Altamira's current practices do not comply with national public policies and we reveal issues that can impact the environment

and public health of the population.

The goal of this paper is to reflect on the reasons for the failure in compliance with water and sanitation requirements of the law, and to reveal implementation gaps that have occurred in Altamira and that can continue to emerge in future hydroelectric development projects envisioned throughout the Amazon Basin and the developing world. Looking at the intersection between social, political, and environmental elements, we identify factors that hinder the provision of better water and sanitation services. We hope to provide insights regarding the implications of policy non-compliance on the basic sanitation and quality of life of communities located upstream of large hydroelectric projects in order to ensure population health and protection of the environment.

1.1. Belo Monte

The Xingú River Basin is the second largest watershed located on the southern banks of the Amazon River, both in area and hydroelectric potential (Agência Nacional de Águas, 2013) making it a prime location for hydroelectric project development. In 1975, a Hydroelectric Inventory Study of the Xingú River revealed the region's energy generation potential and thus, plans for the Belo Monte Hydroelectric Complex were first envisioned. The stated goals of the Belo Monte dam were to meet the energy demands of a rapidly growing nation.

Diverting 80% of the Xingú River's flow, the project is comprised of 24 power generating turbines and 28 reservoir dikes, flooding a total of 478 km^2 of land (Diniz de Figueiredo, 2015). The complex has the potential to generate an average of 11,233 megawatts per hour during rainy season peaks, and an overall annual average of 4500 megawatts (Empresa de Pesquisa Energética, 2015). This energy will be distributed to 17 Brazilian states serving approximately 18 million residences and 60 million people. Belo Monte began running its first turbine in February 2016, with plans to run all 24 turbines by 2019 (Empresa Brasil de Comunicação, 2016).

In the Brazilian Amazon Basin, over 100 dams are planned (Winemiller et al., 2016; Zarfl et al., 2015) as part of government strategies geared to increase energy security, economic growth, and industrialization (Timpe and Kaplan, 2017). Although Brazil has recently announced a halt on mega-dam development in the region, experts warn that threats remain (Branford, 2018). Viability studies have been accepted for the Jatobá dam on the Tapajós River (CanalEnergia, 2018) and Brazil's National Energy Plan for 2026 lists plans to complete energy transmission lines through the region for the Sao Luiz de Tapajós dam (Empresa de Pesquisa Energética, 2017). Impacts of these big development projects in the Amazon region have long been studied, however, questions about the impacts of current and future hydropower in this globally important watershed continue to be debated (Moran, 2016, 1981; Soito et al., 2011; Bingham, 2010; Fearnside, 2001a; Smith, 1982). In cities such as Altamira, the abrupt population increase brought forth by large development projects such as Belo Monte, has played a significant role in the city's water and sanitation services.

1.2. Altamira

Altamira was once a small settlement that acted as a trading post during the rubber boom (1850–1920). Not unlike other towns in the Amazon region, Altamira's population grew considerably during the Trans-Amazon Highway construction which took place from 1971 to 1974. This gargantuan effort at road-building, directed settlement, and geopolitical integration of the Amazon into national development goals was part of the Program of National Integration, announced in 1970 (Moran 1975, 1981, 2016; Smith, 1982). Towns such as Altamira, Marabá and Itaituba began to swell as the construction of the Trans-Amazon and Cuiaba-Santarem Highways opened the region to outsiders. After the first year of highway construction, Altamira's population exploded from approximately 1,000 residents to over 10,000 (Moran, 1975). The large influx of people surpassed the capacity of public services to meet demand. By 1972, Altamira's hospital could not keep up with the explosion in road trauma and malaria cases, and schools could not accommodate the student increase (Moran, 1975). Altamira's urban area had ultimately stabilized in size and commercial activity until 2010, (Moran, 2016, 1981) when project auctions for the Belo Monte Hydroelectric Complex officially began. Located 52 km upstream from the dam (see Fig. 1), Altamira absorbed more than 30,000 construction and service sector workers which poured into the area at the peak of dam construction between 2012 and 2015. Population rose from 77,439 inhabitants in 2010 to an estimated 109,938 in 2016 (IBGE, 2011; IBGE, 2016). Nonetheless, people familiar with the area estimate that the actual population may have been closer to 150,000 inhabitants at its peak, settling back to 110,000 by the end of the construction (Marin & Oliveira, 2016; Moran, 2016).

The city's urban area grew exponentially and currently consists of 112.87 km^2 containing nineteen neighborhoods (IBGE, 2016). Parts of the city, along with a segment of the Xingu River, act as partial reservoir for the dam. As a result, low laying areas in urban Altamira were flooded. Five collective urban resettlements (RUCs) were built in vacant land within existing neighborhoods to provide housing for families displaced by flooding. These relocations, along with the population increase, augmented population density in some neighborhoods and restructured the city's layout. Fig. 2 depicts Altamira's urban growth between 2006 and 2016. Local authorities were unprepared for the significant increase in residents, and the already lacking basic sanitation services in the city were unable to meet the demand. During Belo Monte's construction, Altamira was once again disrupted by a large

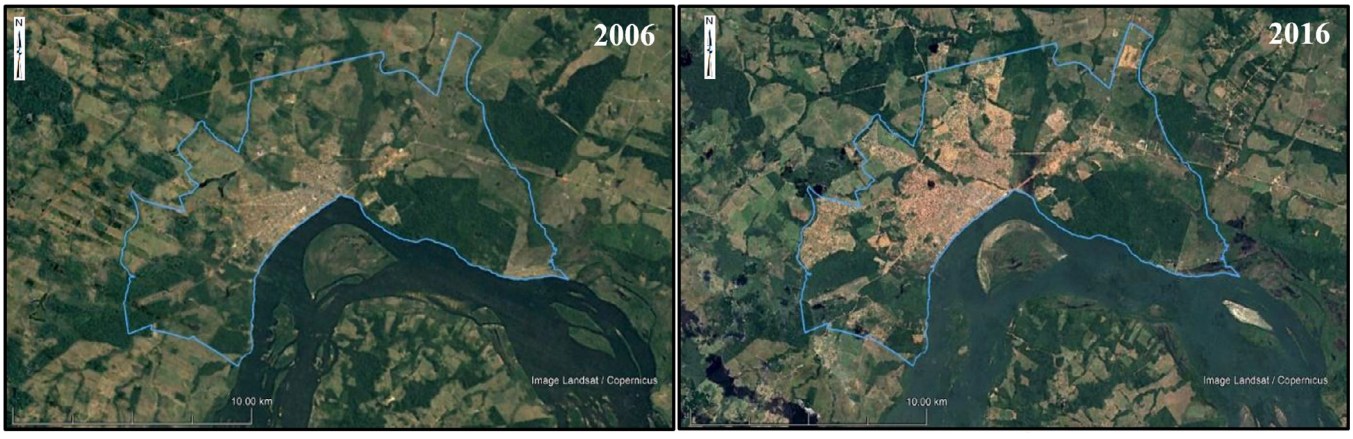

Fig. 2. Urban Growth in Altamira (Google Earth Images).

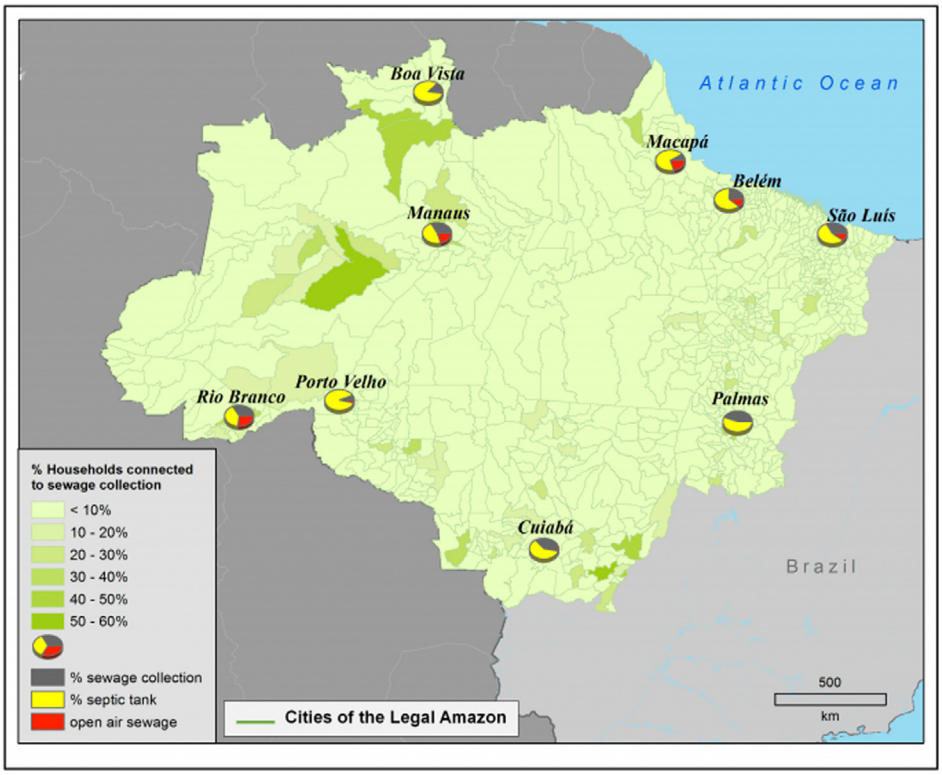

Fig. 3. Proportion of households in Amazonian municipalities and state capitals connected to sewage collection. (Brondizio, 2016).

infrastructure project, reminiscent of the arrival of the Trans-Amazon Highway in the 1970s (Moran, 2016).

1.3. Basic sanitation

Due to the scattered occupation of the Amazonian territory and the rush to extract value from its natural resources, provision of public services has lagged behind the rest of Brazil. In the states of the Brazilian Amazon, 52% of residents receive potable water from a distribution network and only 10% are provided with sewer services (Ministério das Cidades, 2016), leading to dependence on septic tank use. Fig. 3 shows that even the capital cities located in the Brazilian Amazon mostly use septic tanks (Brondizio, 2016).

Non-capital cities, such as Altamira, are even less well-served than those depicted in Fig. 3. A single unconfined aquifer currently supplies groundwater for the majority of Altamira's urban area (CPRM Serviço Hidrogeológico do Brasil, 2014), with residents relying heavily on wells as their main source of water. Furthermore, according to the National Sanitation System, 90% of the population in the municipality of Altamira was disposing of their wastewater in alternate systems (Ministério das Cidades, 2016) with residents relying mainly on septic tanks as their primary source of wastewater disposal. These septic tanks generally have an open bottom, allowing liquids to percolate through the soil. Given that high septic system densities are associated with endemic diarrheal illnesses (Borchardt et al., 2003; Hunt et al., 2010), contaminant transport from septic tanks to water wells is of growing concern in Altamira. As the population increases, new wells and septic tanks are built and distances between new and old structures decrease. This reduces contaminant transport times from septic tanks to water wells and puts the health of the population at risk (Ministerio Publico Federal, 2016; Conselho da Justiça Federal, 2017). A visual representation of contaminant transport from septic tanks to water wells is shown in Fig. 4.

Aside from wastewater intrusion into wells, leachate from solid waste can carry contaminants to the area's water resources (Borchardt et al., 2003; Hunt et al., 2010; Ikem et al., 2002; Mor et al., 2006; Palamuleni, 2002) and rainfall induced infiltration can impact drinking water supplies. In Altamira's wet season, intense rains flood parts of the city along with low laying well heads. Therefore, basic sanitation is important in the protection of the city's water resources as overflowing septic tanks, solid waste contaminants, and feces from scavenger animals can all contribute to pollutant entry to wells.

The sanitation crisis that has erupted in Altamira was deemed critical by Brazil's Federal Public Ministry and in April of 2017, Belo Monte's Operation License was suspended until the crisis was addressed (Ministerio Publico Federal, 2016; Conselho da Justiça Federal, 2017; Harari, 2017a). In the environmental licensing process, the urban residents of Altamira were promised potable water and an adequate sewage system that would improve previous sanitation conditions and quality of life (IBAMA, 2015). These services, however, have yet to be delivered in their entirety. Nonetheless, the judicial decision that suspended Belo Monte's license was not effectively enforced and the dam continues its daily operations (Harari, 2017b). In this sense, Belo Monte exemplifies one of the disconnects between national policy and local reality in Amazonian large hydropower developments that will be further explored in this paper.

The similarity in provision of services and waste disposal practices throughout the region leads us to believe that, if left unaddressed, the implementation gaps we will discuss in this paper are likely to emerge in future hydroelectric development projects currently envisioned throughout the Amazon Basin. As more dams in the Amazonian region are planned, identifying public policy implementation gaps that affect basic sanitation and water resources creates opportunities to anticipate problems that could impinge on the public health needs of residents where such large infrastructure projects will be implemented.

2. Existing national public policies

In Brazil, divergent patterns of development exist across regions, and evaluation of development at a local scale remains a major

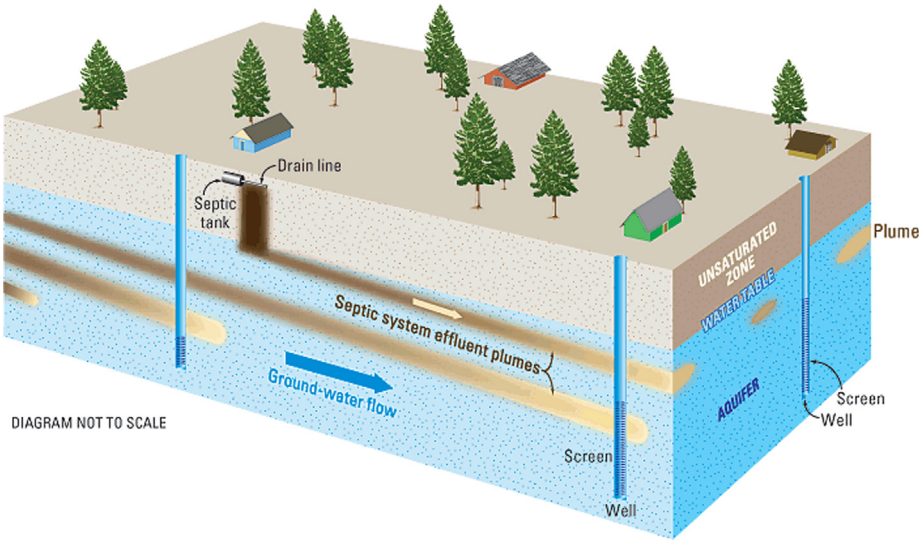

Fig. 4. Contaminant transport from septic tanks to water wells (United States Geological Survey, 2016).

challenge for public policy and administration. An important task that aids in examining local development is coming up with precise definitions of what types of policies should be included in assessing local development projects (Barberia and Biderman, 2010). Using Brazil's National Water Resources Policy and Federal Basic Sanitation Law, we can assess Belo Monte's success in delivering a better quality of life to the population in Altamira through adequate water provision and sanitation services. It is not our goal to provide detailed descriptions of each of these policies, but to briefly discuss them in order to succinctly state their main goals and requirements.

2.1. Brazil's national water resources policy

Established in 1997, Brazil's National Water Resources Policy (Law No. 9.433/97 – Política Nacional de Recursos Hídricos – PNRH) is one of the main instruments guiding water management in the country. The PNRH is comprised of guidelines, goals and programs reviewed and approved by the Ministry of the Environment's National Water Resources Council. While it faces challenges in its applicability to attend to all with equity (Wolkmer and Freiberger, 2013; Caubet, 2006), it provides basic requirements that would improve the water and sanitation of communities in Brazil if its demands were adequately fulfilled.

Its objectives are to ensure: (1) the necessary availability of water to current and future generations in quality standards appropriate to their uses, (2) the rational and integrated use of water resources, including water transport, with a view toward contributing to sustainable development and, (3) the prevention and defense against critical hydrological events of natural origin or arising from the inappropriate use of natural resources (Presidencia da Republica do Brasil, 1997). According to the Ministry of the Environment, the overarching objective of the PNRH is "to establish a national pact for the definition of guidelines and public policies aimed at improving the supply of water in quantity and quality, managing the demands and considering that water is a structuring element for the implementation of sectoral policies from the point of view of sustainable development and social inclusion " (Ministério do Meio Ambiente, 2016).

The PNRH is periodically reviewed and adapted to fit the realities of 12 national hydrographic regions in Brazil, based on technical analyses and public consultations. Each hydrographic region should have its own committee that approves a Basin Water Resource Plan (Presidencia da Republica, 2007). Each committee should count with various representatives from the public sphere (national, state and municipal), users (industry, irrigation, water supply, power generation, etc.) and civil society (Jacobi and Francalanza, 2005). In cases where there are designated indigenous lands within the basin, the National Indian Foundation should also take part in the committee. Basin committees are also in charge of mediating water-related conflicts on a first administrative instance, as well as establishing mechanisms and suggesting price tariffs for the use of water resources (Agência Nacional de Águas, 2011).

Although the holistic perspective of this policy cannot present a single solution for different socioeconomic contexts, it remains a useful instrument that provides recognition of basic water resource requirements for the Brazilian population. Failure to meet PNRH objectives will be discussed as we uncover the situation in Altamira.

2.2. Federal Basic Sanitation Law

Under Brazil's Federal Basic Sanitation Law (Law No. 11.455/07), basic sanitation constitutes a set of services, infrastructures and operational facilities for the public supply of drinking water, the adequate disposal of sanitary sewage, solid waste management, and urban stormwater management. Brazil's Federal Basic Sanitation Law, establishes national guidelines for the Federal Basic Sanitation Policy. One of the objectives of this policy is to "minimize environmental impacts related to the implementation and development of basic sanitation services, and ensure that they are carried out in accordance with the norms related to the protection of the environment, land use and occupation, and health." (Presidencia da Republica, 2007).

The fundamental principles for the provision of such services include, but are not limited to, the universalization of their access; methods, techniques and processes that take into account local and regional peculiarities; services being appropriate to public health and environmental protection; integration of infrastructures and services with efficient management of water resources; the safety, quality and regularity of such services; and their "articulation with urban and regional development policies, environmental protection, health promotion and other relevant social interest policies aimed at improving the quality of life for which basic sanitation is a determining factor." (Presidencia da Republica, 2007) Regional plans for the provision of services must be elaborated and executed in articulation with the State, Federal and Municipal entities involved. Federal, state, and municipal integration stimulates the implementation of infrastructures and services common to Municipalities, through mechanisms of cooperation between federated entities.

The construction of the Belo Monte dam offers an ideal case study to understand the challenges in scaling down and implementing these

national laws and policies. The investments attached to the construction of the Belo Monte dam was an opportunity to bring basic sanitation to a region historically characterized by precarious provision of these services. Instead, there has been a failure to comply with national policies. The processes witnessed in Altamira and discussed in this paper are being replicated in the construction of other dams in the Amazon region, giving added urgency to addressing these issues. Similar projects loom in the region, and adequate implementation of policies is crucial to avoid future sanitation crises caused under the rapid changes brought forth by large development projects. In the following sections, we will examine Altamira's current situation and identify tenets in the national laws that are not being addressed.

3. Data collection and methods

In order to determine Altamira's current basic sanitation services, surveys to the population and semi structured interviews with government officials were carried out in July 2016. Surveys included questions relating to current services provided to the household, the primary source of potable water, wastewater disposal methods used and solid waste collection frequency. The distribution of the surveys was determined by using the "Probability Proportional to Size" method (Graham 1983, Groves et al., 2009, Randell and VanWey, 2014), where the probability of selecting an element is directly proportional to its size, or in this case, the probability of selecting a household is directly proportional a neighborhood's population density. The sample was further stratified by altitude to ensure households in varying elevations were being surveyed. Data on individual neighborhood and total urban populations were gathered from the Brazilian Institute of Geography and Statistics (IBGE) (IBGE, 2016) to determine population density per neighborhood. Information on elevation was gathered from Google Earth imagery and corroborated through the use of a global positioning device in the field.

Ultimately, 130 surveys were performed in the 13 most populated neighborhoods of urban Altamira (see Fig. 5). Sampling these particular neighborhoods yields an accurate representation of the services Altamira residents receive. Given time restraints and limited field assistance, the remaining 6 neighborhoods were excluded from the scope of this study due to their low population. At the end of each survey, coordinates and elevation were collected for each household using a global positioning device to precisely locate them on the urban landscape. Observed community groundwater wells and solid waste dumping locations were also recorded. Fig. 5 shows the location of the households surveyed along with Altamira's neighborhood boundaries.

In addition, semi-structured interviews were performed in June and July of 2016 with the following local offices and government branches: Brazilian Institute of Geography and Statistics (IBGE), Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), Secretariat of the Environment (SEMAT), Public Sanitation Department (DLP), Norte Energia, Altamira Sanitation Company (COSALT), and Secretary of Urban Planning (SEPLAN). Questions relating to the current services provided, and hindrances in their provision from each local office standpoint were discussed. Local population behavior and impressions in relation to water and waste services were also observed during the fieldwork period. This complemented the information collected in the surveys, acting as a bridge to help further understand Altamira's basic sanitation services. Publicly available information regarding public policies, laws, project licensing, reporting, and other legal documents were obtained from government websites such as IBAMA, the Office of the Federal Public Prosecutor, and National Sanitation Information System.

ArcGIS Desktop 10.5 software was used to generate the maps presented in this paper. STATA 14 software was used to create summary statistics of potable water service provision and frequency, wastewater and greywater disposal methods, and solid waste collection frequency.

4. Results

4.1. Availability of potable water

Although Altamira is located on the banks of the Xingú River and has a potable water-treatment plant, 79% of the households surveyed get their drinking water (either regularly or occasionally) from wells. Fig. 6 shows the surveyed households that have a well. This highlights the importance of household surveys in distinguishing between water resource *access* and water resource *use*. Depth of wells range from 3.9 m (13 feet) in low lying neighborhoods to 28 m (92 feet) in higher elevation areas. The most common treatment of drinking water was found to be chlorination and/or boiling. However, during the wet season, groundwater levels rise (IBAMA, 2010) and residents report degradation in the quality of water with observable turbidity and a distinct smell, regardless of treatment. Shallow wells tend to be dug by residents or independent "well-diggers" that offer their services (see Image 1). Such wells are not coated or sealed and are at risk for intrusion of contaminants. Interviews revealed that the wells that are coated with layers of sand and rock have a cost of $13 dollars per foot (per 0.3 m). This makes deep wells, which are less susceptible to variations in the dry months, a costly matter for most households.

The city's water treatment plant only served 35% of the households sampled, of which only 18% reported continuous and reliable service to their homes. During semi-structured interviews with Altamira's Sanitation Company (COSALT) it was disclosed that the water treatment plant is operating at well over half capacity, although not everyone in the city is yet connected to the network. Norte Energia, Belo Monte's construction consortium, made improvements to the city's already existing water treatment plant and water distribution network. While Norte Energia provided infrastructure and equipment to expand the water treatment plant operations, limitations remain. Particularly, the water treatment plant's aerator volume can sometimes be a limiting factor in the amount of water that can be treated per day. Further, a series of lift stations with inadequate pump capacity were installed, preventing higher altitude neighborhoods from receiving city water.

Out of the 13 neighborhoods sampled, 7 relied on private wells for their potable water, only one was connected to the distribution system, and 5 neighborhoods had partial connections. In partially connected neighborhoods, areas not receiving services have wells or are supplied water by tank trucks. According to interviews, tank trucks do not possess a fixed water distribution schedule and may come anywhere between one to two times per week. In some instances, it was reported that the tank truck driver would charge residents for the distribution of water.

Households located in the 5 recently built RUCs are not meant to have private wells, although some residents have attempted to build their own. These RUCs receive water through a shared community water tank and distribution network. COSALT and Norte Energia have built community wells to supply water to the community water tanks. However, in 3 out of the 5 RUCs these wells are supplemented with tank trucks to fulfill the water demand of the residents.

Each neighborhood faces different challenges in their water supply and this diversity of situations within neighborhoods make facile generalizations difficult. Still, the unreliability of the water distribution system is one very important driver for the dependency on household wells, according to the households interviewed. Irregular or no connection to the local water distribution system increases the dependency and density of water wells for all neighborhoods in Altamira.

4.2. Wastewater treatment

All households in Altamira lacked a connection to wastewater treatment. Seventy-eight percent of surveyed residences disposed of their wastewaters through septic tanks. The only ones with some disposal were households located in the 5 recently built RUCs. Households

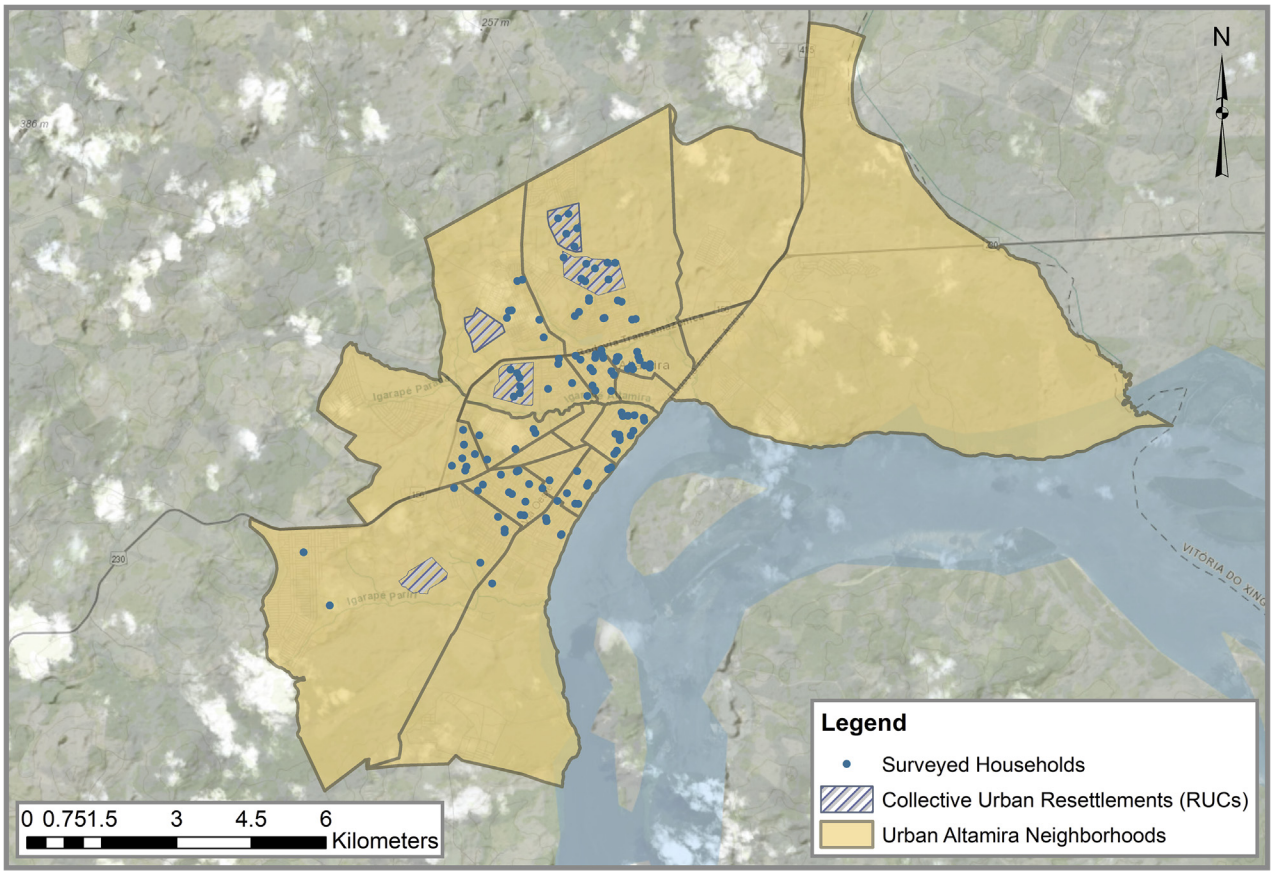

Fig. 5. Location of households surveyed, neighborhoods boundaries, and collective urban resettlements (RUCs).

located in these resettlement neighborhoods collected their waste in aboveground community tanks which were emptied and hauled to the wastewater treatment plant. The wastewater treatment plant, financed by Norte Energia, only serves these 5 locations while the rest of the city entirely lacked wastewater treatment service. This can be observed in Fig. 6, where no use of septic tanks was reported in the households surveyed within the RUCs.

Of the households using septic tanks, 63% were constructed by current residents, family members, past owners, or local independent handymen. Only 4% of the septic tanks had been constructed by a septic tank company or by the municipality. Fig. 6 shows the range of volumes of the septic tank found as reported by the residents of the households surveyed. Interviews revealed that septic tanks tend to lack an impermeable bottom and allow for percolation of wastewater to the soil and groundwater representing a great risk for the cross-contamination to water wells. Greywaters not coming from bathrooms were reported to be discharged directly to the surface or neighboring water bodies in 57% of the households. Interviews revealed that the potable water treatment plant discharges residual filter wash waters (waters used to wash the filters) directly to the surface. Reports show that local commercial and business interests, including the hospital, discharged all non-bathroom greywaters in that same manner (Ministério Público Federal, 2016). Direct discharges onto the river were routinely observed by the research team and reported by civil society on many previous occasions, to no effect. Interviews and surveys conducted in June and July 2016 revealed that connections to a sewage network had not started. Connections to households began at a slow pace approximately 14 months after our fieldwork concluded, but they did not include collection of greywaters.

4.3. Solid waste management

All but one household surveyed was served by solid waste collection services. Collection took place directly from the front of their homes in 94% of the residences receiving services. Alternative methods of solid waste disposal were used in 23% of the households and included burning, burying, dumping in an empty lot, and dumping in a body of water. The main reasons reported for these alternative disposal methods were: (1) to minimize accumulation of wastes in the home, and (2) lack of collection of certain materials (i.e. yard wastes, metal scraps, Styrofoam) by the current collection services. A daily frequency of solid waste collection was reported for 27% of the homes and a frequency of two to three times a week was reported in 68% of the households. Altamira's solid waste collection is not performed at a consistent time of day, which leads residents to leave their refuse in front of their houses for long periods until trucks come. In the meantime, animals, mainly dogs and vultures, break the plastic garbage bags and spread solid waste which in some cases enters the stormwater system given the high and frequent precipitation of this rainforest region.

Prior to the construction of the dam, Altamira's Public Sanitation Department (DLP) had a fleet consisting of 6 compactor trucks and 7 open top trucks. Norte Energia provided an additional open top truck, one compactor truck, and one 40-yard container. All trucks are in rotation and operate daily, rotating between urban neighborhoods and peripheral rural areas. According to Altamira's DLP, 40 tons per day of domestic waste were collected before Belo Monte, increasing to 110 tons per day during dam construction, and currently leveling at 80 tons per day. There was no doubling of trucks to collect the increase in garbage produced by urban and peri-urban residents. Norte Energia provided a new landfill to accommodate the increase in construction and domestic waste. They also performed closure and remediation

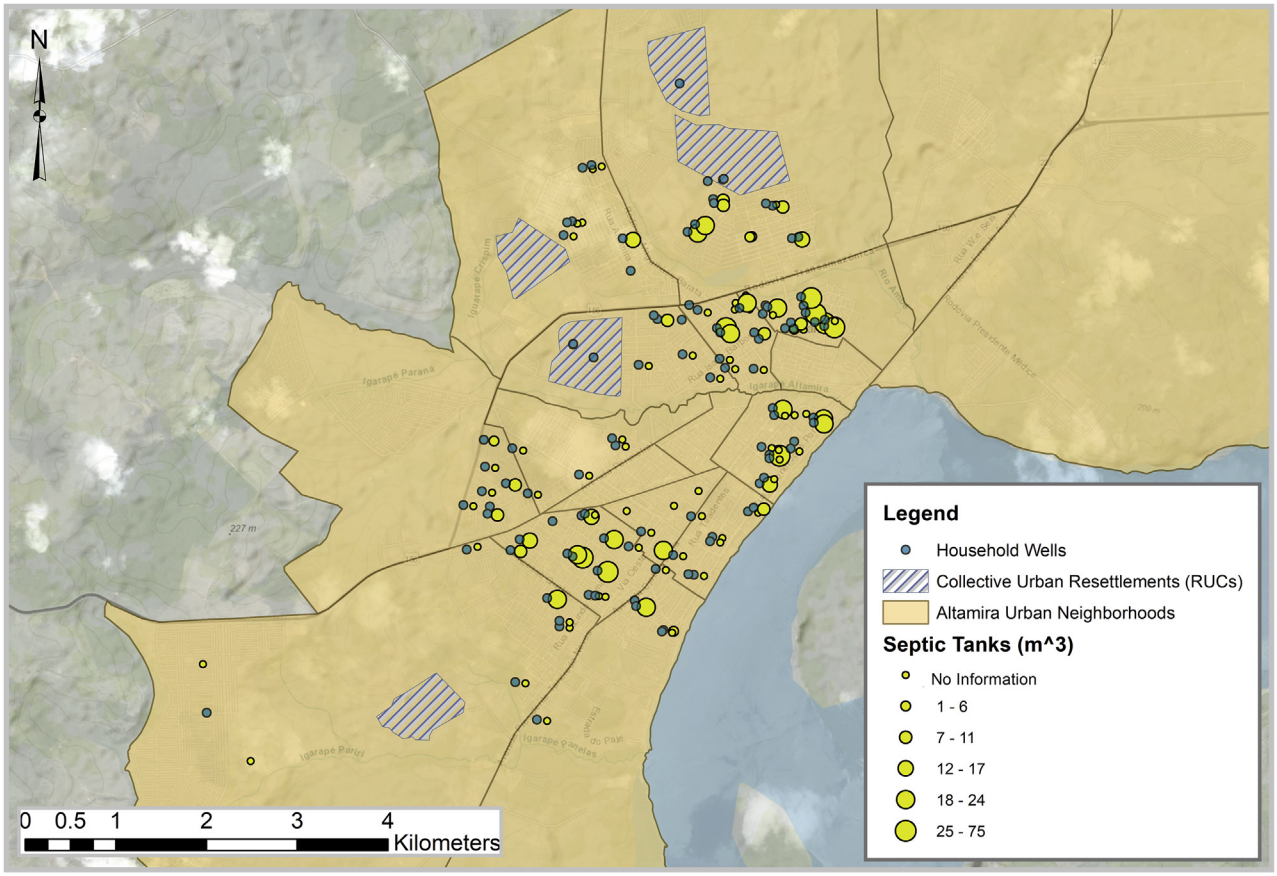

Fig. 6. Septic Tank Volumes and Well Locations of Surveyed Households.

Image 1. "Well digger" making a household well.

activities for the old landfill, installing groundwater monitoring wells to monitor possible pollution. Interviews with the Secretariat of the Environment (SEMAT) revealed that the monitoring for these wells is difficult, due to constraints in laboratory services in the city.

5. Discussion

Aside from the survey results presented in the previous section, the semi-structured interviews revealed crucial insights to hindrances experienced by local agencies in the provision of services to the residents of Altamira. These interviews uncovered an intricate nexus between political, social, and environmental elements which shape Altamira's

current situation and identify hindrances to the provision of better water and sanitation services.

5.1. Resource allocation

Interviews performed revealed that Altamira's local Brazilian Institute of Geography and Statistics (IBGE) offices were not given any financial or human resources to conduct a mid-term census and cannot provide official, verified information regarding the new population that came to Altamira after the 2010 census was performed. Formal IBGE estimates are based on national calculations that do not take into account population booms brought forth by big scale development projects such as Belo Monte. This leaves all other agencies not knowing the population to be served. Without a reliable source for the number of inhabitants, agencies providing services are left in the dark and are unable to justify changes to their budgets to address the change in demand. Implementation of a national scale census is not possible, thus, a more localized approach to better estimate and determine the current population in the city is needed. People familiar with the area contended that the population during Belo Monte's construction peak was between 110,000 and 150,000 (Marin and Oliveira, 2016; Moran, 2016). Acting on such estimation would have been preferable than the dithering by agencies over the lack of a precise census count.

Furthermore, understaffing is an issue pervasive in the local government agencies interviewed. Particularly, Altamira's Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) office counted with only three technicians at the time of this study. Given the magnitude of the project, legal matters and paperwork regarding Belo Monte's Operation License and environmental compliance is mainly administered and overseen at a national level by IBAMA's headquarters in Brasilia, located approximately 2000 km away from Altamira. Local IBAMA technicians are largely battling the ever-present threat of deforestation in the region, which is a feat in itself. Hence, the already limited amount of technicians working at Altamira's IBAMA offices are deterred from engaging in compliance matters at a local level to report to the national office in regards to Belo Monte. This creates a gap between what is happening at the local scale, and what is reported to the agency at the national scale.

Interviews also revealed that equipment available to service the population in the collection of domestic solid waste is a limitation for Altamira's DLP. At the time of the interviews, all trucks were in rotation and operated daily, with no margins for malfunctions or flat tires. Altamira's DLP fleet consists of 7 compactor trucks and 8 open top trucks. In the case of such drastic population increase in Altamira, a significant increase in equipment for public sanitation would have been appropriate since an increase in domestic solid waste is to be expected. Solid waste collection strategies have struggled to efficiently manage the increase in population. The lack of equipment feeds into disrupted collection schedules, which at times can be inconsistent in collecting and handling the increasing solid waste generation in Altamira. Interviews revealed that the city budget will most likely not allow for any additional workforce increase in the DLP, or for revisions in solid waste collection strategies. This will add to an already undersupplied and underprovided solid waste collection service, deterring the department from providing quality services to the population.

Although investments in the infrastructure of the Amazon region have been made by the national government to generate rapid economic growth, the Amazon region trails behind the rest of the country in water and sanitation services. In the 1960s and 1970s, Brazil borrowed from international creditors for industrialization and infrastructure programs, including urban water systems, but aging water infrastructures and growing demands in the region now put great pressure on federal budgets. Water systems have been passed to the state level and, due to the long term and the capital-intensive nature of water infrastructure, there is a general disincentive to make long-term investments for water networks (Swyngedouw, 2005). In the same way that the city budget does not allow for additional DLP staff, the state and local offices all claim lack of funds for the operation and maintenance of Altamira's water distribution network. The state agency in charge of potable water systems in Pará (COSANPA), passed the water system responsibilities to the city of Altamira (COSALT), whose budget is also insufficient to serve the growing population. Initial investments in the sanitation services, including water, were made by Norte Energia. However, after completing its mandated post-dam construction obligations, Norte Energia will eventually leave and Altamira will be left with a smaller local budget that will unlikely sustain long-term fixed capital investments or system maintenance.

A much greater population is being served without markedly improved organization or infrastructure. Integration of infrastructures and services along with efficient management of water resources is crucial to development, yet sorely lacking in Altamira. In this sense, national scale policies such as Brazil's National Water Resources Policy (PNRH), Basic Federal Sanitation Law, and Belo Monte's Environmental Licenses, ultimately failed to be implemented in a manner that considered legal requirements, local patterns of water management, household water demand, and basic sanitation practices.

5.2. Licensing and retributions

Environmental impact assessments (EIAs) are embedded in politics and are imagined as sites of power relations (Spiegel, 2017). EIAs and public policies are crucial instruments for environmental management, yet their entanglements in political processes and associated power structures can hinder these goals. One example is the ongoing national government investigation for inappropriate forms of payment coming from Odebrecht, Belo Monte's main construction company, to the political party under which licensing for the dam was granted. This added component suggests that environmental licensing processes and public policies can be interfered with, disrupting their main objectives and adding yet another dimension to an already complex licensing, oversight, and retribution structure within big development projects. Furthermore, and not unlike other countries, project documents may uphold principles of justice but national political priorities may well override these principles. The degree of administrative and political control from central governments and its obverse are key factors which shape justice outcomes in environmental projects (Blaikie and Muldavin, 2014).

The Belo Monte dam was granted a Construction License under the condition that Norte Energia would improve the water and sanitation systems used in urban Altamira. The company had not yet met this requirement after 4 years of construction, yet was granted its Operation License (IBAMA, 2015). Belo Monte's Operation License approved the dam's reservoir to be filled and the turbines tested. Since the Operation License was granted regardless of previous unfulfilled requirements, it mandated that before filling the dam's reservoir, all septic tanks and water wells were to be cleaned and closed and other inadequate forms of sewage disposal systems were to be eliminated. Additionally, a formal connection of all households to the potable water network was supposed to be established. The Operation License dictated that by September 30, 2016 all households in urban Altamira were to be formally connected to the potable water network and sewer system (IBAMA, 2015). Norte Energia was expected to begin wastewater interdomiciliary connections in July 2016 (Norte Energia, 2016), leaving only 3 months to connect roughly 15,440 households. As of 2017, these conditions had not yet been met, not all households were connected to potable water or sewer systems. IBAMA granted the Belo Monte dam's Construction License and Operation License disregarding the basic sanitation conditions required by both licenses and by Federal law. Partial flooding of the city and population growth added pressure to Altamira's already stressed water and waste management systems, creating a public health crisis. In light of this, the Federal Public Prosecutor filed a Public Civil Action Suit in March 4, 2016. The suit revealed that no

detailed studies regarding the Altamira water table were made in the environmental licensing process and it questioned Belo Monte's compliance with the Basic Environmental Plan submitted early in said licensing process. Specifically, it raised inquiries on the provision of potable water, sanitary sewage, drainage of urban rainwater, and urban solid waste management. The immediate suspension of the Operation License was requested until the sanitation conditions were met, and daily fines were imposed. Norte Energia was also retroactively fined 2,500,000 reais (approximately $773,000 USD) for direct sewage discharges from the Jatobá collective urban resettlement. Moreover IBAMA has fined Norte Energia 27 times, totaling 76,183,605 reais ($23,625,263 USD). This includes a 7,500,000 reais ($2,325,986 USD) fine for failing to provide household connections to a sewage system in urban Altamira (IBAMA, 2017).

Although water is a public good, its degradation becomes an externality that is not taken into account because there is no market value imputed; governments and businesses are unable to internalize the true value of its degradation (Schomers and Matzdorf, 2013). The suits and fines imposed on Norte Energia were not severe enough to halt the operation of the dam nor change sanitation for city residents. Delivery of adequate potable water and effective sewer system services was not completed as observed from the unfinished pipe network, inadequate booster pump capacity, and a water treatment plant with limited volume to handle demand. These are some of the factors that prevent the universalized access and hinder the safety, quality, and regularity of basic sanitation services, mainly potable water, being provided to residents. Belo Monte continues to operate without fulfilling licensing requirements, PNRH, nor Basic Sanitation policies. The energy sector has long used the narrative of an impending energy crisis as justification for overlooking social and environmental impacts and justifying approval of projects questioned by social and environmental impact statements (Boanada Fuchs, 2015; Boanada Fuchs, 2016). Legal requirements need to be executed to protect the health and wellbeing of the population and minimize environmental impacts related to the implementation and development of sanitation services Stronger measures are needed so that environmental enforcement of existing laws and regulations have sufficient power to stop construction or operation until legally mandated conditions are fulfilled.

5.3. Regional practices

Generally, once a dam is approved, construction moves very quickly. Equipment is rented on a 24 hour basis and engineering firms are given incentives to finish ahead of schedule. This pace is diametrically incongruent to that of government agencies in charge of building hospitals, schools, health posts, and other public services. Government agencies are reluctant to use their budgets, which rarely foresee the eventuality of a major project being built in their area. These agencies also have unclear boundaries to their duties, or in some cases they have overlapping responsibilities. State and local governments do not receive additional federal funds for the population increase, since federal allocations are based on the decadal census. In the case of Altamira, within months of the 2010 census, the data was no longer relevant due to the explosive growth in population brought forth by Belo Monte's construction. The lack of official figures for Altamira's population resulted in an unwillingness by the government, at all levels, to provide emergency funding to meet urgent needs. Claiming budgetary constraints, local, state and federal agencies refused to step into this data vacuum and, rather than attempting to quickly address these data deficiencies, a certain bureaucratic immobility set in. The indisposition and apparent inflexibility at a national level to perform a midterm census, or go by informed estimates, was used as justification at a local scale to avoid acting promptly to resolve the matter.

Aside from these issues, there are of course greater social processes that shape Amazonian development. Amazonian development priorities maintain its extractive history: producing wood and spices during the colonial period, rubber in the late 19th and early 20th century, and since the model of development pushed by the military regimes of the mid-20th century, sending minerals and energy to the developed parts of the country. Processes such as decision-making authority, state power, capital flows, resistance by social movements, and the environmental value placed on the rainforest have changed but the course has been remarkably constant. Political interests have advanced their agendas, pursuing an increase in Brazilian national power and a greater influence on the global stage at the same time that capital and market forces at an international scale have influenced the course of development in the Amazon (Brown and Purcell, 2005). The expansion of cattle has been moving inexorably towards the Amazon, as areas of pasture in the South East and Central West have been converted to production of sugar cane for ethanol, and soybeans for export. Most of the hydropower produced in the Amazon goes to industries and urban regions in the developed regions of Brazil, while the Amazon population remains with little voice in these development processes, saddled with severe impacts on its forests and rivers, and without the expected improvements in livelihoods, or in water and sanitation (Morton et al., 2006, Fearnside, 2001b). The migrations that occurred in Altamira are part of the social processes that result from large development projects such as Belo Monte. In Altamira, these migrations doubled population and, coupled with non-compliance of public policy and environmental regulations, impacted basic sanitation provision.

At a regional scale, Altamira is no different than many other small cities in the Amazon. National decisions disregard the needs of the population in the region, concerned as they are with aggregate economic growth in the urban-industrial parts of the country (Walker et al., 2000). The population remains highly dependent on septic tanks for their wastewater management (Brondizio, 2016). Therefore, it is no surprise that closing of all groundwater wells, septic tanks, and other sewer disposal systems has met opposition from civil society. Residents are ill disposed to pay for sewage charges if they have never had to do so before and are reluctant to give up their wells to connect to an unreliable potable water system. At the time this article was written, Altamira's municipality was trying to introduce a payment schedule for water service that charges households nearly the same as businesses or industries. The population was appalled by this price schedule, particularly when services continue to be unreliable. Taking these local characteristics into account can help aid in anticipating pushbacks from residents hesitant to connect to a sewage or potable water system. While these disposal techniques may have been used in the past, the introduction of a large development project, along with the population boom it brings to the area and the regional practices of waste management, further amplifies risks to local water resources by increasing contaminant flows into the watershed. Thus, implementation of basic sanitation services appropriate to public health and environmental protection are imperative, however, deficient in Altamira.

5.4. Environment and Public Health

Current practices in Altamira lead to the degradation of its two main water resources: the local aquifer and the Xingu River. Sanitary discharges from septic tanks to the local aquifer and greywater discharges to the Xingu River infringe upon Brazil's PNRH objectives of maintaining availability of water to future generations in quality standards appropriate to their uses, as well as failing to prevent critical hydrological events arising from the inappropriate use of water resources. An attempt at monitoring the local resources was, however, done by Norte Energia. As per Brazil's PNRH, Norte Energia instituted a Water Resource Plan that established actions to minimize and monitor impacts on surface and groundwater resources. The plan included monitoring programs and schedules for water quality testing of superficial waters and groundwater. Norte Energia also installed groundwater wells to monitor possible pollution in the old city landfill which was remediated and closed. However, monitoring was deferred to the Secretariat of the

Environment (SEMAT). Interviews with SEMAT personnel revealed that the closest water laboratory able to perform the water quality testing required in the Water Resource Plan is located in the capital city of Belém, 460 km northeast of Altamira and, due to this difficulty, they have been unable to continue the monitoring schedule. The fact that there is no adequate water laboratory in Altamira to carry out the requested water quality tests shows that there is a disconnect between national planning and local capacity to carry out the legal mandates. This is yet another instance in which local and regional particularities were not taken into account. Using methods, techniques, and processes that take into account local and regional peculiarities is, in fact, one of the fundamental principles stated in Brazil's Basic Sanitation Law.

The environmental impacts of policy noncompliance on public health can be observed in the sanitation crisis in Altamira. Although different neighborhoods face distinct challenges in the fulfilment of their basic sanitation needs, the diversity of situations still reveal a lack of implementation of existing legislation. Irregular services to households, potential contamination of groundwater, and direct discharges to the Xingú River, shows that the PNRH's overarching objective – improving water supply in quantity and quality, managing water demands, and considering sustainable development and social inclusion – is nowhere close to being fulfilled. Moreover, multiple fundamental principles for the provision of basic public sanitation services are not being met. These include the universalization of access to services; methods, techniques and processes that take into account local peculiarities; services appropriate to public health and environmental protection; infrastructure and services with efficient management of water resources; the safety, quality and regularity of services; and articulation of services with environmental protection, health promotion and other policies aimed at improving the quality of life for which basic sanitation is a determining factor. The basic sanitation services found through our research in Altamira certainly do not ensure the protection of the environment and health.

6. Conclusions

Amazonian development plans to increase energy production for the benefit of the country have overpowered environmental conservation at a regional level, quality of life at a local level, and protection of water resources as dictated by the national public policies discussed in this article. Dam development projects backed by international and national lenders steamroll local and regional concerns. In projects such as Belo Monte, international funds are accepted nationally along with the project document, which may uphold principles of justice, but national political priorities may well override these principles at all levels. Thus, in many cases, justice issues are treated as rhetoric and ignored (Blaikie and Muldavin, 2014). Current implementation of public policies and laws have ignored the population most affected by the construction of the dam, basic permit conditions were not satisfied and yet the dam was built and continues to operate. We have established that environmental variables can combine with resource allocation, regional practices, and licensing and retributions to impact basic sanitation services and thus, public health of the population. Recognizing that such political, social, and environmental elements play into the provision of adequate services, we believe there is a necessity to ensure that current laws and policies are followed and that resources to cope with the doubling of population and their waste are provided as a condition for building hydroelectric projects in the region.

The relationships between local and national levels of government continue to place national energy needs ahead of the most basic human needs of the Amazonian population. The relationships between national, regional, and local scales obfuscate adequate implementation of overarching policies mandated to protect against environmental degradation and provide a suitable quality of life to the population. As with the case of Altamira and the Belo Monte dam, the conditions required and dictated by the discussed national policies differ from local reality and appear to be disconnected. National policies for the provision of basic sanitation services and protection of water resources must take into account local and regional circumstances and financial capacity at the time of their implementation and provide the funds to carry out their obligations. Failure to consider these particularities, and attempting to implement national scale approaches without ensuring a timely provision of funds at the right scale for implementation, has prevented mechanisms of cooperation between different levels of government and private entities from functioning to the benefit the population. Integration of federal, regional, state, municipal, and city levels in the analysis of implementation of policy increases the chances of properly executing them, especially when additional coordination is required with private entities in charge of the dam construction and management. Furthermore, payments to political parties in return for favors are not unusual, even in developed countries, in the area of basic sanitation services (Swyngedouw, 2005). Ensuring stern consequences at all levels for noncompliance with basic sanitation policies is essential in administering change and providing adequate basic sanitation services, environmental protection, health promotion, and other social interests that result in improving the quality of life of the population.

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