

Research Paper

A qualitative analysis on implementing the sewer system for an indigenous village in the influence area of Belo Monte Hydroelectric Plant (Brazil)

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ABSTRACT

In this article, the project and implementation of the sewer system in the Paquiçamba Village, as a condition for environmental licensing, was investigated. This village is surrounded by the influence of the Belo Monte Hydroelectric Plant (Brazil). This research aimed to characterize the context of ethnodevelopment, thus recognizing the social participation of the indigenous people. The research within a qualitative approach between 2009 and 2018 was based on primary data sources (through structured interviews) and secondary data (electronic files related to the environmental licensing). Data were analysed according to descriptive, focused and selective observations until reaching theoretical saturation. The organization of the data was followed by the organization of the themes, which formed a spiral of interconnected activities based on Creswell's proposal. It was detected that indigenous involvement occurred at some moments in the elaboration of the sewage system project. The maintenance of ancestral habits in the disposal of excreta by a portion of the indigenous people, even with the sewage system in place, makes it essential to broaden the debate on the projects proposed on the environmental licensing processes. The indigenous can not only have a consultative role, but assume a deliberative participation, being protagonists in conducting their own development.

Key words: environmental licensing, ethnodevelopment, Indigenous Rights Public Policy

HIGHLIGHTS

- The implementation of the sewage system in an indigenous village was investigated as a condition for environmental licensing.
- The Indigenous continue to transform some habits to resist the negative impacts arising from the construction of the large engineering project.
- The maintenance of ancestral habits by a portion of the indigenous people makes it essential to broaden the debate on environmental licensing processes.

INTRODUCTION

According to the National Electric Energy Agency (ANEEL), hydroelectric plants represent 60% of the installed generation capacity in Brazil, with most of the hydraulic potential located in the North Region (EPE 2018). Such indicators are controversial regarding the preservation of the Amazon biome. The inseparable scenario of conflicts is further intensified by the presence of numerous indigenous communities and by the existence of public policies to protect these people and their territories, which are opposed to the current development model. Thus, a reformulation of environmental indigenous justice is fundamental to connect the rising environmental challenges with respect to local ethnicity (Morrison *et al.* 2019; McGregor *et al.* 2020).

In this context, the viability of hydroelectric projects results in new challenges for the public authorities and for the entrepreneur, the latter being responsible for implementing mitigating and compensatory measures to the negative impacts generated by the plant. It must be considered that, on the one hand, it is necessary to meet the requirements of the economic paradigm; on the other hand, it is essential to keep the diversity of alternatives for human existence (Brazil 2007, 2015).

Many indigenous peoples around the world find dominant models of sustainable development disrespectful. The terms 'sustainable' and 'development' together reproduce patterns of exploitation, while in effect imposing a regime of colonial praxis on indigenous peoples and lands under a benevolent guise of civilization, salvation, and progress (Vásquez-fernández &

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Ahenakew *et al.* 2020). In this context, the aforementioned researchers seek to assess the sustainable development model through indigenous and modernity/colonial approaches. Through indigenous peoples' paradigms, together with respectful inter-being-relationship concepts, indigenous perspectives on 'sustainability' and 'development' can strengthen sovereignty and well-being.

It is known that the need for the inclusion of indigenous residents in the influence of the hydroelectric plants, in the steps of preparation and implementation of mitigating and compensatory measures, corresponds to a demand of increasing prominence, as it leads their desires to the final decision of the Brazilian Environment and Renewable Natural Resources Institute (Ibama) and Indian National Foundation (Funai) – licensing and intervening bodies, respectively.

In fact, indigenous knowledge provides a holistic view of environmental management, which could contribute to strengthening power generation governance, if indigenous people are consulted in a respectful and meaningful way. Thus, the impacts of hydroelectric dams, even small ones, are significant not only for ecological fragmentation, but also for the fragmentation of social relations and the recognition of ancestral knowledge. The relevance of ethnographic observation, by providing information on social and environmental impacts in an interlaced manner, contextualizes place, culture and power dynamics. Thus, to understand alternative power systems and the cultural and environmental changes that they can bring about, research is needed within and with the participation of indigenous communities. Furthermore, the uneven costs and benefits of the transition to renewable energies must be contextualized with the affected peoples (Kelly 2019).

Kurniawan *et al.* (2021) cite in their study that the environmental impact assessment (EIA) follow-up programme that involved an indigenous community was able to verify the effectiveness of a project's mitigation measure. The questionnaire survey ($n = 370$) indicated that the community's opinions emphasized the implementation of programmes in the environmental dimensions; however, they were satisfied with the results of the programmes in the economic and social dimensions. Respondents' work history was consistently ranked well and positively related to respondents' opinions of programme effectiveness. Overall, the study provides insights into how community feedback for EIA follow-up can lead to benefits regarding project corrective actions, as well as providing input for the government to decide permits, contracts, or other legally binding documents.

Therefore, this research covers an empirical case composed of a project developed as a condition for the environmental licensing resulting from the environmental licensing of the Belo Monte Hydroelectric Plant (BMHP), built in the middle course of the Xingu River, in the state of Pará, which implies a new local reality. Among the various measures established in the Environmental Basic Plan to obtain the installation licence, the sewer system design (as a compensatory measure) was implemented in the Paquiçamba Village, the responsibility for which fell under the public power by the Special Secretariat for Indigenous Health (Sesai). The project was ensured by environmental licensing, based on a political incentive to build basic sanitation infrastructure, and resulted in the promotion of actions that led the village sinks and tanks to replace jiraus (grid of poles fixed to the ground, which serves as a grid to expose any objects to the sun), and the construction of masonry bathrooms, with the respective sanitary sewage (Eletrobras 2009).

The core of the research focuses on the hypothesis that the design and implementation of the sewer system (simplified system) in the Paquiçamba Village were permeated by different interests and power relations, which led to the marginalization of indigenous peoples. Thus, the objective of the research was to characterize the process of the sewer system of the Paquiçamba Village within the scope of social participation and ethnodevelopment.

The principles of ethnodevelopment include respect for the autonomy and self-determination of indigenous peoples, developing activities guided by the precepts of sustainability, not generating technological or economic dependence, and with a view to protecting indigenous lands and valuing the knowledge and techniques of these peoples. Sampean & Sjaf (2020) report that ethnodevelopment is used as a critical attitude towards the political economy paradigm of liberal development which is Eurocentric using the modernity paradigm, which also implies both technology and knowledge transfer from the north to the south.

Study area and reference data

The Paquiçamba Village (geographical coordinates 03°30'11"S and 51°48'9"W) is circumscribed in the municipality of Vitória do Xingu, and the Jurunas indigenous are the main ethnic group. The choice of this village was justified by the proximity of the BMHP, as the village is located in the plant's direct influence area, on the left bank of the reduced flow rate section of the Xingu River, and one of the most impacted from social and environmental perspectives.

The Paquiçamba Village comprises, along with two other villages, the Paquiçamba Indigenous Land, which covers an area of 157.3 km², being 17.0 km² of firm ground, and the rest composed of islands, rocks, waterfalls and streams. The streams are shown as the main occupation factor in the region, from which the productive and social processes gain such importance (Eletrobras 2009).

The population of this village is composed of 22 families (77 people), and the adults (>18 years old) represent approximately 70%.

Case study methodology

The case study was based on methodological procedures of qualitative research, using interpretative material practices, with the search for meanings given to phenomena capable of being understood in greater dimension within its empirical reality (Creswell 2014; Miles Huberman & Saldaña 2014). A theoretical–empirical strategy was adopted based on the concept of ethnodevelopment and the logic of the Public Policy Cycle proposed by Howlett Ramesh & Perl (2013), composed of the stages of setting the agenda, policy formulation, decision-making, implementation and evaluation. It is believed that the greatest contribution of this cycle is the discernment that there are different moments in developing a policy, and that the recognition of them can provide a greater capacity for intervention in the political process. It is possible to investigate the role among different institutions, actors and ideas participating in the production of politics and not just government agencies, such as entrepreneurs of hydroelectric plants.

The period from 2009 to 2018 was defined as a time frame which saw the publication of ethnoecological studies of the Environmental Impact Study (EIS) of the BMHP until the year of implementation of the sanitary sewage system.

Data collection – documentary analysis stage

The documentary analysis stage was based on the electronic files related to the environmental licensing of the plant, available in the database of Ibama and Funai, and in the documents acquired in Altamira, in the offices of the entrepreneur (Norte Energia SA – NESA) and the Special Sanitary District Indigenous (SSDI), a decentralized unit of the Indigenous Healthcare Subsystem, subordinated to Sesai and responsible for local health and sanitation.

Data collection – fieldwork stage

The authorization to enter the indigenous land was issued in August 2017 and was valid for 1 year (Proc. 08620.147758/2015-18). To enter the indigenous land, it was necessary to observe the Funai regulations, taking advantage, among other requirements, of consent from the leaders of the indigenous people.

Regarding the number of interviewees, Guest Bunce & Johnson (2006) reviewed, in the Social and Behavioural Science literature, 24 books of research methods and seven databases and reported that there was little progress regarding the concept of saturation. However, the authors state that saturation fluctuates according to the heterogeneity of the interviewed group: the more heterogeneous, the greater the number of interviews. Thus, insofar as it is qualitative research, its validity does not refer to the number of individuals involved (sample size) but to the extent of their involvement. There is no rigour with representativeness, but with the consistency, coherence and transparency of the information. As this is a village with a few families (22 in Aldeia Paquicamba), it was planned to apply for the interview to an adult or senior representative of the family. During interviews, attention was paid to the profile of respondents (sex, age and education) to analyse whether these factors led to trends in the types of responses.

The first moment of primary data collection occurred through a field pre-test, carried out between 20 August and 1 September 2017, carrying out individual interviews in the Paquicamba Village, non-participant observation, verification of the sanitary infrastructure, and photographic records. The offices of NESA, Funai and SSDI Altamira were also visited, with the purpose of obtaining documents not available on the official websites and photographic records of the health structure before the implantation of the BMHP.

The interviews, specifically related to the design and implementation of the sewer system, were carried out according to the script presented in Table 1.

Questions

- (i) Were there difficulties that prevented the construction of the sewer system from proceeding as you expected? If so, what were these difficulties?
- (ii) After the construction of the toilets, is it more comfortable to take care of the needs (urine and faeces) and have a bath?
- (iii) Does everyone in your family use the bathroom?
- (iv) Have there been any problems with the bathroom/sinks/tanks? (If positive, activities reached, frequency and duration)
- (v) Have there been changes in the hygiene habits of the residents, with these new structures?
- (vi) How do residents communicate with NESA, DSEI Altamira and Funai to expose defects related to the new structures?
Do the issues take time to be resolved?
- (vii) Did you know how toilets are supposed to work?

Table 1 | Structured interview script on indigenous views focused on the sewer system after the construction of the Belo Monte Hydroelectric Plant

Date: ___ / ___ / ___ Time (start): _____ Time (end): _____ Number: _____
 Name _____ of _____ the
 interviewee: _____
 Male: _____ Age: _____ School level: _____

 Ethnicity: _____

 Residence time in the village: _____ Number of residents in the house: _____

(viii) Was there any kind of course provided by NESAs or DSEI Altamira to teach the correct use of structures or how to solve possible concerns?

(ix) In general, do you believe that the implemented structures considered the reality of the village?

(x) Are there any comments you would like to make after this conversation?

The field pre-test in the Paquiçamba Village aimed to verify the coherence of the hypothesis, to identify whether the open questions in the script (initially semi-structured) were understood by the indigenous people and were in a correct sequence; whether there were objections to the questions; if the length of the script was adequate, with timing of each interview; whether the script directed respondents to the purpose of the research; whether there were questions whose answers could be obtained by other collection methods; if there were difficulties at the time of the dialogues. At this time of collection, seven interviewees were counted, including the two indigenous leaders.

With the pre-test, it was found that all questions were understood, but some answers were provided by the indigenous person before the corresponding question. Besides, all respondents ended up talking about other topics, generally referring to the various negative socio-environmental impacts caused by the construction of the plant. It was noticed that these other themes were brought up because of great dissatisfactions related to the local prognosis of the plant project, with the various mitigating and compensatory measures carried out by NESAs being considered insufficient or ineffective by the indigenous peoples. These other topics implied a longer interview time, which approached 75 min for each interviewee. There was 86% objection regarding the recording of the dialogues, a procedure which for this reason was not performed.

The non-participant observation technique was chosen because it is considered very useful in obtaining information on aspects of social reality, presenting as one of the main advantages in the perception of facts without any intermediation as reported in the literature (Marconi & Lakatos 2008; Creswell 2014; Ma *et al.* 2020; Malik *et al.* 2021; Nyam & Stella-maris 2021). The moment of observation was followed the guidance proposed by Denzin (2009) and Liu & Maitlis (2010) and was divided into three phases: descriptive observation, focused observation and selective observation, until reaching theoretical saturation, when new observations would not provide any additional knowledge.

The definitive fieldwork was carried out during July 2018 and focused on the photographic records, as well as the consolidation of the analysis of the sanitary sewer infrastructure of the Paquiçamba Village, for an adequate evaluation of its building and functionalities, through systematic non-participant observation and structured interviews, to record the points of view of indigenous peoples regarding the effectiveness of the system.

METHODS

Treatment and analysis of data

The organization and analysis of the data followed Creswell's proposal (2014) (Figure 1), with the activities subdivided into four phases: pre-analysis, coding and treatment of results, inferences and interpretation, representation and visualization.

In its first round, the data were organized in the form of texts using secondary data (preparation and implementation of sanitary sewage projects) and primary data (interviews). The interviews were transformed into texts and subsequently into files inserted into ATLAS.ti, with the addition of new understandings. Then, there were additions of reminders, constitution

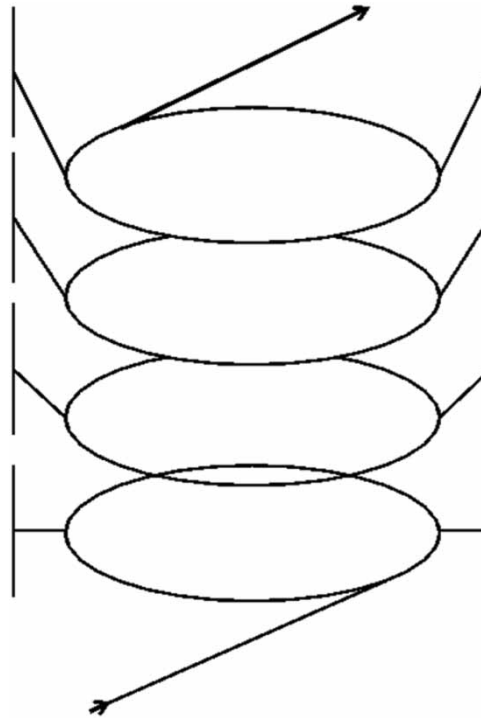


Figure 1 | Spiral used for data analysis. *Source:* adapted from Creswell (2014, p. 149).

of the textual material collected and floating reading. The texts were separated into parts, forming the analysis categories (codes). The first two turns of the spiral are equivalent to the pre-analysis phase, where the events were described in chronological order, with the search for evidence of each step in the evolution of the case.

Through coding, basic units (categories) were sought, around which the content of the texts was organized for consultation. We started from data that had common criteria, or analogies in their subject, and after organization, there was a cut to a semantic level (Registration Unit). Thus, the information elements have been categorized through the themes and their respective registration. The five themes used, related to the sewer system, are: (i) infrastructure, with the sub-themes reaching the goals and attributes of the sewer system implemented; (ii) acceptability of structures and services, with the sub-themes level of approval related to the structure, the level of approval related to services and the level of comfort; (iii) interface with the parties involved, with the sub-theme communication for problem solving; (iv) training, with the sub-themes training to use the sewer system and training to support the maintenance of the system; (v) transformation, with the sub-topics comparing sewage services (before and after implementing the sewer system), number of users of the structures and changes in hygiene habits. The transposition of data from documents into a structure guided by the themes was supported by ATLAS.ti software (Flick 2009; Cantero 2014; Creswell 2014; Friese 2014).

The treatment and analysis of data to represent its content were mediated by descriptions, inferences and interpretations. The interpretation, a step that gives greater meaning to the data, was supported by the theoretical–conceptual framework. While the encoding of secondary and primary data is associated with the third loop of the spiral, the treatment of results, inferences and interpretations are connected with the third and fourth loop.

At the end of the spiral, there is the representation and visualization of the data, where the research results are portrayed in extended verbal and non-verbal language. The last round can be considered feedback of the initial ideas that led to the formulation of the guiding question and the objective of the study, with confirmation or refutation of the hypothesis and pointing out the conclusions and recommendations.

RESULTS AND DISCUSSION

The elaboration of the sewer system design was initially conceived in the ethnoecological studies of the EIS, which contain records on the diagnosis of the health situation of the Paquiçamba Indigenous Land and the forecast of the socio-environmental impacts

on which the design was based. Since developing the EIS, published in 2009, the need for effective participation by indigenous people in the different phases of the study has been highlighted to ensure the good results of the work.

The reach of the effectiveness of projects of this type favours both the indigenous people themselves, in improving the quality of life, and for all: the entrepreneur, in compliance with the environmental condition; Ibama, regarding its licensing; Funai, in promoting indigenous rights; Sesai, in monitoring compliance with the condition and its consequences. In view of the observations and analysis displayed in this paper, it becomes evident that the Jurunas were not simultaneously able to be authors and recipients of a project that outlines their own practices and their territory. Therefore, the social participation developed is visualized as something symbolic, covered by a legal framework for licensing, without the intention of achieving significant reformulations.

Social participation in the process of simplifying sewer system design

In ethnoecological studies, the existence of intense interaction among technicians and Juruna indigenous, in the impacts' assessment and the proposition of the environmental conditions of licensing, is stated. Eletrobras, responsible for the studies, selected the Problem Tree as a methodology to support indigenous people in the joint identification of impacts (Eletrobras 2009). This methodology is one of the tools of the Participatory Rural Diagnosis in diagram format that aims to analyse the relationship between the cause and the effect of aspects linked to a problem (in this circumstance, the impacts that the indigenous people thought had already occurred, and the potential caused by the Belo Monte design). The other tools used in developing ethnoecological studies and derived from the methods of direct observation and Participatory Rural Diagnosis were represented by individual interviews, spoken map, brainstorm, river expedition and impact matrix (Eletrobras 2009).

When opening space for residents to expose their own understandings, the three trees built took on importance as a complementary method of information when conducting of ethnoecological studies. The selection of this type of tool followed the provisions of Funai's terms of reference, which determined that studies should be characterized by interdisciplinarity and applying methodologies from the exact and natural sciences, as well as from the human and social sciences, with meetings in the villages. However, in parallel, it appears that in the same term the need to promote the effective participation of indigenous groups was also pointed out. Also, in the empirical case, although the Problem Tree and the other methodologies used have a democratic nature and potential for developing awareness, criticism and power acquisition, its use also incited superficial engagement. A kind of grant of participation took place in Paquiçamba Village, with the performance of Jurunas within parameters previously outlined by the technical team responsible for the studies.

Among the measures arising from ethnoecological studies, the sewer system and solid waste disposal project were suggested with a view to building suitable sanitation conditions. Until environmental licensing, the first two stages of the Public Policy Cycle, proposed by Howlett Ramesh & Perl (2013), are identified. These stages confirmed the recognition of the precariousness of basic sanitation in the village, and the prediction of the design is equivalent, respectively, and preliminarily, to that of a definition of a problem and to the proposed first draft of the solution.

The Basic Environmental Plan (BEP), one of the documents required to obtain the Belo Monte plant's installation licence, was published in 2011, with the sewer system design envisaged therein. The design started from the sanitation deficit diagnosed in ethnoecological studies and from the need to seek sanitary improvements for each home space and for collective spaces, to promote local health conditions and, consequently, individual and collective health. For this purpose, sinks, tanks and bathrooms with toilet, shower and sink were installed, connected to the sewer system, septic tank and filter. Collective spaces were also contemplated, seeking to improve hygiene conditions, in addition to promoting health and environmental education (NESA 2011). At the Aldeia Paquiçaba Indigenous School, a handwashing tank and three bathrooms with a sink and toilets were built (one for male children, one for female children and another adapted for the physically handicapped), whose effluents are intended for the septic tank and filter (NESA 2018).

In the sewer system design proposed in the BEP, which reiterated the policy formulation, the stages of execution for the resolution of the problem were identified and refined (prospecting, basic design, executive design, implementation and monitoring). This moment included a smaller number of indigenous participants compared to the phase of ethnoecological studies. This fact confirmed the positioning of Howlett Ramesh & Perl (2013) regarding the formulation of the policy. In this sense, it is emphasized that the legal framework that governs the licensing does not refer to the inclusion of the population in the preparation of the BEP, making use of this the previous moments of definitions. And the communication channels created.

In view of the evidence on the sewer system design, this case would deal with external resources (NESA's financial contribution) and decisions initially taken together (NESA and indigenous people) in the elaboration of ethnoecological studies.

Thus, the selected proposal for a technical solution fits into the imposed culture, representing the continuity of Funasa's policies. Paradoxically, the same proposal can also be classified as an appropriate culture, as the indigenous people could choose the technical solution. This framework is possible so much that the control of cultural action can be partial, and creates a foundation for ethnodevelopment.

After approval of the BPE, Funai determined the presentation of its Operational Plan, a document that reflected the actions to materialize in the villages: the schedule of products to be delivered by each of the plans, programmes and projects; the means for its implementation; and the performance of the different actors involved. The document, which reflects decision-making (third stage of the Public Policy Cycle), was approved by Funai in April 2013 and presented six stages of execution: prospecting in the field; prospecting, preliminary studies, preliminary, basic, and executive designs, and civil construction.

The field prospecting (identification, qualification and mapping of the current situation of infrastructure conditions, and definition of emergency actions) had already started before the publication of the Operational Plan. It was carried out by applying a form in the Paquiçamba Village on the socioeconomic diagnosis and on the infrastructure to assist the elaboration of designs and the definition of priorities (NESA 2018). The prospecting (elaboration of diagnosis and consolidation of the surveys on the infrastructure) extended beyond the planned term due to the understanding, on the part of the entrepreneur, that the Paquiçamba Village was subject to daily changes due to the works resulting from other designs, also resulting from licensing, leading to a constant updating of the information that made up the diagnosis. In addition, preliminary studies took place only in 2014, whereas the preliminary design and basic design of the family and collective nuclei, for which the SSDI Altamira is responsible, had already been made available in 2011. The planned executive design (2012–2014) was carried out and completed in 2015. The civil construction stage, completed in 2016, encompassed actions that went through the infrastructure works, such as the bidding process to select construction companies, the authorization of Funai to enter the Indigenous Land for the start of construction, and the vaccination of workers, as also determined by Sesai.

It seems there was an overlap of other steps indicated in the Operational Plan. One of the justifications issued by NESA is related to the inclusion of the project in the Emergency Plan for the Protection of Indigenous Lands in the Middle Xingu under the influence of the Belo Monte plant, which determined the anticipation of some measures and the postponement of others.

Evaluation of the effectiveness of the sewer system design

Non-participant observation and applying the structured script became moments of learning, the uses of different spaces being captured, how people appropriate, the structures implanted, and the opinions and feelings of the indigenous people about such structures.

Thematic content treatment and analysis (Bardin 2016), connected to the third and fourth laps of the analysis spiral (Creswell 2014), allowed the description, interpretation and inferences according to the village. However, the descriptive and interpretive process had already started during the fieldwork, given the dialogues and the observed social and cultural reality, and was especially related to the theoretical–conceptual framework under development.

During the fieldwork, 21 of the 77 indigenous residents in the village were interviewed, one per residence between adults and the elderly, making it possible to detect saturation of responses. Residence time in the village, among adults, varies from 3 to 82 years. The recording of interviews was not authorized by most of the respondents, even though their anonymity was ensured through the consent form, which made it difficult to record part of the data for later transcription. Regarding the level of education, most adults do not have elementary school education (~51%); the complete elementary school comprises about 26% and the average level 23% of the population (Table 2). One of the difficulties in the context of education in the village lies in the fact that there is no option for students who complete elementary school, requiring them to travel a long distance (~48 km) to the city of Altamira. Even though the village belongs to the municipality of Vitória do Xingu, in practice some issues related to the education of its residents have Altamira as the responsible municipality.

Before the new sewer system, the indigenous people of the Paquiçamba Village had in their homes only jiraus for washing domestic utensils (Figure 2), structures that still exist in some residential nuclei. Although the water reached the taps, sometimes intermittently, these structures were not connected to a sewer system. With this breakdown, the wastewater was thrown directly onto the ground, together with food scraps, which flowed to other parts of the land.

For bathing, the Jurunas mostly used the Xingu River itself or the units built by themselves; some of these are still present in the Paquiçamba Village. The physiological needs were carried out in the open or in individual solutions without water, named

Table 2 | Data related to the residents of the studied indigenous village

Number of residents in the investigated indigenous village	Number of indigenous people interviewed	Age of people interviewed	Respondents who do not have primary education (%)	Respondents who have completed elementary school (%)	Respondents who have completed high school (%)
77	21	3–82 anos	51	26	23

dry pits, quite common in isolated places such as the study area. The dry pits are composed of a covering that serves to shelter the user and be a complement to the protection of the structure, with a base and floor, a set-up called ‘sanitary’ by the indigenous people. Because some residents did not consider defaecation comfortable, they sought to overlap a toilet over the pits. In [Figure 3](#), it is possible to observe these structures.

When asked about the places where they met their physiological needs, almost 55% of the indigenous people replied that they used both dry pits and bush, while 14% used only bush and 4% the river. Thus, open defaecation was a recurring practice, bringing, in this case, a counterpoint to be discussed. If, on the one hand, the United Nations has as one of its objectives ‘to achieve access to adequate and equitable sanitation and hygiene for all, and to end open defaecation [...]’ by 2030 ([UN 2015](#)); on the other, it also deals with local cultural habits. Reconciling the two issues and promoting ethnodevelopment is a major challenge, because even if this type of defaecation is devoid of any sanitary and hygienic measure, representing one of the most extreme manifestations in the context of public health, it is necessary to consider the specificities of each indigenous ethnicity.

For some residents, these locations were not safe due to the presence of certain types of venomous animals; therefore, the occurrence of some problems was registered. In addition, accidents involving domestic animals have already occurred, which fell into dry pits when children forgot to close the door of the ‘toilets’. Furthermore, in addition to many residents not feeling safe using dry pits or undergrowth, some also did not find the act of squatting defaecation comfortable, seeking for the latter case the placement of a toilet over the pits. Likewise, this alternative did not have a sewer system attached. Therefore, in response to the sewer system design, a tank for washing hands and three bathrooms with a sink and toilets were built (one for male children, one for female children and another adapted for the physically disabled), whose effluents are destined for the septic tank. Implementing the structures included in the sewer system design in the Paquiçamba Village occurred in 2017 and 2018 ([NESA 2018](#)), completing the fourth stage of the Public Policy Cycle (implementation).

Due to several obstacles to the work (not reduced work, lack of material and delays), the dimensions of the bathroom were below what many wanted, contrary to the expectations of those interviewed. ‘...*What we wanted was a bigger bathroom, which could be shared, a place to bathe on one side and the toilet on the other. We also asked for a shower, they didn’t want to do it*’.

**Figure 2** | Household jiraus with wastewater disposal.



Figure 3 | Improvised unit for bathing, 'sanitary', and dry pit with toilet.

After the construction of the bathrooms, the fulfilment of the physiological needs and the bath became more comfortable for the interviewees' unanimity. However, when they are away from home, some children still use the river to defaecate and urinate, as they prefer not to travel long distances just to meet these needs. When they are carrying out agriculture and fishing, adults choose to use the bush to defaecate and urinate.

An elderly woman interviewee illustrated this perception. She stated that she only uses the bathroom, because the recent opening of roads in the region has increased the number of people who move around the village, which gives her a feeling of lack of peace and risk of being surprised by these people.

The proposition of projects of this typology must always consider the ethnic particularities of each person, as there are marked differences in indigenous sanitary habits in the universe of the Belo Monte Plant, which interfere in assessing the effectiveness of the sewage infrastructure.

The allocation of resources (whether public or private) can be better used when discussions with indigenous peoples are expanded in choosing the solution, so that before choosing a technology, they need to be more aware of their advantages and disadvantages.

In the case studied, the construction of masonry toilets led to the need for new sanitation habits. These new habits do not always materialize, either because of the indigenous conception of the health-disease process that outlines their hygiene practices that are sometimes small in relation to the surrounding society, or because of the inability of the management bodies' resources to promote health and sanitation campaigns in the villages, which could encourage cleaning of toilets.

With the insertion of the Belo Monte Hydroelectric Plant in the Xingu valley and under pressure from the physical, biotic and socioeconomic environments, the indigenous peoples continue to transform some habits to resist the negative impacts arising from the construction of the large engineering project. Some of these habits are related to sanitation, and the appropriation of the new structures claimed by themselves. In this sense, the search for appropriation should not be seen as a negative change in the way of life. It should instead be seen as an exchange of knowledge that must guarantee not only access to structures, but also the control of new knowledge so that they can better use them.

CONCLUSION

Although the sewer system design was conceived together with the mixture of technical and traditional knowledge, and its procedures endorsed by public bodies, it is worth mentioning that Jurunas are in a situation of inequality of knowledge regarding inputs to technological developments of this nature. It would be up to the observance of basic principles of ethnodevelopment and, thus, it would not be just a matter of overcoming the local deficit in sanitation and of transforming residents through education and effective participatory democracy to expand the potential of indigenous knowledge.

The Belo Monte Hydroelectric Plant is the third plant in the history of the Brazilian electricity sector – preceded by Tucuruí and Balbina – whose implementation included indigenous health issues, and its measures can serve as a basis for future projects that include plans, programmes and projects aimed at indigenous peoples. Thus, it is recommended that the future realization of projects of this nature in indigenous lands should be preceded by a wide range of activities aimed at health education for users, highlighting the benefits of improving the quality and extending the life expectancy of the affected peoples.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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First received 17 May 2021; accepted in revised form 14 December 2021. Available online 28 December 2021