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Multidimensional and multitemporal energy injustices: Exploring the downstream impacts of the Belo Monte hydropower dam in the Amazon

Laura Castro-Diaz^{a,b,*}, Maria Claudia Lopez^c, Sharlissa Moore^d, Lucero Radonic^e, Jennifer Hobdod^f, Emilio Moran^g

^a Global Institute of Sustainability and Innovation, Arizona State University, Tempe, USA

^b School for the Environment, University of Massachusetts, Boston, USA

^c Department of Community Sustainability, Michigan State University, East Lansing, USA

^d Pacific Northwest National Laboratory, Richland, USA

^e Department of Anthropology, Northern Arizona University, USA

^f Sustainability Research Institute, School of Earth and Environment, University of Leeds, UK

^g Center for Global Change and Earth Observations, Michigan State University, East Lansing, USA

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ABSTRACT

Energy transition technologies, such as hydroelectric dams, have been seen as symbols of progress, cheap energy, environmental sustainability, and resource abundance, leading to overestimating their benefits and underestimating their drawbacks. In this study, we use the tenets approach of energy justice and a qualitative case study to explore, from a multidimensional and multitemporal perspective, the impacts faced by the inhabitants of a community located downstream from the Belo Monte hydroelectric dam in Brazil. Through observations and in-depth interviews with fishers, data were collected at three points: during the late stage of construction (2016) and early operation (2017, 2019). We found that individuals confront multiple and diverse energy injustices at various stages of dam construction, and perceptions of their severity change over time. Thus, we show how the multidimensional and multitemporal perspectives are intertwined and point to the need for further multi-temporal studies to better understand the impacts of energy transition efforts on communities.

1. Introduction

The most recent Intergovernmental Panel on Climate Change report [1] emphasizes the urgency of a swift energy transition from fossil fuels to cleaner, low-carbon energy sources. Additionally, there is an anticipated increase in global energy demand of 50 % by 2050. Countries in the Global South have favored hydropower for achieving these goals under the premise that it is a low-carbon and sustainable energy source that will meet their energy growth needs [2–4]. However, the construction of hydroelectric dams increases social and environmental inequities across multiple scales [5–8] due to their social-ecological effects. These effects include the displacement and resettlement of human populations with little or no prior consultation [9–11]; an increase in deforestation [12,13]; reducing access to common-pool resources such as fisheries and forests [14,15], increasing food insecurity [16,17]; and reducing social capital [18,19], among others. Thus, the construction of dams has

deepened poverty and hunger near the construction areas [20–23] and has affected the livelihoods of people in nearby communities [24–30].

Some regions within the Global South have expanded the construction of hydroelectric dams in rich cultural and biological river basins, such as the Amazon and the Mekong [13,31]. To illustrate, Brazil has the second largest hydropower capacity in the world (260 GW) [32,33]. The Brazilian Amazon has the greatest hydropower potential within the country (70 %), with 221 hydropower dams already operating and more than 200 dams planned [34–36]. It is noteworthy that while the energy from these hydroelectric facilities is generated in the Amazon, the main consumption centers are in the southern and coastal areas of the country, where the larger cities and industries are concentrated [5]. The Brazilian government and a privately-held consortium, Norte Energia, promoted the construction of Belo Monte as a national interest project for the country's development and economic growth, disregarding local social-ecological impacts and opposition from civil society [37,38].

* Corresponding author.

E-mail addresses: Laura.Castro.Diaz@asu.edu (L. Castro-Diaz), mlopez@msu.edu (M.C. Lopez), sharlissa.moore@pnnl.gov (S. Moore), lucero.radonic@nau.edu (L. Radonic), J.E.Hobdod@Leeds.ac.uk (J. Hobdod), moranef@msu.edu (E. Moran).

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President Rousseff gave the construction approval before the completion of the Environmental Impact Assessment (EIA) and against the recommendations of the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) [19,39].

We use the tenets approach of energy justice to explore, from a multidimensional and multitemporal perspective, the impacts faced by the inhabitants of a community located downstream from Belo Monte who were not officially recognized as affected, yet depended on the river for their livelihoods. We conducted a multitemporal qualitative analysis, which adds to the literature on dam development, given that most studies around dams are done at one period of time [40] while overlooking the temporal dynamics of the effects generated by dams [29,41]. Energy justice [42–44] provides a way to understand and assess energy dilemmas since it allows researchers to explore the distribution of (in)justices (distributional justice), wherein historically disadvantaged stakeholders are misrecognized or ignored (recognition injustice). It also allows exploration of whether diverse stakeholders were included in the processes of decision-making (procedural injustice) and how to redress historic and longstanding injustices (restorative injustice). More recently, energy justice scholars have started to include capabilities justice, as it focuses on individuals' well-being to counter a mainstream tendency to concentrate only on overall economic growth and ignore the multiple dimensions of livelihoods at the individual level [45–47].

In the Global South, most of the literature on energy justice focuses on integrating distributional and procedural justice [48], downplaying the multidimensionality of energy (in)justices. Likewise, the hydropower literature mainly focuses on distributional and procedural injustices faced by communities affected by the construction of dams [49–51]. As such, some energy justice issues are identified, such as the negative impacts of hydroelectric dams on communities living near the construction sites and their lack of participation in meaningful decision-making processes. However, this focus misses a deeper understanding of how local actors experience multiple energy injustice dimensions and how these dimensions interact to further the injustices.

We present a systematic overview of the energy injustices experienced by local actors in a community downstream from Belo Monte. Downstream communities are usually not included in EIAs and decision-making processes related to dam development [17]. They are excluded from compensation and resettlement due to their location and distance from the dam [24]. They suffer from the impacts without compensation, and researchers have overlooked their effects in the Amazon Region and globally [20,24,29]. Additionally, this study expands the understanding of the justice implications of hydropower development in the Brazilian Amazon, a timely issue and a research gap in the literature [52].

Finally, given that the temporality of energy injustice is understudied, this paper also demonstrates the value of energy justice in understanding the time-dependent change processes near a hydropower dam. In particular, we studied the energy injustices perceived by the inhabitants of a community downstream from Belo Monte during three different periods: the late stages of construction (2016) and two early periods of operation (2017, 2019). Our approach highlights how energy injustices manifest themselves over time and how addressing them in the future may be possible. This paper illustrates how downstream communities face multidimensional and multitemporal energy injustices.

2. Theoretical background: energy justice

This section reviews the literature on energy justice in the context of hydroelectric dams in the Global South. At its core, energy justice directs attention to how social effects related to energy are distributed across space and time to human populations [53]. There are two main theoretical frameworks to explore energy justice. One focuses on a set of principles for providing tools for energy decisions. It considers availability, affordability, due process, transparency and accountability, sustainability, intragenerational equity, intergenerational equity, responsibility, resistance, and intersectionality [53–55]. The second

framework is motivated by the theories of justice, which initially considered three central tenets of justice: distribution, recognition, and procedural [43,44]. Then, Heffron and McCauley [42] included restorative justice as a new tenet. In this study, we use the latter framework because it provides a multidimensional and systemic perspective of energy (in)justices and allows the inclusion of other justice theories, such as capabilities, that are meaningful to analyze this case study. The principles framework assumes a universalism that risks being hegemonic. This is particularly salient for this study since the researchers are determining how to categorize issues of justice implicitly addressed by research participants.

Distributional justice refers to the uneven allocation of outcomes an energy project generates, such as electricity and long-term employment [53]. It also recognizes the unequal distribution of environmental and other ills, such as water and air pollution [43,56]. Distributional injustices can occur across energy consumption and production and at different geographical scales. Regarding energy consumption, distributional justice is clearly observed in disparities in energy poverty. Over 759 million people worldwide have no reliable, safe, and efficient electricity access [57]. In terms of hydropower development, communities living near the energy infrastructure face most of its damaging social-ecological impacts, while communities living further away receive the benefits without experiencing the ills [5,20].

Procedural justice refers to the fairness of institutional decision-making processes [58]. It focuses on how decisions are made to reach social goals [53]. It evaluates who participates and each actor's participation level by looking, for example, at the transparency and accessibility of participation [59]. The literature on procedural justice offers yardsticks for evaluating equitable energy decision-making processes, including the transparency and type of information disclosed and the representation of different social and cultural groups in processes [43,44]. Research has shown that in the context of large-scale hydroelectric dams, there is a persistent lack of participation of local communities regardless of the state's political regime type [38,51].

Recognition justice calls attention to local histories of oppression and exclusion; therefore, understanding how individuals and communities are recognized is inseparable from distributional and procedural justice [60]. Fraser (1996) explores injustices that are rooted in social patterns of representation and include the following: cultural domination, one being subjected to patterns of interpretation associated with another culture hostile to one's own, nonrecognition, being invisible and disrespected, and undergoing routine abuse [61]. From this perspective, recognition justice, as well as the other tenets, relates to inequity. Energy projects should acknowledge all those affected by energy injustices; however, there are often issues of misrecognition or complete lack of recognition. In the context of dam development, many of the communities around dams lack political and economic clout; therefore, governments have not prioritized them. They are invisible unless someone wants to extract their resources [62].

Restorative justice aims to repair the harm done to society or the environment, including by energy projects. Restorative justice focuses on the people who have been harmed; this tenet seeks recognition, reparation of their harm, and restoration of their dignity [63]. It aims to repair the damage concretely and symbolically, requiring "those who have been harmed to provide an opportunity to define their needs, rather than having others or a system define needs for them" [64]. Heffron & McCauley [42] stated that including this justice tenet would open the possibility for decision-makers to consider the whole energy system—from project planning to operation—its issues, injustices, and means of rectification. It can help point to where prevention strategies and restorations are needed [42,65]. Thus, restorative justice could be implemented before an injustice occurs (to prevent it) and after an injustice has taken place (to restore peoples' dignity) [65].

If an injustice occurs, restorative justice calls for including the voices of those affected, which can lead to remediation of the harm through compensation or other means [65]. Many governments have

implemented EIAs and Social Impact Assessments (SIAs) to avoid or propose mitigation actions to compensate for potential injustices [65,66]. Unfortunately, these methods are widely critiqued as perfunctory exercises in checking boxes rather than substantive initiatives that shape project results [67]. As mentioned before, in the case of Belo Monte, the decision to build the dam was made *before* the assessments were approved. This, unfortunately, is not an exception in Brazil, as it has occurred for other large dams such as Jirau and Santo Antonio [68]. EIAs and SIAs are often conducted by the same firm in charge of the dam construction, casting doubt on the validity of the results [69]. In addition, some have pointed to other significant problems, such as the lack of consistent rules for compensating populations for the impacts [70].

Capabilities justice is based on the work of Sen [45] and Nussbaum [46,47]. The capabilities approach broadens the idea of justice by considering how the distribution of in(justices) affects people's well-being [58] or their freedom to do things they value and the ability to not just to survive but to thrive [45]. Sen [45] noted that there are two main reasons why freedom is valuable in this approach. First, it gives more opportunities to pursue objectives, as it increases an individual's ability to decide how a meaningful life is defined. Second, freedom is vital since it matters whether individuals are being forced to do something because of others' imposed actions—in other words, freedom of choice matters for achieving justice [45]. For instance, someone who decides to move from their house has more freedom than someone who is forced to leave their home and resettle. Nussbaum [46,47] added a list of capabilities that are central, minimum requirements for a life with dignity and full access to human rights, although they have been critiqued for diverting from the capabilities approaches' focus on individuality [46,47].

Capabilities justice suggests that we look beyond the resource to what people could do or become because of this resource. In this approach, energy systems should aim not only to provide energy but also to expand the capabilities of individuals, households, and communities to achieve their goals and reach their human potential. Energy projects could impede or enhance people's capabilities [71]. For instance, the lack of access to energy could limit an individual or a community's capability to live (by increased premature death). On the other hand, constructing a hydroelectric dam could limit human capabilities for communities at the construction site or downstream, such as good health, shelter, and nourishment.

In the case of dams, researchers have not simultaneously applied all the theories of justice previously described. Some scholars have studied the distribution of costs and benefits [72]. For instance, Hess et al., [5] showed that dams have poor performance by distributional justice standards, because local communities suffer the negative impacts (burdens) but have access to very little of the electricity (benefits). Siciliano et al. [73] explored Chinese investment in Global-South dam development. They reported procedural injustices in the form of poor participation of affected communities and distributional injustices due to irregular compensation. Mayer et al., [50] identified procedural injustices as a lack of participation of locals in the processes of resettlement and compensation for Belo Monte. Castro-Díaz et al. [27] showed how in the case of 33 dams, there is a persistent lack of participation of populations living near dam construction. Mayer et al. [51] described that in the Madeira hydroelectric complex case, locals faced procedural injustices, such as limited access to information about the projects. Moreover, the participation process was not transparent.

3. Belo Monte background

Belo Monte is a hydropower facility with 11 GW of installed capacity, located on the Xingu River in the Brazilian Amazon. It was authorized by presidential decree, over the environmental agency's recommendations [50] and opposition from local actors and social movements [37,38,74]. The complex has two dams, *Pimental* and *Belo Monte*. The former supplies water to an artificial channel that powers the turbines at the central

power station: *Belo Monte* (see Fig. 1).

The project is near the municipalities of Vitória do Xingu and Altamira. Altamira was the most affected by resettlement. Over 20,000 people, in the region, were resettled from low-lying areas and islands that would be flooded by the dam reservoirs [75]. Resettled communities were located in areas that lack access to public transportation, high electricity prices and far away from their relatives, reducing their social capital [19,50]. During the construction boom period, the area's wages doubled. Then, in 2015, employment plummeted during the late stages of construction [26]. In 2015, people in Altamira supported the construction of Belo Monte. They saw it as essential for Brazil's national economic development, but from the perspective of resettled communities, it was not generating any local benefit since the construction company did not keep their promises to generate employment, improve water systems, or provide education services [50].

4. Methods

4.1. Data collection

The lead author collected data in Vila Nova, a community located 30 km downstream from Belo Monte, from June to August of 2016, 2017, and 2019 during the late stages of construction and the early operation of the dam. We selected Vila Nova because of its location downstream from the dam, which meant that the community was not recognized as affected or a part of the EIA or SIA. We also chose it because its dwellers—riverine people or *Ribeirinhos*—are people of diverse origins and ethnicities that depend primarily on fisheries for their livelihoods [76]. Vila Nova has 752 inhabitants living in 156 households. Fishing is the foundation of Vila Nova's livelihoods, and interview data reveal that in recent memory, fishing has always been important, but its role in people's livelihoods has changed over time.

In 2016, Belo Monte was still under construction, and, upstream, the Pimental dam's reservoir had just been filled. At that time, the first author started observing people's everyday lives and having informal conversations with locals, affording her insights into the community's dynamics and residents' perceptions of the dam. She also identified the activities men and women did to support their livelihoods and how these had begun to change because of the dam's construction. In 2017, she returned to follow up on the changes Belo Monte had caused in the lives of the inhabitants and the community. At that point, five of the eighteen turbines had begun operating. Finally, the third visit was in 2019, when 13 turbines were operating. During this visit, the first author collected data on the dam's impacts on community members' lives and livelihoods and how they cope and adapt. During the three visits, the first author resided with a family from Vila Nova.

We conducted in-depth interviews and direct observation during the three visits, collecting detailed data [77]. We conducted interviews (Appendix 1) with women and men of different ages living in the community, which let the interviewer guide the conversation but also allowed interviewees to bring up topics the researcher was unaware were important [77]. The study's participants were sampled based on their reputation as skilled fishers within their community. They participated based on their willingness to participate, availability, and at least ten years of experience fishing in the area. Data saturation was achieved, meaning that additional interviews were not raising new themes.

We recorded the interviews with the interviewees' consent, and local research assistants transcribed them verbatim. We conducted 71 interviews across the three years of data collection, 28 in 2016, 16 in 2017 and 27 in 2019. In total we interviewed 39 individuals, including 24 women and 18 men. They lasted between 60 and 90 min each. We interviewed 8 individuals three times, 13 twice, and 21 once. The first author conducted all interview in Portuguese. Fig. 2 summarizes the number of participants per year and the number of participants interviewed during more than one data collection period.

In addition to the interviewees described in the Venn Diagram, we

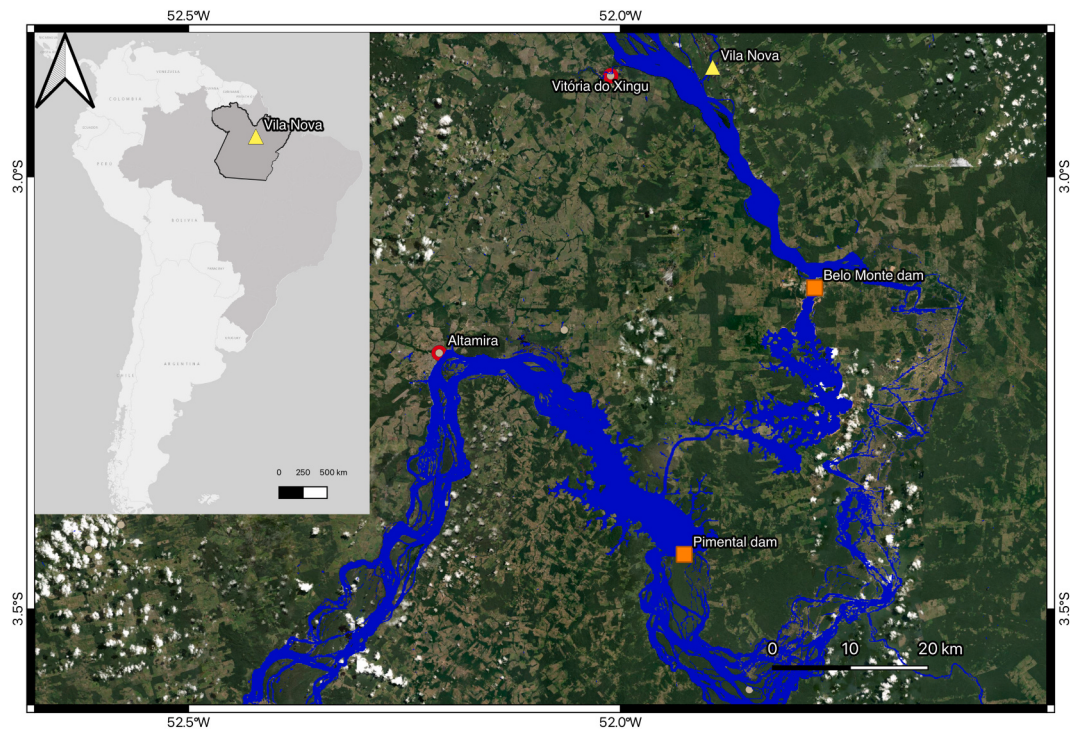


Fig. 1. Area of study.

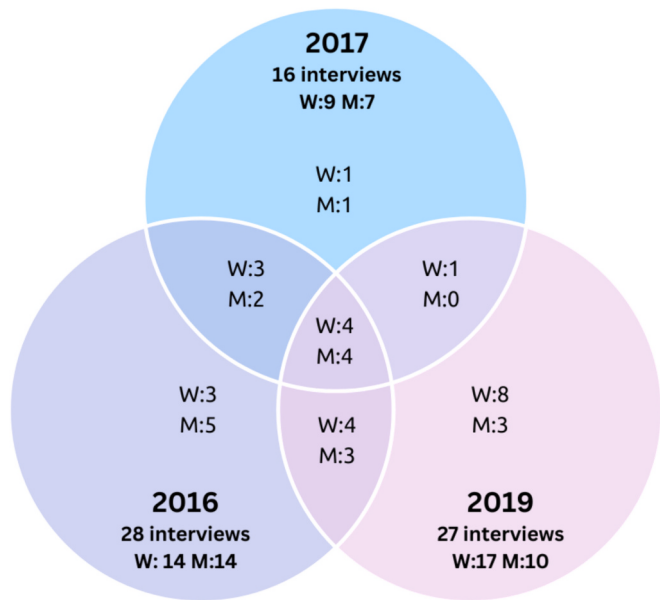


Fig. 2. Number of participants interviewed and intersections with multiple data collection points. W: women; M: men. Bold letters represent the total per year.

conducted nine interviews with members of diverse organizations in the region. In 2016, we interviewed a member of the regional office of IBAMA, a representative from the Fishers Association, and a member of MAB (Movement of Those Affected by Dams). In 2017, we had an informal interview with a group of fishers composed of 1 fisherwoman and 2 fishermen. In 2016 and 2019, we interviewed two members of LEME Engenharia, later called Tractebel (global engineering and consulting company), a company that oversaw a project financed by Norte Energia (The consortium), which monitors the fishing activity in the region. In 2019, we also interviewed 3 members of the health center

in the community to explore and triangulate information regarding changes in the health status of the population.

Our study has some limitations. We did not collect any data before the dam's construction. This implies that certain impacts of Belo Monte may have already occurred, but we were unable to document them. Furthermore, it is imperative to consider all stakeholders' perspectives within the hydropower realm. In our manuscript, we prioritize examining the perceptions of riverine communities living downstream from the dam, communities that have been historically marginalized and are understudied. By spotlighting their experiences, we aim to address this gap in research and contribute to a more comprehensive understanding of the social dimensions of hydropower development.

4.2. Data analysis

After each fieldwork phase, the first author reviewed all the transcripts and compiled all information with field notes. After the last data collection period, we analyzed the data using Miles, Huberman & Saldaña's [78] system, developing a codebook based on deductive codes from the energy justice literature. The codebook includes all tenets of energy justice discussed in the literature review as parent codes (Appendix 2). We used NVivo 12 for the coding process. To understand the issues of energy justice local actors experienced, we coded all data for 2016, followed by data for 2017, and lastly, data collected in 2019. We summarized the coding references under each child code and compared them across fieldwork phases.

5. Results

In this section, we present the energy justice issues described by Vila Nova inhabitants. First, we summarize the frequency of references related to each tenet of justice (Fig. 3). Then, we provide an overview of the results of each tenet, followed by the in(justices) experienced by Vila Nova inhabitants. This case shows that, over the years, local actors have voiced issues of distributive justice more frequently, followed by capabilities, procedural, restorative, and recognition justice. This does not mean that distributive justice is more important than the other

Energy Justice Tenets Addressed by Vila Nova’s Residents by Year

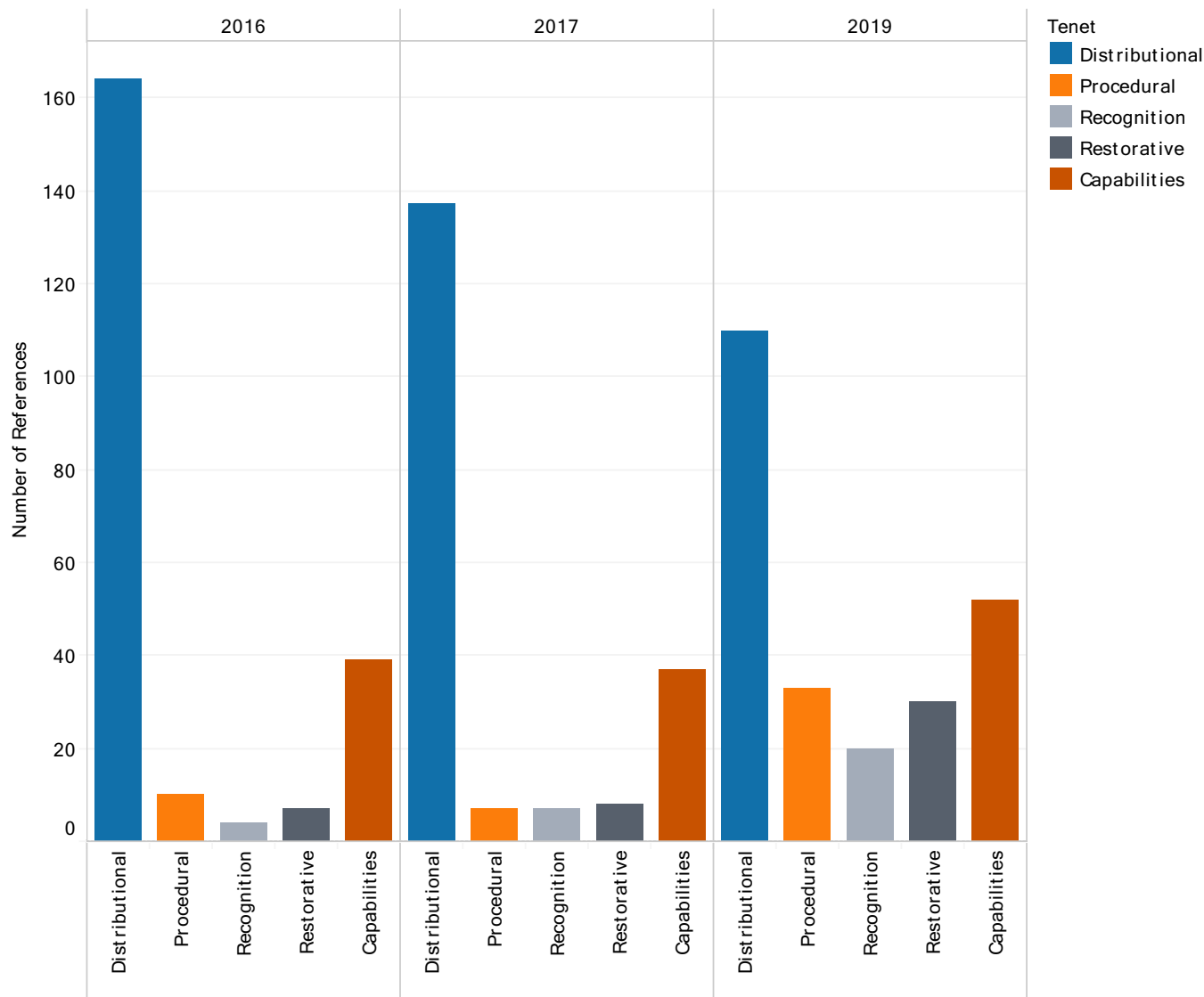


Fig. 3. References to energy (in)justices over time.

categories. Rather, it came up more often in the interviews.

5.1. Distributional justice

Vila Nova’s inhabitants experienced an unequal distribution of the benefits and drawbacks of Belo Monte’s construction. The data identified social-ecological, economic, and energy access issues.

5.1.1. Social-ecological issues generated by the dam

Most distributional justice references focus on the impacts that interviewees faced because of the dam’s effects on their social-ecological system. As reported in the literature [15,17,27,79,80] and articulated by the interviewees, dams deleteriously affect fisheries by blocking fish migration. In Vila Nova, this led to the loss of the top predator fish (e.g., *Cichla melaniae*), which are economically important because they are larger than other fish and highly valued in the market. In 2016, locals reported high fish mortality as the dam’s floodgates closed, which immediately impinged on their livelihoods. This effect was sustained owing to the persistent blockage of the river to migrating species.

While both men and women are fishers, their fishing practices differ due to patterns of mobility, fishing gear used, and household

responsibilities. Men’s perceptions of the effects of Belo Monte are related to the loss of fish, whereas women are concerned about their families’ food security and the water’s turbidity. The decline in river water quality had an immediate social-ecological impact on women who washed their clothes in the river and drank water from the river. Thus, men and women highlight different but interconnected impacts.

The adverse effects on fisheries were constant throughout the study. Since 2016, interviewees noted that Belo Monte has changed the river’s flow. They indicated that because of this change, specifically during the rainy season, fish could not travel upstream to spawn or eat the fruits and seeds from the flooded forest. Women also reported that they found dried eggs inside the fish when cleaning them before cooking. Fishers remarked on the loss of preferred fish species, such as Filhote (*Brachyplatystoma filamentosum*) and Barba-Chata (*Pinirampus pirinampu*), and a decreased abundance of fish. A participant explained:

We fish in the rainy season. The thing [the dam] diminished the number of fish. We used to catch many fish, but now, in this season, there are very few fish. The water didn’t rise anymore. If it had risen, I think the fish would have come here. But it did not.

(Fisherman, 2016)

In 2017, when the dam was starting operation, interviewees continued describing the change in the river's flow, claiming that during the rainy season, the water level was lower than before the dam's construction, and fish abundance decreased. As they had done in the previous year, they described how the dam had affected fish migration and noticed more substantial periods of drought during the summer (June to November), limiting their transportation and affecting their fisheries.

The fish disappeared, it's disappearing, and the water also dried up. It didn't rise the way it used to because when it was wintertime, from December on, this igapó [flooded forest] was filled up with water, and the fish used to eat there. Now it doesn't fill up with water like it used to. No! For example, here, on this island [pointing at a fishing spot], everything used to flood. Half of the island used to flood. We used to go inside the bush and the forest. This one was only water. We used to catch a lot of *Pacu* and *Piau* [fish], and now it doesn't fill up the way it used to; some parts stay dry, and water doesn't come in anymore.

(Fisherman, 2017)

Fishers described how fishing with their traditional fishing gear (e.g., hooks and lines) was getting more challenging because that gear was used to catch one fish at a time. According to the interviewees, catching one fish at a time required patience, but they used to catch enough for household consumption and sale. After Belo Monte, they could not catch enough fish for subsistence by using their traditional gear. In 2019, fishers continued catching fewer and smaller fish.

We catch fish, but it is not as good as we used to. Look at this other one [he points out a fishing spot]. Oh, this one right in front of Vila Nova is also a fishing spot. We fish with handlines; we used to catch a lot of *Piau*, and we used to catch with handlines *Pacu* and many other fish. Today, we don't see them anymore; we catch a few. I don't know where the fish went; everything disappeared.

(Fisherman, 2017)

As the river flow during the rainy season was lower than before the dam's construction, interviewees described a dichotomy related to its impact on their lives. On the one hand, they said they enjoy the dam's flood control because the community was not getting flooded every rainy season as it used to. On the other hand, they are bearing negative impacts on their fisheries, such as a reduction in fish abundance, size, and diversity and adverse effects on water quality. An interviewee summarized this complexity: "So, because for us here, it is not so bad because we don't have to wade in the water. But it is bad for fishing because when the water does not rise, there are not many fish." (Fisherwoman, 2019).

5.1.2. Economic issues

The dam affected the inhabitants economically through loss of income and increased costs of goods. As early as the first phase of fieldwork (2016), participants discussed the increased price of goods. Dam supporters, such as governments and construction companies, argue that dams will boost the economy in the regions where these are built [37]. However, particularly in nearby Belo Monte, communities faced steep inflation early in construction [26]. For the interviewees, the dam caused hunger in the community as the prices of goods such as beans and *farinha* (cassava flour) skyrocketed, making them unaffordable.

There are times when the money we have is not enough to buy gasoline; even gasoline has gone up a lot, and here it costs—R\$5.1 kg of *farinha* costs R\$6. We get R\$3 for a kg of fish, so a kg of fish is not enough to buy a kg of *Farinha*.

(Fisherwoman, 2016)

In 2017, the distributional issues highlighted by interviewees mainly focused on the loss of fish of high economic importance. Still, they

continued to notice the high prices of goods (e.g., gasoline, *Farinha*, and food), which impeded their food security and ability to purchase gasoline to go fishing, which provided the income they needed to buy these now-expensive items. In addition, interviewees saw that other communities were receiving compensation for the dam's drawbacks, but they were not. They even described how relatives and acquaintances received compensation because they had a house in areas Norte Energia considered impacted.

In 2019, interviewees said that some inhabitants living in the cities of Altamira and Vitória do Xingu (Fig. 1) had received compensation (at the community and household level) from the dam's construction. In the case of Vitória do Xingu, the closest urban center to Vila Nova, participants noted that Norte Energia had paved roads and constructed roads, medical posts, schools, and offices for the fisheries association. They also knew that some people received other types of compensation, such as houses, due to resettlement from areas the project flooded. As the dam's harmful effects on the fisheries became a chronic problem for the household economy, the lack of financial compensation became a salient issue and a perceived example of energy injustice.

I think that Vitória do Xingu benefited the most. Vitória, Altamira, and Belo Monte: these cities received many benefits from the dam.... Today, you can walk around Vitória; all those streets have sidewalks, and everything is paved. It seems that they are reforming the asphalt on the roads. Vitória looks very pretty. The money that came out for Vitória would have been enough to pave it all over, lay carpet, and tile the streets all over, and there was still much money left over. Right here, oh, there's nothing from the dam here.

(Fisherman, 2019)

5.1.3. Electricity access issues

Surprisingly, Vila Nova inhabitants do not receive electricity from Belo Monte. Since the 2000s, their electricity has come from the Senador José Porfírio's grid and the Tucuruí hydroelectric dam, 300 km from Vila Nova. Before this, they relied on diesel generators for four hours per day, usually between 6 pm and 10 pm. Since being connected to the grid, they have had access to electricity 24 h a day, but the service is unreliable due to grid instability. People in Vila Nova sometimes lack electricity for two to five days.

There are times when we go three days without power, there is no power, we keep calling and calling [the electricity provider], and the people don't come until one day they decide to show up and fix it.

(Fisherman, 2019)

Vila Nova's lack of reliable electricity leads to other challenges, such as limited access to drinking water, as the community needs electricity to pump water. Some households have water storage tanks that allow them to have drinkable water for several days without electricity. Yet, the electricity Belo Monte generates is connected to the national grid that provides service to the south of the country [81,82]. Therefore, nearby households cope with the drawbacks of the dam, while cities in the south of the country benefit from the access to electricity.

In 2019, when discussing the dam, interviewees expressed concerns about the high electricity prices for the first time. High prices led some to stop paying for electricity and others to tap into their neighbors' meters illegally.

And the energy bill is up from R\$50.00 up to R\$65.00. It has increased. It has increased because we used to pay 20—up to 20 and a bit we used to pay—at most 30!

(Fisherwoman, 2019)

In sum, interviewees acknowledged that other communities in the region benefited from the construction in terms of infrastructure and compensation. However, they did not benefit but experienced

significant drawbacks, illustrating significant distributional injustices. The most common drawbacks include decreased fisheries' access and increased prices of goods, including gasoline, which community members require to engage in fishing and access markets to sell their fish. In addition, they have unreliable and expensive energy that affects their water access, while far-flung urban areas that did not shoulder the dam's drawbacks benefit from its electricity.

5.2. Procedural justice

Respondents experienced two issues related to procedural justice: lack of participation in the decision-making processes and insufficient access to information about the dam. Both are related to the local residents' perception of unfair decision-making and, consequently, the lack of trust in dam developers. This perception became more salient over time as they became more familiar with how differently they were treated compared to communities that had been recognized as affected by the dam's construction from the start.

5.2.1. Lack of participation in decision-making

Because Vila Nova was not slated to be permanently flooded—arguably the most immediate and visible impact of dam construction—its inhabitants were not invited to be part of the decision-making processes regarding the dam's construction. They were not consulted before or during the construction of Belo Monte, which led them to argue that others, particularly the Brazilian president, had approved the dam without their consent. An interviewee described this procedural injustice, stating:

The president signed [on] to have this dam because it would not have happened if it were up to us. We never signed any document to do this dam; everyone was right against it. It was only the president who signed, and that's why the dam was built. But before [our community] was excellent; before this dam, it was very good. It was very nice for us to be here.

(Fisherwoman, 2019)

The consortium held meetings before and during the construction of Belo Monte in the main urban centers: Altamira and Vitória do Xingu. However, these meetings had limited space and primarily focused on Norte Energia's engineering team discussing the technical aspects of the dam [83]. National Public Security Force (Força Nacional) intimidated the meeting attendees. When asked questions, several representatives from the developer—IBAMA and LEME—and the government were evasive [84]. Residents of Vila Nova were not invited because the community was not considered affected by the project. Still, locals belonging to a regional fisheries association highlighted that they had a representative in some of the meetings because the president of the fisheries association was invited. This association represents fishers from different communities, including areas where invitations to meetings and compensation were provided. Nevertheless, in 2019, interviewees noted that they did not participate in the decision-making process, and their voices were not heard.

The president [from the fisheries association] used to come [to the community], and he said we would get compensation. By now, we should have been compensated. They said that people who were members of the fisheries' association would get something. But no one has come here, just the president, who held some meetings with the members. They said they would give some boats, motors, and other things.

(Fisherwoman, 2019)

5.2.2. Insufficient access to information

An issue that emerged in 2016 and stood out throughout the

fieldwork stages was a lack of transparency and limited access to information. Since 2012, the dam consortium has collected data about regional fisheries as part of the "Sustainable Fishing Incentive Project" in eight localities, including Vila Nova. They collected data about fish landings, fishing partners, fishing gear, visited fishing spots, species and quantity caught, and expenses. From the perception of fishers, this data is used to keep a record for the fisher's association of who are active fishers without the record; they believe they could lose their fishing permit. However, it is a one-way flow of information. While fishers share data with Norte Energia (because they perceive they must), the aims, results, and analysis of the ongoing data collection have not been shared with them.

They [data collectors] fill a form and give a copy to us. ...I think an inspector from the Fisheries Association came to get some papers from her [data collector]—the records with our information. We keep one, and she keeps the other to deliver it to the association; with these records, they know who fishes and who doesn't.

(Fisherwoman, 2016)

Difficulties accessing information about the project, including data that comes from the villagers, demonstrates its lack of transparency. For instance, it requires an internet connection, which is unavailable in Vila Nova. But even with internet access, it is difficult to find.

In 2019, interviewees shared that they learned from others in the region and local media about a crack in the dam, and the region's inhabitants became nervous. According to them, Norte Energia held an unannounced meeting in Vila Nova to deny the rumors, stating that the dam was in good condition. The lack of announcement is a procedural shortcoming. Moreover, despite the meeting, interviewees distrusted the information provided. As one respondent noted, "They [Norte Energia] say no. But it's true, and the guys went there to film [the crack]. It's true; it's not a lie, it's them [Norte Energia] lying to us." Fisherwoman, 2019.

The quotation above illustrates broken trust between locals and dam developers. From the first two phases of fieldwork, interviewees shared a lack of trust in dam developers, which intensified over time. In 2016, this was because they were not included in the participation processes. In 2019, the lack of representation in decision-making processes and the lack of trust in dam developers continued to be discussed.

5.3. Recognition justice

Data collection revealed two forms of misrecognition Vila Nova inhabitants faced: nonrecognition and disrespect.

5.3.1. Nonrecognition

Vila Nova locals are riverine people: a historically marginalized group often ignored in decision-making processes [85]. They continued to experience nonrecognition during the dam process. Because Vila Nova is downstream from the dam, Norte Energia categorized it as not directly affected. Yet interviewees highlighted how the community's proximity to the dam led to negative impacts.

Vila Nova inhabitants' lack of compensation and the company's lack of mitigation measures to reduce the impacts stemmed from their nonrecognition as legitimate stakeholders who are affected. Participants questioned why other people in the area, like inhabitants of Altamira, were resettled and compensated while they were not, as described in the following quotation:

Here is a zone of risk; why don't they [Norte Energia] want to compensate us? They don't want to compensate us, so we will be able to leave the community. What do they see in Altamira? They resettled people from the risky areas, built houses for people, and resettled them to higher altitudes; why not us? We are human beings like them there; we need help, but no one wants to help us. Nobody. I have said that we are forgotten; only God for us!

(Fisherwoman, 2019)

5.3.2. Disrespect

While closely linked to nonrecognition, the second issue of misrecognition reflected in the interviewees' accounts was disrespect. The government and private developers misrecognized them as not being legitimate stakeholders in the siting process. These actors disrespected the inhabitants by ignoring them and not providing them with accessible information. The state and the company did not see the Vila Nova dwellers as having the right to be informed and consulted before the dam's construction, and they disrespected the inhabitants by excluding them from the process. An interviewee stated:

They [Norte Energia] didn't come! They went to other places, but here we were abandoned. They did not come to talk. They said they wouldn't harm us here, but this area is where most harm has been done.

(Fisherwoman, 2016)

Data revealed issues of disrespect before, during, and after the construction of Belo Monte. In the last year of fieldwork, interviewees described how they felt mistreated, and the dam developers and the police derided them when they protested the construction of the dam. One woman said:

There were even children there, pregnant women. I didn't think we would get out of there alive! Those police with those things [shields] in front of them to protect themselves, as if we were bandits. The president comes here and cries when he speaks. [Members of the community] were injured...

(Fisherwoman, 2019)

In sum, references to issues of recognition justice increased over the years of data collection (see Fig. 3). Over the years of data collection, women made more references to nonrecognition issues than men. In the last year of data collection, men shared disrespect problems, mainly explaining how dam developers mistreated them, particularly when they participated in protests.

5.4. Restorative justice

Data revealed issues of restorative justice in the mitigation mechanisms. As previously mentioned, communities downstream from Belo Monte were not involved in the EIA. Therefore, there are no strategies for addressing and restoring the harms and injustices that Vila Nova locals experienced.

Since 2016, interviewees' references to restorative justice issues primarily describe how the dam negatively impacted their lives and livelihoods and how Norte Energia should compensate them. They argue that despite their closeness to the dam and the consequences experienced, Norte Energia has not provided any compensation (see distributional and recognition justice). This issue of lack of compensation and mitigation was predominant in the fieldwork.

Participants discussed how they deserve compensation to sustain their families in the aftermath of dam construction and its effects on their fisheries. They also have clear ideas of how they think their livelihoods and lives could be restored. We present three examples they mentioned. First, locals discussed their interest in getting some support for creating economic projects in the community, as described by a participant.

They [Norte Energia] should create an alternative to compensate the fishermens' economy. For example, they can do projects for planting crops and raising pigs, poultry, or fish, like aquaculture. Any project that could stimulate fishermens' economy.

(Fisherman, 2016)

Participants also revealed their interest in receiving not only monetary compensation for the livelihoods lost but also supplies for their fishing activities under the new circumstances,

Because of the change in the water, fishermen's activity is more complicated... People who are members of the fisheries association should get boats, motors, other things... maybe a salary, R\$2000 or R\$3000 a month, for each fisherman. But nothing has come.

(Fisherwoman, 2019)

The third restorative practice that locals described to remediate the dam's harms to their livelihoods is an opportunity to immigrate, as portrayed by the following quotation,

They [Norte Energia] should give each family at least something to get out of here. We should get compensated; we are many fishers and not asking too much. If they compensate me, I will be the first to leave. I don't even know, if they gave me the chance to go away with my family, it would be too good! I want to get out of here and find a place where I can get a job to support my children and my grandchildren.

(Fisherwoman, 2019)

During the last data collection phase, participants pointed out they were still waiting for compensation. However, they were not hopeful about receiving anything because, at the time, dam developers took no responsibility for the impact on Vila Nova, neither provided any support nor helped restore people's livelihoods. This is described by the following quotation: "*Because for us here, the dam has done nothing for us. Nothing, nothing, nothing, there is nothing done by the dam here*" (Fisherman, 2019).

In sum, the themes of restorative injustices were constant over time. Locals' references to a lack of restoration strategies, especially compensation, increased over time.

5.5. Capabilities justice

Data from interviews and observations revealed how the dam's construction impacted individuals' capabilities to live a fulfilling life.

5.5.1. Bodily health

Interviews revealed that locals in Vila Nova lack opportunities to be healthy and well-nourished. The dam directly impeded this capability. Women referred to issues such as lack of drinking water and struggling to afford sufficient food for their households. Children were reported to have limited access to food, eat less protein, and consume more processed foods than before the dam's construction. In particular, women argue that limited access to fish reduced their household food security and, therefore, their children's well-being. Since 2016, interviewers acknowledged that the dam had caused hunger, as described by a participant,

That dam ended with us here in Vila Nova, right? It ended with us. It's over! Because families are going hungry, hungry! Do you know what hunger is? They [fishers] go out in the morning and try to catch the fish to sell, to buy rice, Farinha, coffee, and sugar. If they don't fish, how can they live? Sometimes, you can't even catch one fish to cook for your kids.

(Fisherwoman, 2016)

Bodily health is a prerequisite to other human capabilities, such as access to a good education and the ability to imagine, limiting the focus of individuals' lives to survival.

5.5.2. Emotional well-being

Over the periods of fieldwork, locals shared the dam's effects on their livelihoods and lives. Women and men shared their emotions and

attachment to their livelihoods. Men described effects on their emotional well-being, such as feeling inadequate because they could not provide for their families. They used to be proud of fishing but not anymore.

So today, it's tough for you to get food for your family. Fishing is no longer enough to survive. I mean that it has changed a lot. And so, in general, fishing has changed. It has changed a lot. Today, it is more difficult for fishermen to sustain their families on fish.

(Fisherman, 2016)

This situation led to a feeling of hopelessness. Older males stated that fishing is the only activity they can do to survive. They pointed out that learning new skills or changing professions is harder for them than younger men. In contrast, younger men changed how they fish to support their families, such as using fishing gear with smaller mesh sizes, even though they knew these would harm the ecosystem.

Now, we are going in the easiest direction because it is difficult to catch with hooks or hand nets. Now we are going to use the fishing nets more often, that's why, as I just told you, in a couple of years, this other year, things are going to get even worse because the water is going to dry out, the fish that stay here in the river, in the river! They won't die this year, but the fish left in the breeding lake will die. The water will decrease, and if it dries up, they will all die. Then, fish will be reduced even more.

(Fisherman, 2016)

Women described living in fear because of the rumors of a crack in the dam and the associated risks. In 2016, they were primarily afraid that dam developers would open the floodgates during the rainy season and the community would be underwater. They highlighted that they live downstream from the dam and will be affected.

Ah, we have been worried here for awhile, all worried, all afraid, because people say that it was cracked, when the rain was pouring down, it was breaking, and everyone was desperate... And we had a hard time here with fear. And there is nowhere to run, no! If, God forbid, it blows up, it will be like those [dams that have collapsed in other regions], killing many people; there's nowhere for us to run. Where will we run?

(Fisherwoman, 2019)

In brief, men's references to emotional well-being primarily focused on their livelihoods and challenges in providing for their families. In contrast, women spoke of living in fear of a dam collapse.

5.5.3. Control over one's environment & capability to resist

As described in the procedural and recognition justice sections, the inhabitants of Vila Nova could not participate in the decision-making process related to a project that affected their lives and livelihoods, reflecting a lack of control over their environment. However, in the second phase of data collection, they shared that they had participated in protests against the dam. These events were emotional for some respondents. Additionally, the police's response was aggressive, and two male interviewees were injured by rubber bullets. The protests were ineffective in gaining recognition and compensation for Vila Nova. They lacked the capabilities and power to change the government's and the company's decisions.

Additionally, Vila Nova dwellers lacked representation from an organization with greater capabilities for resistance. This led to the creation of the Conselho Ribeirinho (Riverine Council), which aims to ensure access to justice and reparations for displaced riverine families. As a result, riverine people are finally recognized as a collective subject with rights of self-determination and territory [86].

In summary, the references to issues of capabilities justice increased over the years of data collection. Women noted a lack of opportunities to

be healthy and well-nourished. Fishers, both men and women, described how the dam affected their emotional well-being. Men focused on livelihoods, and women on living in fear. Lastly, locals participated in protests against the project.

6. Discussion and conclusions

This paper provides a comprehensive overview of the experiences of a downstream community affected by the construction and early operation of the Belo Monte dam. We used the distributional, procedural, recognition, restorative, and capabilities energy justice tenets to describe how local actors experience different energy injustices and how injustices interact to further the injustices.

This study brings attention to the harmful consequences that the construction of dams can have on communities that depend on fishing as a source of sustenance and income. Scholars have shown that the building of dams can negatively impact fisheries by obstructing fish migration [13], increasing fish mortality, reducing the number of fish, reducing fisheries' yields [79], and thereby lowering the earnings of fishermen [15], among other effects.

Our results show how the multidimensional and multitemporal perspectives are intertwined. As described, the nonrecognition of Vila Nova inhabitants (that has occurred in all stages of the dam's construction) has exacerbated other types of injustices. To illustrate, our results show a reinforcing feedback loop between a lack of recognition and procedural injustices. As Schlosberg [58] describes, "If you are not recognized, you do not participate; if you do not participate, you are not recognized." We explained how dam developers did not recognize Vila Nova as impacted by the project because of its location downstream from the dam. Therefore they were not included in the EIA (intended to be a mechanism of prevention and mitigation) and were not involved in the participation processes previous to the construction, reflecting procedural issues. These two facts perpetuated the marginalization of this community.

The case of Vila Nova shows how the knowledge, perceptions, and injustices faced by groups with no political or economic power are overlooked and hidden by elites' political and economic interests. This reflects an intersection between recognition and restorative justice since the impacts of the dam on this riverine community belonging to a historically marginalized group were overlooked. Nonetheless, affected communities have clear ideas of how they would like their lives restored. Unfortunately, they have not been heard or offered any help, perpetuating the injustices riverine communities face. It is important to note that compensation processes are complex. For instance, it is challenging to measure non-physical assets [87], e.g., sense of place and spiritual connections. Furthermore, compensation alone has also been proven not to prevent the impoverishment of local actors [88]. Also, community power dynamics can play a role in making it difficult to reach a consensus. Some groups may have more influence or better access to decision-making processes than others, further complicating efforts to reach a fair and equitable agreement.

This study is novel in integrating capabilities justice, we showed how it intersects with other types of justice and how capabilities injustice becomes more salient over time. Most of the work on capabilities and energy justice has focused on energy poverty and how access or lack of access to the resource has expanded or limited people's capabilities [89]. We explored how the construction of Belo Monte impacted individuals' well-being and found similar trends. However, our results also show how women and elders expressed the ways in which the dam affected them and their families due to the negative impacts on the social-ecological system. Women described their concerns regarding their emotional well-being and their children's food security, while older people noted how young people use other fishing gear and migrate when needed, but they feel trapped in a situation without options. These results show how dam developers and governments need to realize that dams generate differentiated impacts, and more importantly, they need

to implement ways to alleviate those impacts. This is not an isolated case since development programs frequently fail to recognize children, the elderly, the disabled, and people without land [90]. This counterbalanced the fact that dam development projects describe affected people as genderless [91] rather than acknowledging that people with different identities, values, aspirations, and needs will be impacted differently. Similarly, the effects on local communities will vary based on their proximity to the dam and other geographical factors (e.g., upstream, downstream, host, or resettled communities) [24,27,92,93], underscoring the need for deeper investigation into these dynamics.

Methodologically, our case study exemplifies the need for multi-temporal studies to understand the complexity of energy justice issues, highlighting three major trends. First, a temporal dimension: individuals faced multiple and different energy injustices at different stages of the dam's construction. We presented how some energy (in)justices were more predominant early in the data collection (e.g., impact on fisheries), while others emerged at the end of the study (e.g., capability to resist). Second, the qualitative research design allowed us to gain in-depth information and build trusting relationships with the inhabitants of Vila Nova, which provided the space for participants to share emotional and personal experiences and fears associated with the dam.

This study provides a clear example of a disconnect between energy policymaking and communities living downstream of construction sites and a need to revise the energy sources associated with a modern energy transition. Hydroelectric dams could help decarbonize energy systems. However, as this paper shows, dam construction generates multidimensional and multitemporal energy injustices, perpetuating structural inequalities in marginalized communities. Not only hydroelectric dam developers but also developers of other energy sources in the energy transition should look beyond carbon emissions. For those interested in energy transition, it is important to take a holistic and systemic approach. This means considering the social-ecological and economic conditions of the areas where energy will be generated and the potential externalities these systems can generate at the local, regional, and national scales. By doing so, we can ensure that the transition towards sustainable energy is done in a responsible and effective manner.

CRediT authorship contribution statement

Laura Castro-Díaz: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Maria Claudia Lopez:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Sharlissa Moore:** Writing – review & editing, Supervision. **Lucero Radonic:** Writing – review & editing, Supervision, Methodology. **Jennifer Hodbod:** Writing – review & editing, Supervision. **Emilio Moran:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

We collected data that includes identifiers, and because of IRB, we cannot share the data. We included in the supplemental materials the interview guides and codebook for data analysis.

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Appendices. Supplementary data

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