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Pretend Participation: Procedural Injustices in the Madeira Hydroelectric Complex

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ABSTRACT

Energy infrastructure projects have long been associated with a lack of participation by impacted, local populations—this history is evident in the case of hydropower projects in the Global South. Ever since the World Commission on Dams' Report (WCD 2000), there has been substantive evidence, and numerous recommendations, that have called on governments, financial agencies and construction companies to increase community engagement and participation in dam construction and in their governance thereafter. Further, community groups, activists, and scholars have long articulated the need for participatory governance in energy projects. In this analysis, we evaluate participation in institutionalized mechanisms provided by dam builders—such as public meetings and negotiations—in Brazil's Madeira hydroelectric complex. We evaluate how perceptions of positive and negative impacts, among other factors, predict engagement, estimating a series of logit models based on a social survey of 673 households carried out in 2019/20. Perceptions of negative and positive impacts of the dams before construction are related to participation in the meetings promoted by dam builders. Yet our results also imply that participation was rare, fleeting, and insufficient and points to the need to ensure community engagement and governance to ensure energy justice in future dam projects in Brazil and elsewhere.

1. Introduction

Since the industrial age, energy systems have relied upon large-scale, centralized projects that generate substantial social-ecological impacts at local, regional, and global scales. Such infrastructure projects—ranging from oil refineries to hydroelectric dams—deleteriously impact communities that have had little say in their construction and operation. Often, host communities receive few direct benefits. This long history of energy development's negative impacts on populations near them has led scholars and activists to call for more participatory, just, and democratic models of energy governance (Sovacool and Dworkin 2015; Jenkins 2019).

Research evaluating or advancing participatory models in energy governance is emerging, typically for wind turbines and photovoltaics in the Global North, in which impacted communities provide meaningful insight into where and how a facility can be located, designed, or operated (Müller et al., 2020; Bauwens and Devine-Wright 2018; Bidwell 2016; Jami and Walsh 2017). Other scholars have pushed the boundaries of participation even further, arguing that energy systems can be governed by democratic principles, often coupled with community ownership (Szulecki 2018; Burke and Stephens 2017; Van Veelen 2018; Seyfang et al., 2014). Of course, both research on participatory governance and energy democracy dovetails significantly with concerns about energy justice (Allen et al., 2019).

There are hundreds of planned dams in the Global South and more dams are coming online every year, despite the problems created by large-scale hydropower (Moran et al., 2018; Zarfl et al. 2015). Hydropower projects have been especially prevalent in nations like China, Brazil, India, and Vietnam (Dao 2010; Hall and Branford, 2012; Kazi 2013; Middleton 2018; Hess et al. 2016). The negative impacts of hydropower projects are well-documented, with voluminous analyses describing the social-ecological, and economic impacts of hydropower (Cernea 2003; Lees et al. 2016; Wild et al. 2019).

Hydropower projects are often imposed on communities near the

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siting of such projects (Ty et al., 2013; Morvaridi 2004; Asiama et al., 2017; Jusi 2006; Virtanen, 2006), and as a result, are marred by accounts of vast, involuntary population displacement, flooding of communities, and other undemocratic outcomes (Cernea 2004, 2008; Del Bene et al. 2018; Garcia et al 2021). In the case of Brazil, at least 3.4 million hectares of land have been flooded, and over 1 million people have been displaced for hydropower development (Zhouri and Oliveira, 2007). Hydroelectric dam projects have not included the participation of those affected by dams and reservoirs (Baldwin and Twyford, 2007; Hay et al., 2019; Siciliano and Urban, 2017; WCD, 2000), a common situation regardless of whether the country is democratic or autocratic (Garcia et al. 2021).

Correcting this injustice was a central recommendation of the World Commission on Dams (WCD, 2000) and one of the main arguments given by some of the countries most committed to hydropower for not accepting the recommendations (such as China, Brazil, and India) (Schulz and Adams, 2019). People most directly affected by hydropower often have limited opportunities to have their concerns addressed or otherwise heard in the planning and implementation of hydropower and the mitigation of its impacts (Ty et al., 2013; Morvaridi, 2004). This situation has persisted across political contexts and over time (Garcia et al., 2021), despite the guidelines from the WCD (WCD 2000), the pressure of some international financing agencies (e.g. Asian Development Bank), and the actions of social movements that advocate for community participation (Baldwin and Twyford 2007; Hay et al. 2019; Siciliano and Urban 2017; McCormick 2006).

Scholars have identified national and international conditions that influence participation in hydroelectric dam projects, especially in processes of resettlement and compensation. Some aspects include the country's geopolitical conditions (e.g., opportunity to export energy as a commodity), presence of effective social movements, and international pressure (e.g., expectations of donors and support of transnational NGOs) (Blake and Barney 2018; Burrier 2016; Olson and Gareau 2018; Hall 1994; Hall and Branford 2012; Mohamud and Verhoeven 2016; Wang et al., 2020). Given that communities living nearby dams do not have much of a say in whether the dam will be built or are not allowed to participate in decisions regarding the dams, it is not surprising that there are not many studies looking at participation. We are interested in understanding how perceptions of affected populations about the impacts of hydropower projects encourage or discourage their active participation. In this context of limited opportunities to participate in decisions, there is little survey-based research that explains why some actors participate and others do not.

We address these gaps by identifying the determinants of participation in existing institutionalized mechanisms organized by dam authorities in a hydroelectric complex with two dam projects in the Brazilian Amazon: *Santo Antônio* and *Jirau*. We understand *institutionalized participation* as the use of formal institutions provided by the state or the dam company, such as attending meetings to receive information and participate in negotiations. Following Arnstein (1969) we argue that participation takes many forms and, accordingly, we use multiple indicators. Using survey data collected from communities near the hydroelectric complex, we ask whether factors such as perceptions of positive and negative impacts influenced the likelihood and nature of participation. In this paper, we advance the literature by using quantitative methods to illuminate gaps of knowledge regarding public participation in hydropower decision-making.

2. Background

2.1. Hydropower impacts

Emerging economies—particularly Brazil and China, and many others as well—have embraced hydropower to provide a consistent power source to facilitate economic growth, energy independence and less dependence on fossil fuels (Zarfl et al. 2015; Winemiller et al 2016; Fearnside 2006; Siciliano et al. 2016). Hydropower is often framed by its boosters as necessary for the good of the nation (Atkins 2017; Atkins 2019; Weist 1995) yet has immense social-ecological impacts which tend to be overlooked in the decision-making process (Kirchherr and Charles, 2016; Kirchherr et al., 2016) and regional economic and social effects are not always positive (de Faria et al. 2017). Fan et al. (2022) examined 631 dams across the world and found that hydropower dams had a negative impact on GDP, population, and land cover within a 50 km radius of the dam. Ecological impacts include deforestation, loss of biodiversity, disruption of rivers, and significant damage to fisheries (Ziv et al., 2012; Benchimol and Peres 2015; Fearnside and Pueyo 2012; Doria et al. 2021)—this can, in turn, create complications for riverine communities who depend upon regular and plentiful fish for their livelihoods and free-flowing rivers for transportation (Moran et al. 2018; Moran 2020; Fearnside 2015; Stevenson and Buffavand 2018; Wiejaczka et al. 2018; Ezcurra et al. 2019; Doria et al. 2018). Impacts on fisheries and fisheries governance are given limited attention by dam developers but have been shown to result in declining catches and income of up to 30 percent (e.g. Doria et al. 2021; Doria et al. 2018; Arantes et al. 2021). Dams have historically been built in rural places with limited infrastructure and community resources, typically engendering a rapid and sudden population increase that causes a range of social problems ranging from strain on insufficient infrastructure (e.g. sanitation and health systems), to traffic and crime (Cernea 2004; Siciliano and Urban 2017; Marin and da Costa Oliveira 2016; Grisotti 2016, Gauthier et al., 2019, Mayer et al. 2021), and loss of critical cultural spaces (Naithani and Saha 2019).

Hydropower projects have displaced an estimated 80 million people globally in the past century (Scudder and Gay 2011). China's Three Gorges dam, the world's largest dam, displaced 1.1 million people alone (Scudder and Gay 2011), and Belo Monte in Brazil, the fourth-largest in the world, around 20,000 people (Randell 2017). The early history of hydropower development is replete with examples of governments forcibly removing populations, sometimes resorting to violence and repressive efforts to quell protests (e.g. Del Bene et al., 2018; Finley-Brook and Holloman, 2016; Webber and McDonald 2004). Hydropower is often promoted by authoritarian regimes like China and in parts of Africa under decidedly un-democratic conditions (Jing 1997; Zhao, Wu and Qi 2020), and in emerging democracies that implement top-down policies for large infrastructure projects such as the cases of Sardar Sarovar in India and Belo Monte in Brazil (Hall and Branford, 2012; Wood, 1993; Fearnside 2012; Zanotti 2015, Garcia et al. 2021).

2.2. Energy systems, Participation, and Social Mobilization

Energy systems have historically relied upon large-scale, centralized projects developed by some combination of state and private sector actors to create large volumes of power at a single facility (or network of facilities). Energy development has rarely been democratic. Rather, state, and private actors impose energy projects on communities, often under the auspices of legal authority and framed in terms of economic development and nationalist goals (Atkins 2019). Thus, decisions around energy infrastructure have typically occurred with little to no participation from populations in the region affected (Athayde et al. 2019).

These historical outcomes have contributed to calls for energy justice from researchers and activists. Energy justice is multi-dimensional, with procedural justice a key dimension. According to Sovacool and Dworkin (2015), procedural justice is "concerned with how decisions are made in the pursuit of social goals, or who is involved and has influence in decision-making" (p. 437). The authors further explain that procedural justice in the context of energy has four dimensions: 1) access to information, 2) meaningful participation in decision-making processes 3) lack of bias in decision-making processes and 4) access to legal means to achieve redress. Most scholarship on procedural justice emphasizes the importance of participation in decision-making processes, equitable

treatment of all parties, and real decision-making power for impacted groups (McCauley et al. 2013; Ottinger, Hargrave and Hopson 2014).

The literature is replete with concepts like citizen participation, public engagement and community participation, potentially complicating the understanding of what procedural justice looks like in practice, with over-lapping conceptualizations and a wide array of terminology. In a highly influential article, Arnstein (1969: 216) defines participation as “redistribution of power that enables the have-not citizens, presently excluded from the political and economic process, to be deliberately included in the future.” Thus, the point of departure for Arnstein and those who have built upon her work are questions of power, particularly the extent to which previously disempowered groups can actively make decisions that influence outcomes.

Arnstein (1969) proposed a ladder of eight types of participation divided into three major steps, from situations in which citizens have little to no power in the decision-making of a development project, to true decision-making authority. These three main types are a) non-participation that includes manipulation and therapy activities that request people to form groups to be educated by authorities; b) tokenism that covers the instances when people receive information from authorities and give their opinion, but do not have the right to make decisions; and, c) citizen power that includes partnership (negotiation), and citizen control.

Participatory models are becoming increasingly common in the energy systems of many nations, although the specifics of participation vary quite substantially. This literature argues that communities should be consulted for decisions regarding the siting and design of energy facilities so these will not disrupt important aspects of the site, damage viewsheds, or otherwise cause unwanted impacts (e.g. Devine-Wright 2014). Notably, the move towards participatory governance and public engagement has not yet diffused to hydropower to any large degree. One exception, is described by Noda et al. (2020) showing community involvement in the planning and implementation of hydropower—they considered the case of small-scale hydropower in the irrigation systems of Japan, a decidedly democratic and consensus-seeking society.

Governments and dam builders have implemented compensation programs mostly for displaced populations. These programs range from new housing to farmland to direct cash payments, but are generally insufficient at fully compensating for all losses (Akça et al., 2013; Cernea and Mathur 2007; Cernea 2003; Vanclay 2017; Pulice and Moretto 2017). For instance, displaced farmers are often compensated with lower-quality land—resulting in lower crop yields—and social and cultural losses are rarely included in compensation programs (Bro, Moran and Calvi 2018; Calvi et al. 2020; Cernea 2008; Vanclay 2017; Tilt et al., 2009, Mayer et al 2022). At times, resettled populations are provided choices by dam builders and governments regarding their compensation—such as choosing where they will resettle, or the type of compensation available (Randell 2017). Still, despite calls for more participation of impacted communities in compensation schemes (e.g. WCD 2000; Xia et al. 2018), there are few examples of participation in large-scale hydropower development (Finley-Brook and Thomas, 2010; 2011; Mills-Tettey 1989; Souksavath and Nakayama 2013; Scabin and Pedroso Junior, 2014). In Brazil, developers are required to hold public meetings, but the meetings are infrequent and the information presented is often highly technical (McCormick 2007). In a place with low population, large distance between households and difficult mobility, the challenge of getting to a public meeting is enormous and the developers do not make much effort to provide transportation to these meetings.

Mobilization against specific hydropower projects in Brazil has been primarily led by indigenous peoples, and by MAB (Movimento dos Atingidos pelas Barragens). Mobilization is motivated by multiple goals—ranging from trying to stop the project, gaining decision-making power, or advocating for just compensation for the harms on communities and livelihoods. As an example, indigenous and environmental activists were able to effectively thwart the construction of the Belo Monte dam on the Xingu River for decades, until construction began by presidential decree in 2011 that disregarded this long-history of social and environmental protest (Fearnside 2006, 2012; 2017, Atkins 2019; Randell, 2016a,b).

Although impacted populations may engage in both institutionalized and non-institutionalized opposition to energy infrastructure projects (McAdam et al., 2010) such as lawsuits or protests, successful anti-dam movements (i.e. movements that halt the construction of a dam) are uncommon (e.g. Kirchherr 2018). For instance, the Munduruku tribe was successful in halting the completion of a dam on the Tapajos River in the Amazon (Bradford and Torress, 2017). Collective action is difficult to achieve, especially as states and dam builders work to reframe the perceptions of impacted populations and may resort to violent repression (Evren 2014; Del Bene, et al., 2018; Atkins 2017, Atkins, 2019; Huber and Joshi 2015, Mayer et al 2021).

However, even if negative impacts are occurring, some affected communities may not organize to stop construction, mitigate impacts, or negotiate with builders. One reason relates to perceptions of impact—if impacted populations do not recognize that a project is harmful, they may not mobilize to hold the industry accountable. Dam builders and governments frame the construction of dams as something that will positively impact local communities by bringing things like jobs and promoting regional development. This is described for the Belo Monte dam case by Mayer et al. (2021). Perceptions of impacts, both positive and negative emerge due to a complex mix of media framing, information made available by the construction company, social relations within the community, and various socio-demographic and political factors (Kasperson et al. 1988; Renn et al. 1992; Dake 1992). Moreover, national governments release information to the media in which they promote the benefits of dams, but not the costs borne by local communities. Recent research has shown that newspapers in Brazil rarely publish critical views of hydropower but instead tend to repeat the government's discourse or focus on the technical achievements of dams (Mourao et al. under review). Critics have argued that the limited participatory strategies and economic benefits offered by dam builders to communities are a means to repress potential opposition and mobilization (Habich, 2017).

2.3. The Madeira hydroelectric complex and Amazonian hydropower

The current study is part of a larger, long-term research project evaluating the implications of hydropower for the Amazon region, where there are 140 dams under construction or planned (Zarfl et al., 2015). Brazil has long pursued hydropower development to provide an affordable and reliable energy source and reduce dependence upon imported energy—hydropower was strongly promoted by the military dictatorship (1964–85) and has continued to be favored by subsequent democratically-elected governments.

Furnas, a Brazilian state electric company and Odebrecht, a large private developer, began planning a hydroelectric project on the Madeira River in 2001 (Switkes and Bonilha, 2008). In 2007 IBAMA published a technical report (Parecer Técnico) stating that the complex was unfeasible. However, later that year the preliminary license was granted for the Madeira hydroelectric complex, from then on the process of licensing was independent for each of the dams (Allan Silva et al., 2013; Amorim et al., 2008). *Jirau* and *Santo Antônio* were part of the federal government's Growth Acceleration Plan (Plano de Aceleração do Crescimento or PAC) promoted as a way to create jobs to address the Global Recession of 2008 (Scabin and Pedroso Junior, 2014). The final cost of the dams was significantly higher than initially projected and the developers consistently downplayed the potential environmental and social impacts of the projects. Various legislative efforts have weakened environmental regulation in the Amazon (Fearnside 2017) and the developers were granted a provisional license on July 9, 2007.

The construction of *Santo Antônio* and *Jirau* began in 2008 before the EIAs were completed (Fearnside 2014). Each has an installed capacity of approximately 3000 MW. Both are “run-of-the-river”-style dams, which

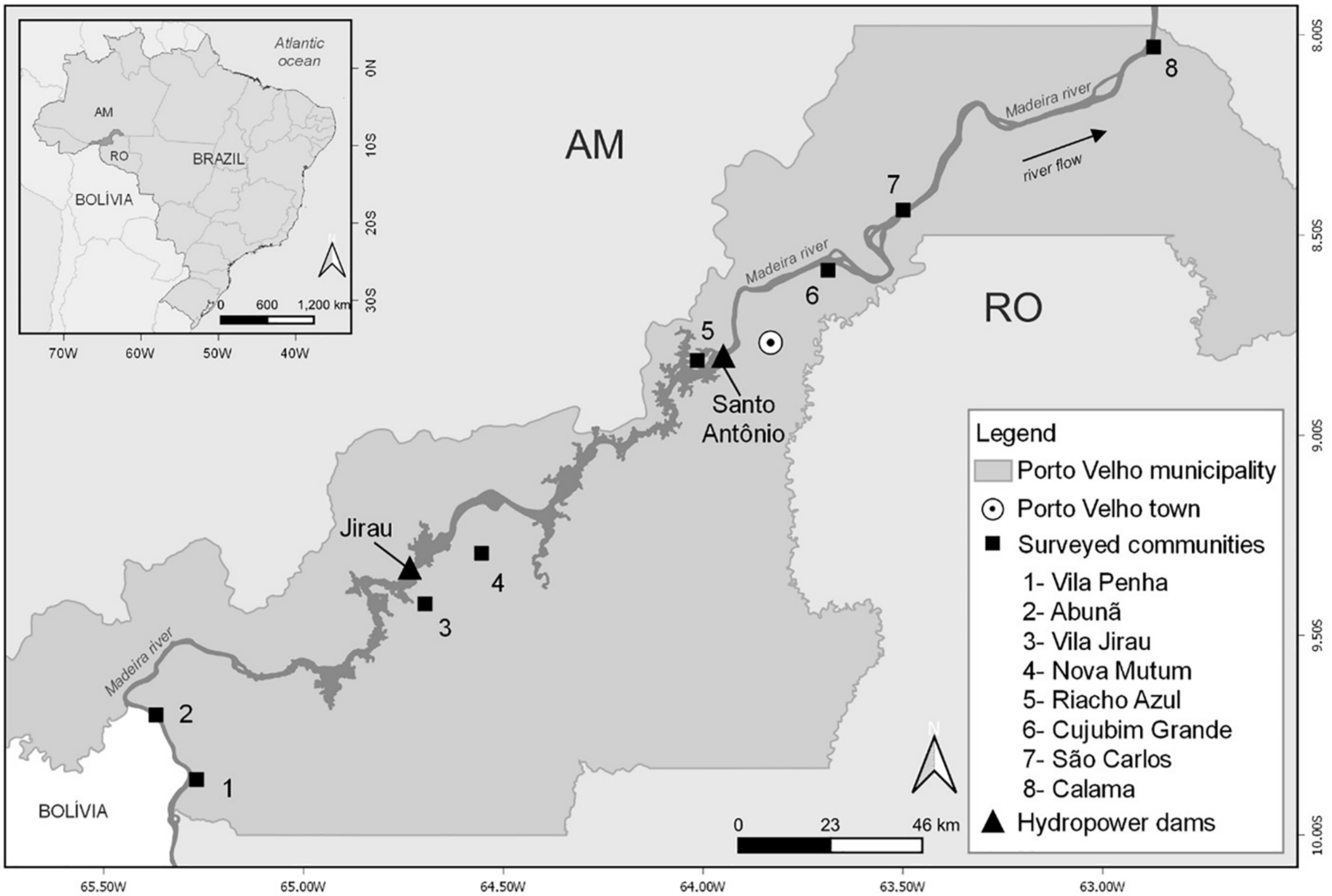

Fig. 1. Map of the Madeira hydroelectric complex and sampled communities. Map courtesy of Dr Igor Cavallini Johansen.

require a smaller reservoir than more conventional dams. The dams were constructed with fish ladders, which were supposed to reduce impacts on fish populations, but according to fishers in the area do not work and the high fish mortality of migrating large species has been significant. The dams are 120 km apart and a large reservoir was created between the two dams.

Although regulators recommended that the license to build not be issued, there was significant pressure from the Minister of Mines and Energy, the Civil House Ministry, President Lula da Silva, and private companies to push forward (Novoa Garzon, 2008a,b; Sherwood 2013). Burrier (2016) reports that government authorities and the dam builders undertook efforts to mitigate impacts from the dams, and at least attempted to attend to some of the social and ecological damages engendered by the dams via compensation programs. However, these efforts were insufficient and haphazard. Rezende (2009) explains that, before the dams were constructed, a consulting firm was hired to conduct meetings with potentially impacted populations. The author notes that several meetings were held, but their account implies that the construction of the dams was a foregone conclusion and the input of the communities was neither documented nor considered. The dam consortia held four public hearings in November 2006 one in each of the following locations: Jaci-Paraná (800 attendees), Porto Velho (1,100), Abunã (404), and Mutum Paraná (669) (Fonseca, Rezende, Oliveira, & Pereira, 2013). González-Parra and Simon (2008), argues that these hearings lacked transparency and dialogue and were not held at convenient locations and times—for instance, the environmental impact assessment (EIA) associated with the dams was not made publicly available. Gugliano and Luiz (2019) state that most meetings were held in a single town—Porto Velho—and at times the company pre-selected representatives from the community to attend the meetings rather than invite all concerned members of the community. Further, Gugliano and Luiz (2019) also observed that armed security was present at meetings, potentially contributing to an environment in which community members could not engage in true dialogue without a degree of fear in expressing themselves.

As a response, processes of mobilization against the projects began to emerge. These have been mainly organized by the Movement of Dam Affected People (MAB- Movimento dos Atingidos pelas Barragens), and the Independent People's Forum of the Madeira (FIPM-Fórum Independente Popular do Madeira). Other groups that also mobilized against the dams were religious communities, educators' unions (Sindicato Nacional dos Docentes do Ensino Superior), NGOs, fishermen's associations (Associação de Pescadores de São Carlos), rural movements (Via Campesina) and indigenous communities (Amorim et al., 2008). Most of these groups criticized the lack of participation of locals and the absence of negotiation (Amorim et al., 2008). An activist fisherwoman named Nilce de Souza Magalhães who campaigned against the dams disappeared for several months and was eventually found dead (Urnau, 2021).

Dam supporters started a well-resourced movement that they called "Comitê pró usinas" (Pro-Hydropower Committee) in 2007. Local newspapers report the use of coercion from the government to make local actors agree with the construction of the hydroelectric complex through the collection of signatures. Children at local schools were requested to ask parents to provide signatures favoring dam construction. Moreover, it was suggested that the payment of government subsidies such as *Bolsa Familia* might be at risk for families that did not sign (Rondoniaovivo, 2008). Viewed from the lens of Arnstein's ladder of participation, these accounts suggest that the meetings and other engagement efforts did not transfer significant decision-making

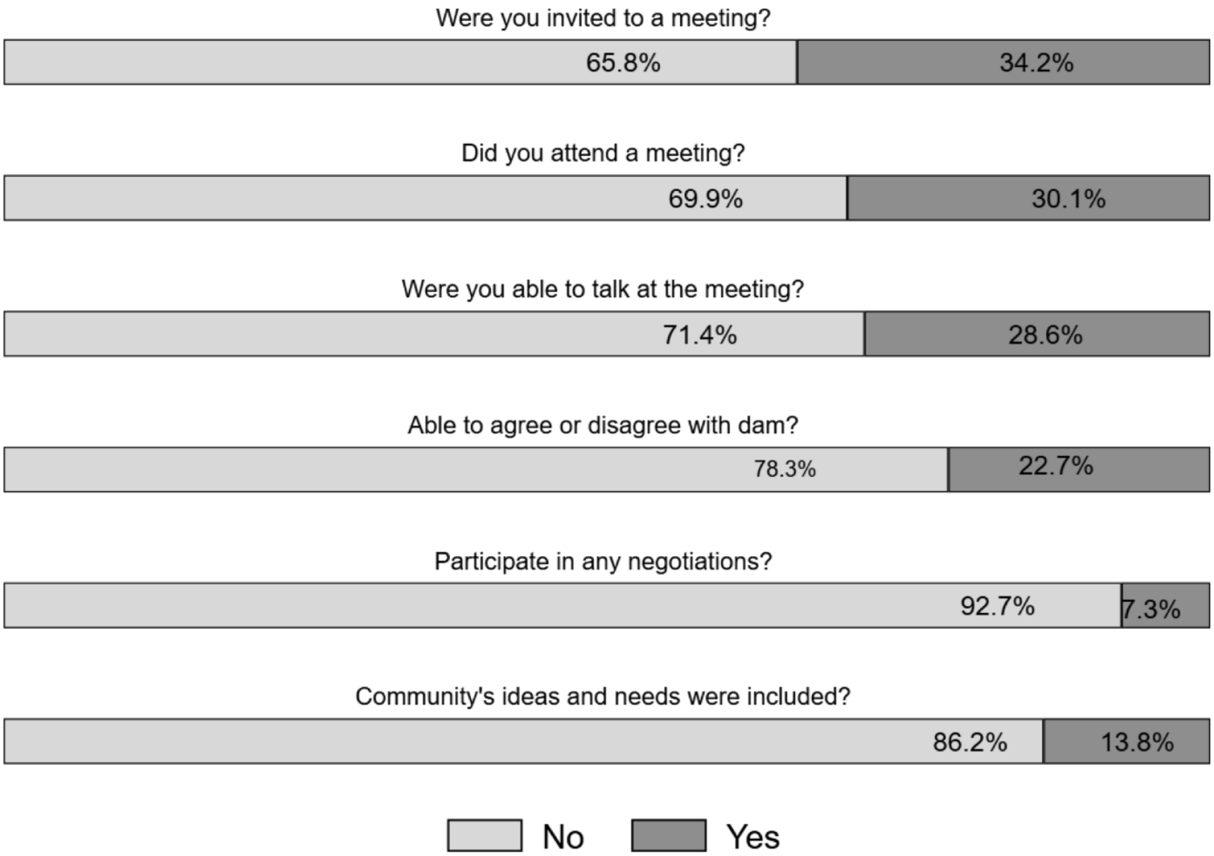

Fig. 2. Outcome variables for meeting attendance and negotiations from before dam construction began.

authority to communities, and on the contrary community members were pressured to accept the construction of an infrastructure that was going to impact their lives and livelihoods, representing a procedural injustice.[1]

3. Research questions

Claims of widespread economic benefits have long been a dominant framing of hydropower in the Amazon (Atkins 2017, 2018; de Sousa Júnior et al., 2010). Therefore, the perceptions of the impacted community of the potential economic benefits of the dam could influence their propensity to participate in institutionalized mechanisms provided by dam builders.

We ask how *perceptions that the hydropower projects will provide jobs, or perceptions that job opportunities have increased due to the dam, are associated with engagement in participatory mechanisms provided by the dam builders* (Research Question 1).

In their study of Brazil's Itapara and Sobradinho dams, Hall (1994) argues that experiences with the construction of prior dams explained the differences observed across communities in terms of activism against the dam. We expect that a similar process might happen when people decide to participate in meetings organized by dam authorities. That is, negative perceptions around the project may influence participation. This leads to the second research question we evaluate in this manuscript: *does the perception of negative impacts from the dam lead to greater engagement in participatory mechanisms provided by dam authorities?* (Research Question 2).

3.1. Methodology

Santo Antônio is located 7 km from Porto Velho, the state's capital city of 400,000 people. Jirau is located 125 km upstream. One small town—Mutum Parana—was flooded as a result of the dam, with its residents resettled mostly into Nova Mutum and Vila Jirau. Fig. 1 displays a map of the study region.

Three of the co-authors of this paper traveled to the region on reconnaissance trips to do ethnographic work. This made them familiar with the local context, the communities, and the organizations involved in the dam construction and operation process. They also met with university researchers and activist NGOs who followed the Hydroelectric complex from social sciences and natural science perspectives. In addition, during the field survey the team spent 9 months going to the communities and talking to people informally as well as asking the formal questions in the survey and this information has informed this paper.

Based on that information we chose to study 8 communities in the Lower Madeira river basin (Appendix A), of these 6 are upstream from Santo Antônio dam and two downstream. Although the communities have varying degrees of experience with the dams, it is important to note that they were all impacted to some extent given the geographically dispersed effects of dams that are well-documented in the literature described above.

3.2. Data collection

We collected data from 673 households based on face-to-face interviews between August 2019 and March 2020 for a 3.04% margin of error at 95% confidence. Interviews were conducted by local university students that were supervised by two post-doctoral scholars headquartered in Porto Velho and trained by the principal investigators. All

[1] Other hydropower projects with efforts to ostensibly include local communities to varying degree include the Sardar Sarovar in India and Ralco in Chile (Garcia et al. 2021; González-Parra & Simon, 2008; Wood 1993).

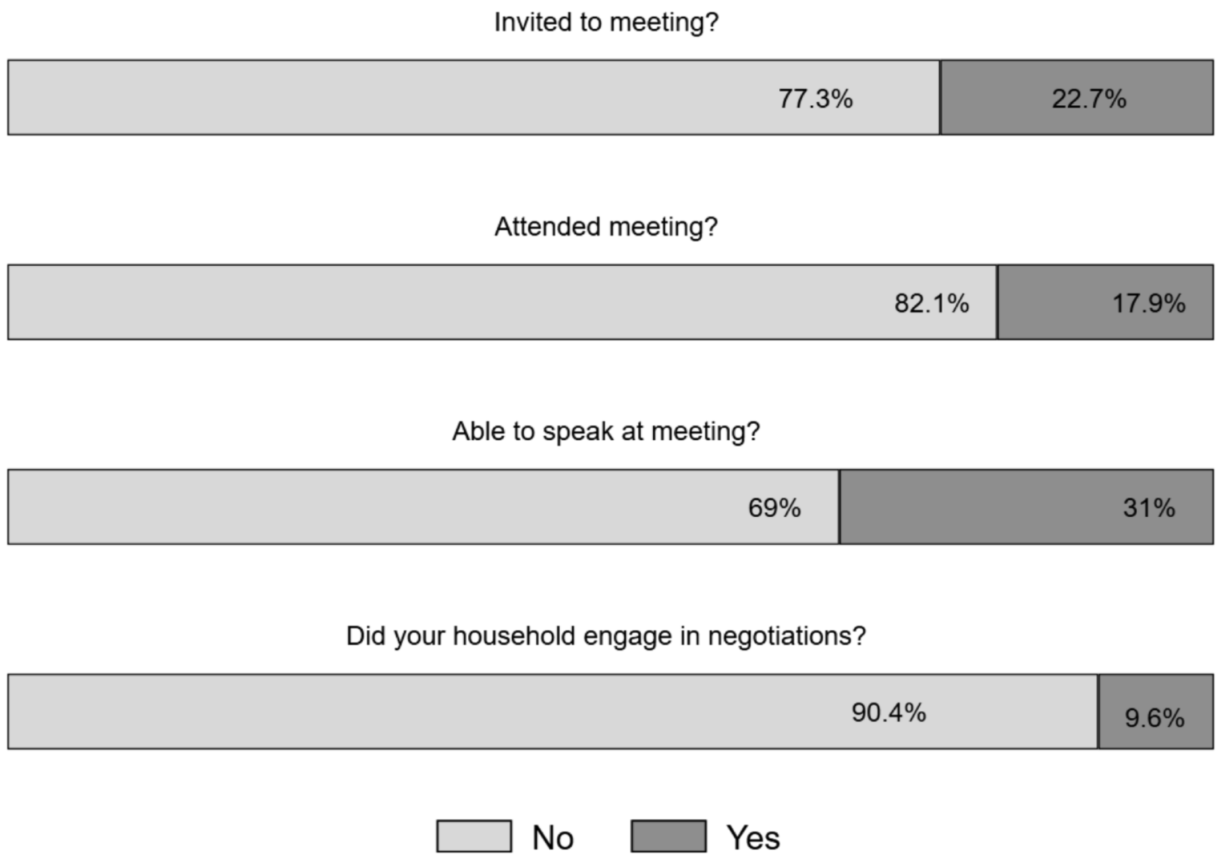

Fig. 3. Outcome variables for after dam construction began.

relevant staff were native or fluent in Portuguese. Enumerators were assigned to two-person interview teams with one interviewer administering the survey using a tablet equipped with Qualtrics and GPS, and a second taking notes or assisting with minimizing distractions. Typically, four teams administered the survey in a community at any given time.

We used a geospatially stratified sampled based upon maps produced from satellite data (Google Earth) and employed ArcGIS to view buildings with visible roofs that could be houses. That is, we excluded obvious schools, businesses, or community centers. Each one of those roofs was assigned a number and from this numeration a random sample was drawn. The sample was sorted in a random order. Interviewers were provided with a list of the numbered buildings and used up to five contact attempts. We sampled proportional to the size of each village. We also had randomly selected alternates in case the structures ended up being businesses, abandoned houses or after visiting and failing to find a family to respond after five attempts.

The instrument contained around 500 questions, but respondents typically answered far fewer questions depending on their responses (e.g. all farming questions were skipped if the respondent did not farm). Interviews used tablets equipped with the Qualtrics platform and interviews took about 1.5 h. Only 3–5% of households in any given community refused to participate. The survey contained socio-economic information, as well as questions related to engagement with the dam, among other topics. It also included their perceptions of how the dam had impacted their lives. Fifty-two percent of the sample respondents identified as female, the average age was 48 years, and the most frequent level of education was primary school completion (roughly 56% of the sample). Respondents held a mix of occupations such as fisherfolk, government worker, and homemaker and 19% of the sample had retired status.

3.3. *Outcome variables*

3.3.1. *Before dam construction*

Our data included a series of questions to address participation before and during dam construction. As we noted above, participation is typically understood as a spectrum ranging from rather superficial engagement to actual negotiation and decision-making power. Our questions reflect this understanding of participation.

For the period before the dam was constructed[2], we asked respondents if they were invited to a meeting and used two follow up questions: those who were invited to a meeting stated if they attended the meeting and those who attended the meeting were asked if they were allowed to ask questions and speak at the meeting. Respondents also reported whether they could disagree with the dam and if the community's ideas were included. Fig. 2 provides the distribution of these outcome variables from before dam construction. A minority of respondents (34.2%) reported receiving an invitation to a meeting, while only 30.1% of those attended a meeting. Very few (7.3%) indicated that they had directly negotiated with the dam builders and a strong majority (86.2 %) felt that their community's input was not used by the dam builders.

3.3.2. *After dam construction*

Our next set of outcome variables were constructed from questions that asked respondents about their experiences after dam construction had already begun. In this case, respondents also answered a series of nested questions about receiving a meeting invitation, attending a meeting and if they were able to speak at a meeting. The final outcome

[2] Since two dams have been built in the region, we asked participants to answer the questions based on the dam that impacted their lives the most.

Table 1
Descriptive statistics for predictor variables.

Before Dam Construction			
	Description	Mean	SD
Heard Negative Information?	0 = did not hear negative information, 1 = heard negative information	0.18	0.38
Heard about jobs before?	0 = did not hear dams provide jobs, 1 = did hear about jobs	0.25	0.44
After Dam Construction			
Jobs			
Remained the same	0 = all others, 1 = jobs have remained the same	0.384	0.487
Gotten Worse	0 = all others, 1 = gotten worse	0.509	0.5
Improved	0 = all others, 1 = Improved	0.11	0.31
Control Variables for both periods			
Age	Age in continuous years	48.12	15.18
Education			
No formal education	(0 = all others, 1 = no formal education)	0.12	0.32
Primary Education	(0 = all others, 1 = primary education)	0.53	0.50
Secondary Education	(0 = all others, 1 = secondary education)	0.27	0.44
Technical or higher	(0 = all others, 1 = technical education or higher)	0.08	0.27
Female Sex	(0 = not female, 1 = female)	0.52	0.50

variable for the models after dam construction was constructed from a question that asked if the respondent or anyone in their household had engaged in negotiations with the dam builders. Again, a relatively small number (22.7%) indicated that they had been invited to a meeting, and only 17.9% of those who had received, an invitation attended a meeting. Only 9.6% indicated that they or someone from their household had engaged in negotiations. Fig. 3 presents the distributions of these outcome variables.

It is possible that these seemingly low levels of participation could be a response that impacted communities chose to pressure the dam builders through direct action such as protests, rather than institutional processes like meetings. However, only 92 respondents, or about 13% of the sample, indicated that they ever attended a protest because of the construction of the dams, and about half of those who engaged in a protest also attended a meeting. This shows that in many cases, protesting did not supplant going to meetings or other actions. Another explanation for these low levels of participation is that respondents may have chosen to have a community leader negotiate on their behalf, or that dam builders asked them to do so. About 7% of the sample indicated that a community leader negotiated for them, and roughly half of this 7% also attended at least one meeting. Again, this finding suggests that meeting attendance or other actions were not rendered less likely because respondents had a community leader representing their interests.

3.4. *Predictor variables*

3.4.1. *Predictor variables for before dam construction*

Our dependent variables asked about participation in meetings before and after the construction of the dams. Accordingly, some of our predictor variables are unique to each period. With Research Question 1, we theorized that positive economic perceptions of the dam would improve the likelihood of participation. Respondents were asked what information they had about the positive effects of the dam before construction, with the possibility of several responses. A large amount of the sample indicated that they had heard nothing about the dams (either positive or negative), before construction began—82% did not hear any negative information, and only 25% had heard that the dams would provide jobs. There was relatively little overlap between those who had heard that the dams would provide jobs and those who had heard negative information about dams (only 53 respondents, or about 7% of the sample). To capture negative perceptions for research question 2, we include a binary variable for whether the respondent had heard anything negative before dam construction (0 = had not heard anything, 1 = had heard a negative impact). Table 1 provides descriptive statistics for all predictors.

3.4.2. *Predictors for after variables*

After dam construction begins, communities start to experience negative as well as positive impacts. Our survey included several questions to capture the perception of community members of these impacts—these include social capital impacts such as changes in the frequency of meeting with friends, relationships among members of the household, membership in community organizations, and religious service attendance. Respondents also answered questions about changes in their health status, stress levels, and access to health care. Finally, we also measured impacts on housing quality, satisfaction with housing, land quality, access to electricity, and access to education. These variables were scored with three categories: increased, stayed the same, and decreased. We conducted a factor analysis to reduce the number of items and understand the dimensionality of our impact questions. This analysis implied a single factor solution. We estimated a factor score for use in our regression models that we call "social impacts". Appendices B and C provide more details about the factor analysis procedures. Our final variable for perceptions about the dam project "after" dam construction is an indicator of perceived changes in job opportunities with three categories (improved, remained the same, decreased). Table 1 provides descriptive statistics for all predictors and controls.

3.5. *Control variables for both models*

We include control variables standard to many social scientific analyses in our models. These include a categorical variable for education (1 = no formal education, 2 = primary education, 3 = secondary education, 3 = Technical/ Vocational training, 4 = university education). Age is scored in years and gender is a binary variable. The impacts to downstream communities are often ignored as they are routinely left out of any negotiations, and Environmental and Social Impact Assessments. But there is evidence that these communities are impacted by the dams (Adams 1985; Richter et al. 2010, Castro-Diaz et al., 2018). Accordingly, we control for whether the respondent's community was upstream or downstream using a binary variable.

3.6. *Analytic strategy*

Our analysis occurs in two steps. As described earlier, many of the outcome variables are nested within other questions—for instance, only respondents that indicated that they attended a meeting were asked if they spoke at the meeting. This design, while appropriate for our survey, presents some challenges because responses to one question determine whether a respondent gets the next question. For these questions—receiving an invitation to a meeting, attending a meeting, and being allowed to speak at the meeting—we rely on a multi-process structural equation modeling strategy fit via Stata 15/IC's *gsem* command. This class of models has been implemented extensively in demographic research, where the outcome of one process might depend upon another prior process, or more formerly, processes that may involve endogeneity or selection. These models can be understood as a series of nested logistic regression models. For the non-nested dependent variables, we rely upon more conventional binary logistic regression models. Recall that we have six dependent variables from before dam construction, and four after dam construction, for a total of ten outcomes across the two time periods.

Table 2
Multiprocess logistic regression models for before dam construction.

	Invited to Meeting?	Attended Meeting?	Able to speak at meeting?
	OR(SE)	OR(SE)	OR(SE)
Heard Negative Information	2.352***	1.704	1.065
	(0.54)	(0.71)	(0.44)
Heard about jobs	1.576*	1.33	1.62
	(0.33)	(0.49)	(0.65)
Upstream	3.083***	0.721	0.345**
	(0.59)	(0.25)	(0.14)
Age	1.008	154.432***	1.084***
	(0.01)	(55.34)	(0.02)
Education (ref. *no formal education*)			
Primary Education	0.729	0.882	2.472
	(0.22)	(0.28)	(1.47)
Secondary Education	0.842	1.129	11.222**
	(0.3)	(0.43)	(9.06)
Greater than Secondary	1.288	1.642	18.576**
	(0.56)	(0.75)	(16.5)
Female Sex	0.771	0.76	0.617
	(0.15)	(0.15)	(0.26)

*** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$.

4. Results: Models for before dam construction

4.1. Multiprocess models for meetings

Table 2 displays the multi-process models for the first three dependent variables from before construction began—whether the respondent received an invitation to a meeting, whether they attended the meeting, and whether they were allowed to speak at the meeting. Recall that these variables are all scored on a binary scale, where a “yes” is the upper category and “no” is the lowest category.

Those who had heard negative information about the dam beforehand were more likely to report having received a meeting invitation (OR = 2.352, $p < 0.001$). We also suspected that the hope that the dams would provide jobs would increase the likelihood of meeting attendance— our models imply that those who had heard that dams may provide jobs were more likely to recall a meeting invitation (OR = 1.576, $p < 0.05$) and report attending a meeting, although the effect is not statistically significant.

The average marginal effects for these variables (Fig. 4) help qualify these findings. Panel 1 implies that individuals who had heard negative information about dams before construction began were 0.18 more likely to report receiving a meeting invite, but were not more likely to report attending a meeting or being able to speak at a meeting. The second panel implies that those who had heard about jobs were slightly

Table 3
Binary logistic regression models for before dam construction.

	Community Agree/ Disagree	Community Negotiations	Community Input
	OR(SE)	OR(SE)	OR(SE)
Heard Negative Information	1.793*	1.373	1.269
	(0.45)	(0.54)	(0.39)
Heard about jobs before?	1.143	0.973	1.015
	(0.28)	(0.34)	(0.3)
Upstream	1.342	28.327***	1.643
	(0.29)	(20.85)	(0.44)
Age	1.004	1.01	1.004
	(0.01)	(0.01)	(0.01)
Education (ref. *no formal education*)			
Primary Education	0.863	0.969	0.948
	(0.31)	(0.49)	(0.41)
Secondary Education	0.68	1.1	0.796
	(0.29)	(0.67)	(0.41)
Technical Education or more	0.759	0.309	1.147
	(0.39)	(0.35)	(0.7)
Female Sex	0.533**	0.577	0.525*
	(0.12)	(0.2)	(0.14)

*** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$.

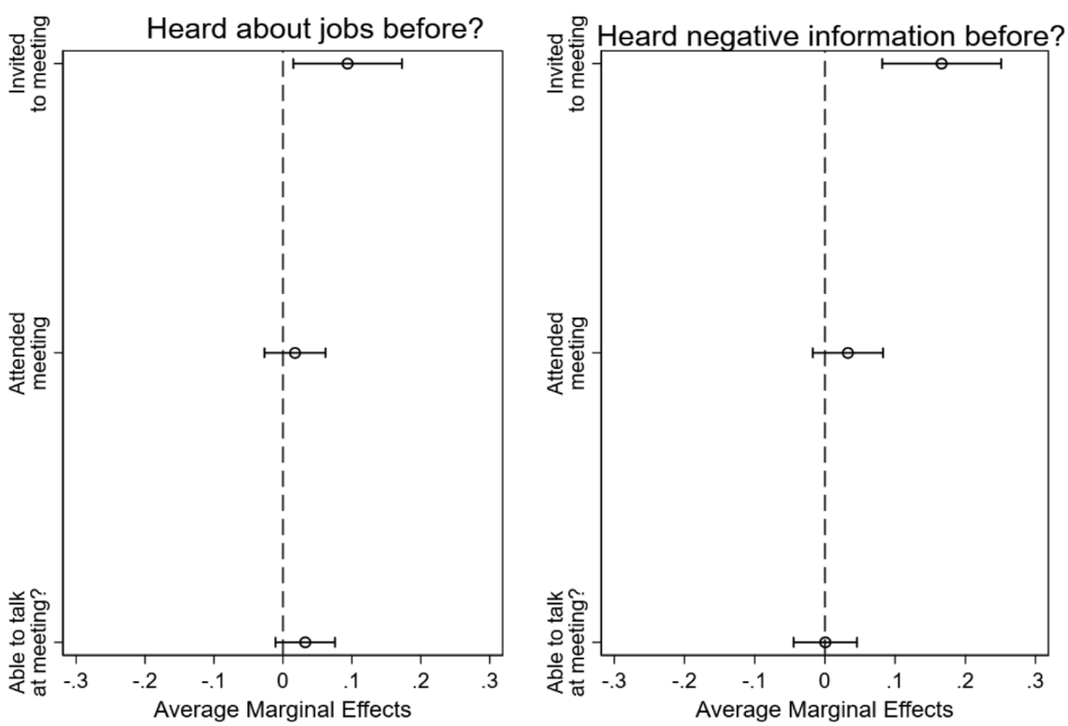

Fig. 4. Average marginal effects for hearing about jobs, and hearing negative information before dam construction for being invited to a meeting, meeting attendance, and being able to speak at a meeting.

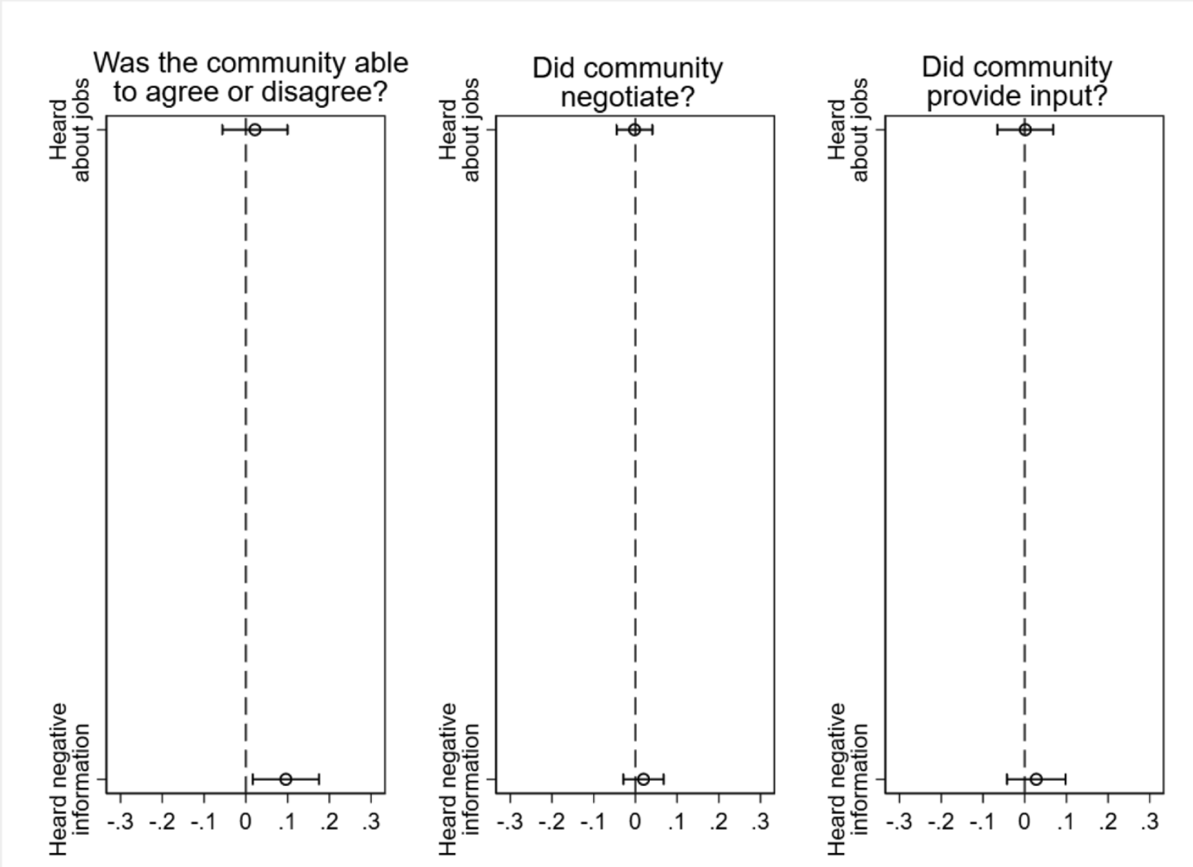

Fig. 5a. Average marginal effects for hearing negative information, and hearing about jobs before dam construction for community's ability to agree or disagree, community participation in negotiation and community input. Note: Estimates derived from Table 3.

more likely to attend a meeting (AME = 0.03), although the 95% confidence interval crosses over zero.

4.2. *Binary logistic regression models*

We now turn to the binary logistic regression models for the final three variables for events before the dam began— was the community able to agree or disagree with the dam, did the community engage in any negotiations with the dam builders, and did the builders use the community's input (Table 3). The first model shows that those who heard negative information about hydropower before the dam construction were more likely to report that the community was able to agree or disagree with the dam (OR = 1.793, $p < 0.05$). The AME for this variable is 0.10, indicating that hearing negative information is associated with a 0.10 greater probability of stating that the community was able to agree or disagree with the dam. Those upstream of the dams reported a much greater likelihood of the community engaging in negotiations (OR = 28.327, $p < 0.00$). Few other variables have statistically or practically significant effects in any of the models.

4.3. *Multiprocess models for meetings after dam construction*

The next portion of our analysis evaluates the results for the models regarding the events that occurred after dam construction had commenced—dam planning and construction typically unfold over several years, so it is appropriate to evaluate participation at multiple stages. Compared to the previous suite of models, these models drop the indicators for perceptions *before* dam construction began and add in the factor score for the impact items described earlier. The factor score for the impact items (*Social Impacts*) also had a positive, statistically significant effect in the models for meeting invitation (OR = 1.635, $p < 0.01$) and meeting attendance. Figs. 5 provides AME for these variables to make intuitive sense of the results. The AMEs imply that *Social Impacts,* although statistically significant, do not have an especially large substantive effect (panel 3). On the other hand, perceptions about jobs did not have a statistically significant effect in any of the models after construction and the AMEs imply that this effect could be null in practical terms also. Residents of upstream communities were more apt to report receiving a meeting invitation compared to downstream communities, but less likely to have attended a meeting, and less likely to feel as if they could speak at the meetings. This finding, to some degree, may be an artifact of the fact that some residents elected to move before the dams were constructed.Table 4.

4.4. *Binary logistic regression models for after dam construction*

Table 5 provides results for our final dependent variable, where we asked if the respondent or anyone in their house had engaged in negotiations after dam construction began. Perceived impacts (i.e. the variable *Social Impacts*) also did not reach statistical significance. The AMEs displayed in Fig. 6 largely corroborate these null results of the regression models. Table 5 below displays odds-ratios and standard errors for the binary logistic regression models for negotiations. Recall that the dependent variable is constructed from a question that asked if the respondent or anyone in their household had engaged in negotiations with the dam builders. On the other hand, those who had reported that

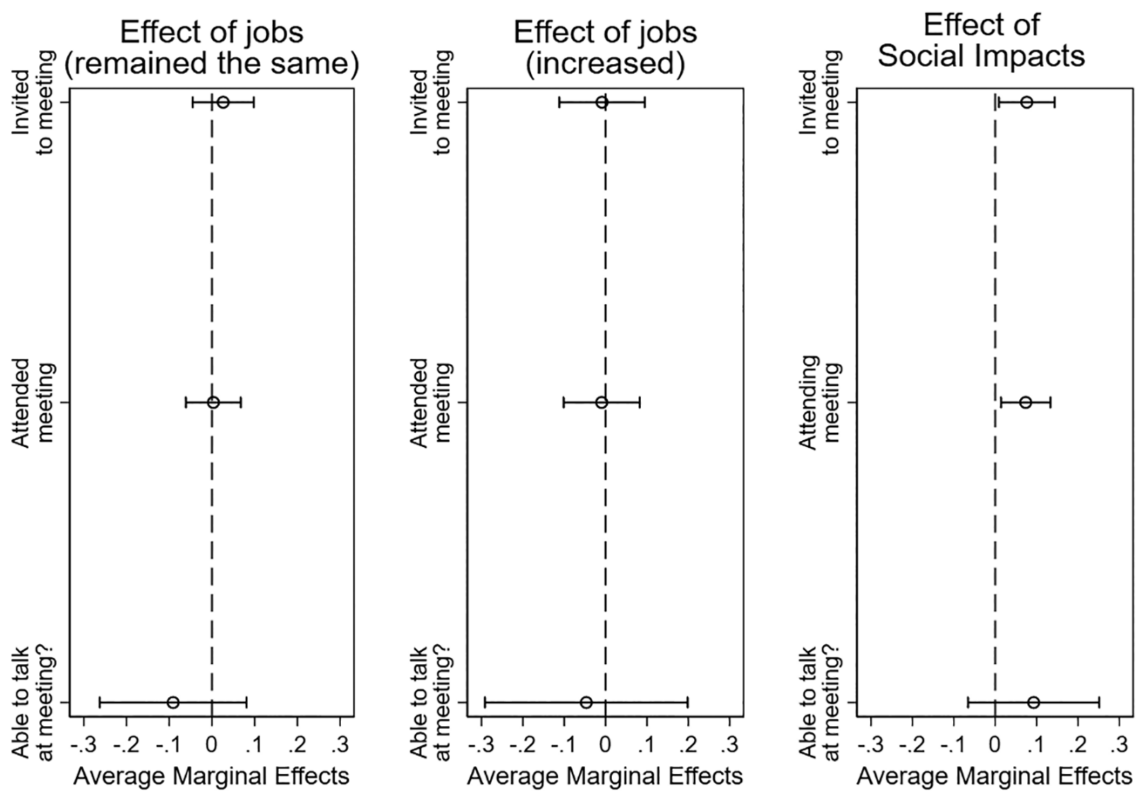

Fig. 5b. Average marginal effects social impacts and perceived changes in the availability of jobs during dam construction. Note: Estimates derived from Table 4.

Table 4
Multi-process models for after dam construction.

	Invited to Meeting	Attended Meeting	Able to Speak at Meeting
	OR(SE)	OR(SE)	OR(SE)
Social Impacts	1.635*	1.773*	1.717
	(0.37)	(0.42)	(0.82)
Jobs (*ref. gotten worse*)			
Remained the same	1.185	1.027	0.59
	(0.28)	(0.26)	(0.31)
Improved	0.945	0.928	0.763
	(0.32)	(0.34)	(0.56)
Upstream	3.083***	0.721	0.345**
	(0.59)	(0.25)	(0.14)
Age	1.023**	1.021*	1.025
	(0.01)	(0.01)	(0.02)
Education (ref. *no formal education*)			
Primary Education	1.16	1.422	1.576
	(0.41)	(0.54)	(1.12)
Secondary Education	1.721	2.027	1.038
	(0.71)	(0.89)	(0.95)
Greater than Secondary	1.635	2.618	2.136
	(0.83)	(1.39)	(2.13)
Female Sex	0.868	0.762	0.309*
	(0.19)	(0.18)	(0.17)

*** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$.

Table 5
Binary logistic regression model for household negotiations during dam construction.

	OR(SE)
Social Impacts	1.629
	(0.49)
Jobs (*ref. gotten worse*)	
Remained the same	2.120*
	(0.72)
Improved	2.625*
	(1.13)
Upstream	15.633***
	(7.58)
Age	1.033**
	(0.01)
Education (ref. *no formal education*)	
Primary Education	0.961
	(0.42)
Secondary Education	0.603
	(0.35)
Greater than Secondary	1.792
	(1.16)
Female Sex	0.821
	(0.26)

*** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$.

job opportunities had improved or remained the same were more likely to state that their household had engaged in negotiations, and the AMEs reported in Fig. 6 imply that this effect may be practically large also. Residence in an upstream community also had an important effect on the propensity to negotiate (OR = 15.633). This could be explained by the fact that downstream communities were largely overlooked by the Madeira dam consortium, as they were not considered as impacted so they were not consulted or compensated (Novoa Garzon and da Silva,

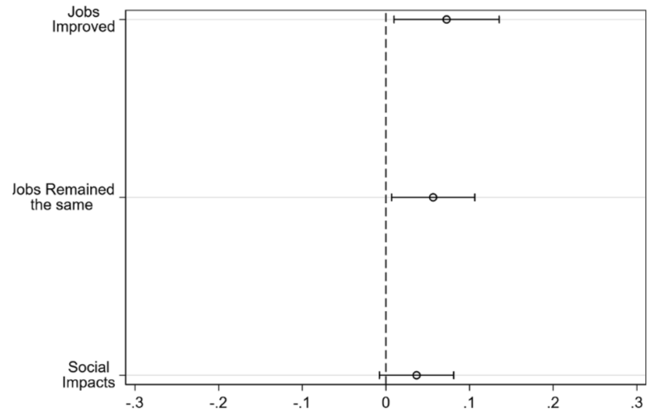

Fig. 6. Average marginal effects for social impacts and jobs for participation in negotiations after dam construction began. Note: Estimates derived from Table 5.

2020).

5. Discussion and conclusion

In this section, we bring our results into dialogue with the four dimensions of procedural justice described by Sovacool and Dworkin (2015)—1) access to information, 2) meaningful participation in decision-making processes 3) lack of bias in decision-making processes and 4) access to legal means to achieve redress. We describe the role of perceptions in encouraging or discouraging participation and conclude by discussing limitations of the current work and future research needs.

There appears to be insufficient access to information. Our results show that many of the respondents were not aware of the negative and positive effects the construction of dams can bring to communities living nearby. Reports from the news in the area mentioned that dam authorities used a technical language that was not accessible to local actors in the meetings held to present the project (Novoa Garzon, 2008a,b). The fact that the construction of the dams started before the EIAs were completed is another example of how consultation and access to information to communities living nearby the construction of the dam were not relevant in the process.

With respect to meaningful participation in decision-making processes and its potential biases, previous research and media reports for our study area implied that decision-making processes before the dam construction was not transparent or participatory (Gugliano and Luiz, 2019; Fonseca et al., 2013). In particular, meeting invitations were likely not comprehensive, not many meetings were held, and in general efforts to allow participation appear insufficient. These news reports are confirmed by our analysis—relatively few respondents indicated being invited to a meeting, attending a meeting, engaging in negotiations, or negotiating. This shows that participation in hydropower is relatively sporadic and not common even among groups that are directly impacted by dams. For instance, far less than a majority who had received a meeting invitation reported attending a meeting, and even fewer reported negotiating with dam builders. It is possible that some did not attend the meetings as an act of resistance or protest, particularly if they believe that meetings or other participatory mechanisms will not redress their concerns, and thus preferred to take their complaints to court, or to the streets. Others, may not have attended the meetings because they knew the decision to build the dams was already made and their participation in the meeting was not going to change the outcome. It is worth recalling that the attendance of local actors at these meetings does not guarantee their active participation.

Finally, with regards to access to legal redress, our analysis does not include whether respondents took their complaints to courts, but the information we have about negotiations shows that these were uncommon, and that households who experienced impacts were not more likely to have engaged in negotiations.

Despite the prolific deployment of hydropower in the Amazon, and the media attention to these grand projects, many of our respondents did not have particularly strong opinions before construction began. Following research on negative perceptions and energy impacts (e.g. Sousa Junior 2014) we suggested in Research Question 1 that, before dam construction, hearing that dams would provide jobs would lead to more participation in meetings, in Research Question 2, we tested that having heard about the negative impacts of dams will lead to more participation in meetings. Negative perceptions before the dam did indeed increase engagement, implying that those individuals who were concerned about impacts were driven by these concerns to attend meetings offered by dam builders. Positive perceptions—in the form of the belief that the dams will bring jobs—also increased the likelihood of participation before dam construction commenced. However, the effect of both negative perceptions and the belief that the dams would bring jobs did not increase the likelihood of all types of participation—these beliefs appear to only increase the likelihood of reporting an invitation, not actually attending a meeting. Thus, we find mixed support for our research questions, wherein we hypothesized that both negative perceptions and positive perceptions about jobs would increase participation. Further research is necessary to investigate why people that recall being invited to the meeting did not attend the meetings.

Our findings for participation after construction began are quite different. We found that those who have experienced negative impacts are more likely to recall receiving a meeting invitation and more likely to have attended a meeting. The perception that the dam was creating jobs was associated with a greater propensity to negotiate with the dam builders, but negative impacts had little to no association with negotiations. One may imagine that even though the impacted populations would surely seek redress for problems that they are experiencing, they may not feel that the company or the government, that imposes the harm on them will hear and address their concerns, or will act positively to solve the problems. Research in other domains implies that some groups deleteriously impacted by infrastructure development may hold feelings of apathy or hopelessness (e.g. Auyero and Swistun 2008; Eaton and Kinchy 2016; Shriver et al., 2014). Certainly, the history of hydropower is marred by non-participatory, even authoritarian, approaches to development. This history may have contributed to the low levels of participation we observed, and whether or not large hydropower projects can be governed democratically is an open question (Garcia et al. 2021).

Some of our control variables have effects that warrant discussion. The effect of upstream residence was statistically significant, and even quite powerful, in multiple models, indicating that those living upstream of the dams were more likely to participate. This result shows once again, that those living downstream are not considered as impacted by the dam, then they are not invited to participate in any consultation or negotiation process. Age was also a salient predictor in some models, with older respondents having a greater propensity to participate. We can only speculate as to the effect of age—perhaps older respondents are more politically engaged or more concerned about community issues due to a stronger sense of place, and hence more likely to attend meetings. An alternative explanation is that younger people may be contemplating migrating, and therefore do not feel the need to participate in these decisions.

Returning to the notion that participation occurs along a spectrum (e.g. Arnstein 1969), it appears that superficial participation like attending a meeting is unlikely, and actual negotiations are rare. Thus from the perspective of local dwellers, following Arnstein's (1969) ladder of participation, these projects fall into the nonparticipation side of the spectrum. This lack of participation has important implications for the participatory governance of energy projects moving forward. That is, activists and planners seeking to encourage community participation may need to do more to ensure that more avenues are available for

participation, and that said participation can lead to real decision-making power. The development of participatory and democratic models can bring welcome changes to a global energy system that has historically been characterized by gross injustices. However, the current analysis indicates that non-participation is a likely outcome with business-as-usual approaches.

Yet as Gugliano and Luiz (2019) note "the experiences of the public meetings provide examples of the difficulties involved in instituting democratic procedures in situations in which the economic interests are hegemonic, and other social concerns are considered secondary" (p. 22). Our findings of limited participation need to be interpreted with a broader understanding of the political economy of energy in Brazil, wherein dam builders and their allies in government hold far more power than the rural communities that often host hydroelectric plants. The process of decision-making of the Madeira hydroelectric complex was loaded with political and economic interests at the national and regional level because the complex is part of initiatives that aim to make the Amazon region a provider of the energy needs for other areas in Brazil[3] (Novoa Garzon, 2008a,b).

This study is not without limitations. Our work is situated in the Brazilian Amazon, which has its own ecological, social and political context. We suggest that our work may not fully generalize to other regions that are actively promoting hydropower, such as China and parts of Africa, but understating how local actors are invited to participate or not in one of the most dammed basins in the word is relevant since Brazil has a unique history with hydropower development. In addition, we did not directly observe the meetings held by the dam builders, or the government, but we are describing what is reported in the literature. This particular study is only looking at institutionalized mechanisms for participation and does not take into consideration the non-institutionalized mechanisms or the other forms of social movements. Future research could compare multiple hydroelectric dams built in Brazil or elsewhere whose builders use different ways of engaging the public.

With the boom of dams planned in the Global South, it will be crucial that, before meetings are held and information is disseminated, dam builders and governments should engage communities to determine the participatory mechanisms that are most appropriate for their specific context. Participation mechanisms designed by external parties without the involvement of impacted communities will likely not lead to meaningful engagement and continue the unacceptable procedural injustices that characterize the history of hydropower (Garcia et al 2021). Further, the construction of the dams, including their design and location, was a foregone conclusion that local communities were not allowed to negotiate over. This may have also reduced interest in participation. Future scholarship needs to give greater attention to these barriers to participation, and policy makers need to consult with greater seriousness those most directly affected by large infrastructure projects**.**

CRediT authorship contribution statement

Adam Mayer: Conceptualization, Writing – review & editing. **María Alejandra García:** Conceptualization, Writing – review & editing, Methodology. **Laura Castro-Diaz:** Conceptualization, Writing – review & editing, Methodology. **Maria Claudia Lopez:** Conceptualization, Writing – review & editing, Funding acquisition, Methodology. **Emilio F. Moran:** Conceptualization, Writing – review & editing, Funding acquisition, Project administration.

[3] IIRSA (Initiative for the Integration of the Regional Infrastructure of South America)Avança Brasil (Advance Brazil)Programa de Aceleração do Crescimento (Growth Acceleration Program), better known as PAC.

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.

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Appendix

Table A1
Communities included in the study, community type, and completed surveys.

Community	Number houses	Location relative to dam	Completed surveys
Calama	440	Downstream	151
São Carlos	282	Downstream	109
Cujubim Grande	220	Downstream	79
Abunã	212	Upstream / Reservoir	100
Nova Mutum	267	Reservoir	79
Riacho Azul	82	Reservoir	51
Vila Jirau	240	Reservoir	70
Vila Penha	148	Upstream	33

Table B1
Distribution of Impact items from after dam construction began.

	Improved	Stayed the same	Gotten worse
Relationships with Friends	5.44	44.71	49.85
Relationships between household members	7.49	72.78	19.72
Health	8.68	50.23	41.1
Satisfaction with House	30.66	39.43	29.91
Access to Electricity	29.27	18.14	52.59

Table B2
Rotated Factor Loadings for Impact Questions.

Variables	Factor 1	Factor 2	Factor 3
Relationships with Friends	0.596		
Relationships between household members	0.694		
Health	0.346		
Satisfaction with House			0.410
Access to Electricity		0.475	

Note: Factors extracted from a polychoric correlation matrix using the iterated principal factors method and a varimax rotation. KMO = 0.66. The eigenvalue for the first factor was 1.24 and 0.33 for the second factor. The first factor accounts for 70% of the interitem variance and the second accounts for 21%. Based upon these results and the inspection of a scree plot, we extracted a single factor for use as a predictor in the regression models for after dam construction began.

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