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Socioeconomic impact assessment during the stages of building and operating hydropower plants in the Legal Amazon Region

Análise dos impactos socioeconômicos nas etapas de construção e operação de usinas hidrelétricas na Amazônia Legal

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ABSTRACT

Hydropower plants (HPPs) play an important role in the Brazilian energy matrix, largely in the Amazon region where the largest amount of hydropower generation potential is found. Therefore, this study aimed to analyze socioeconomic impacts caused in the stages of building and operating a large HPP in the Legal Amazon region. For such a purpose, the socioeconomic impacts detected in environmental studies of five projects (Belo Monte, Jirau, Peixe Angical, São Manoel and São Salvador) were analyzed. Socioeconomic impacts were sorted out according to the stage of their life cycle (construction and operation); these impacts were compared using a matrix and a descriptive analysis of data. Many similarities and correlations between the socioeconomic impacts were found in five studies. During the analysis, it was found that numerous impacts were improperly mitigated in these studies. Furthermore, social costs, such as population relocation, are typically underestimated, and gains brought by operating the HPP are overestimated. It is expected that an assessment of socioeconomic impacts caused by HPP in the Legal Amazon is going to allow broadening discussions about these constructions in areas of socioenvironmental sensitivity. Moreover, it is found that socioeconomic impacts in assessed studies are associated with multiple conflicts between the population affected by the project, government, and enterprise.

Keywords: HPP; relocation of populations; socioenvironmental sensitivity; affected population.

RESUMO

As usinas hidrelétricas (UHE) ocupam importante papel na matriz energética brasileira. Sobretudo, na região da Amazônia, onde se localiza a maior parcela do potencial hidrelétrico inventariado. O presente trabalho teve como objetivo analisar os impactos socioeconômicos ocasionados nas etapas de construção e operação de UHE de grande porte na região da Amazônia Legal. Para isso, foram analisados os impactos socioeconômicos identificados em Salvador). Os impactos socioeconômicos foram segregados de acordo com a etapa do ciclo de vida do empreendimento (construção e operação); comparou-se os impactos em uma matriz e os dados foram analisados de forma descritiva. Verificou-se que existem muitas similaridades e correlação entre os impactos socioeconômicos levantados nos 5 estudos selecionados. Durante a análise, verificou-se que muitos dos impactos levantados nos estudos não foram devidamente mitigados. De maneira geral os custos sociais, como a realocação da população são subestimados, e os ganhos pela operação da UHE são superestimados. Espera-se que o levantamento realizado dos impactos socioeconômicos ocasionados por UHE na Amazônia Legal possibilite ampliar a discussão sobre estas obras em áreas de sensibilidade socioambiental. Por fim, conclui-se que os impactos socioeconômicos presentes nos estudos avaliados estão associados a múltiplos conflitos entre a população atingida pelo empreendimento, o poder público e o empreendedor.

Palavras-chave: UHE; realocação de populações; sensibilidade socioambiental; população atingida.

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Introduction

Brazil has several hydropower plants (HPP) spread across its territory. Currently, its hydropower generation potential is 176 gigawatts (GW), out of which 108 GW refers to HPPs in operation and construction and 68 GW of hydropower generation potential (Energy Research Company — EPE, 2020). It is predominantly generated in areas of great socio-environmental sensitivity, especially in the Amazon region (globally important tropical ecosystem) where half of its size is covered by legally protected areas (EPE, 2020). Furthermore, in recent decades, the size of HPPs has changed in terms of installed capacity, as it is expressed in GW nowadays (Cavalcante et al., 2021). Among the HPPs in operation with high installed capacity in the Amazon region, the following stand out: Tucuruí (Pará) with 8.5 GW, Jirau (Rondônia) with 3.4 GW and Santo Antônio (Rondônia) with 3.2 GW (Cavalcante et al., 2021).

These enterprises encompass negative environmental effects triggering significant biophysical and socioeconomic disturbances (Ansar et al., 2017; Catolico et al., 2021; Serrão et al., 2023). The complexity of measuring impacts on dams is far beyond the scope of other types of projects, since each location has very peculiar geological and hydrological conditions, among other factors (Ansar et al., 2017; Catolico et al., 2021). Furthermore, these large works involve several interests to be considered, as populations neighboring these large projects end up suffering from an exacerbated price of electricity, while private capital companies exponentially boost their profits every year (Castilho, 2019).

One of the mechanisms enabling a more efficient investigation of the environmental viability of these projects is the Environmental Impact Assessment (EIA). It was originally designed to mitigate harmful environmental consequences by providing scientific assessments of proposed projects. Its pillars are based on public participation in works directly affecting the community, such as the construction of dams. Thus, popular participation is based on democratic processes to analyze a series of events affecting the daily life of a community supported by mechanisms to ensure an adequate level of influence and participation in decision making for the general population (Rojas, 2022).

In this context, projects involving the construction of large dams have sparked off an intense debate in recent years (Ansar et al., 2017; Bratman and Dias, 2018; Climent-Gil et al. 2018; Catolico et al., 2021). Such a debate involves questionings about EIA, separating the community into supporters rallied to contribute to human development and detractors highlighting social and environmental costs considered unacceptable in numerous cases (Bratman and Dias, 2018; Climent-Gil et al. 2018).

Thus, the Social Impact Assessment (SIA) is the main instrument used in environmental sociology to analyze socioeconomic impacts caused by such projects (Climent-Gil et al., 2018). These impacts caused by large projects are generally unevenly spread among the human groups affected, which are determined by a few factors such as: a) the degree of exposure to the impact (location and proximity of individuals to a given risk); and b) the level of social vulnerability (characteristics and circumstances of a population, system or asset making it susceptible to harmful impacts of a potential risk) (Climent-Gil et al., 2018). Therefore, these impacts not only vary in intensity, according to location and activity, but also depend on social class.

Compelled displacements and resettlement of local communities who are generally subjected to homogeneous remuneration packages, in addition to disregarding the complexities of each social group. are examples of these negative social effects (Catolico et al., 2021). A territory is not simply understood as a geographic area, but also as having value (Santos et al., 2020). In the case of traditional communities, displacement may involve changes in geographic area and value. Deterritorialization is the process of mapping indigenous peoples outside their native territorial domain and confining them in spaces such as reserves, thus shunning them from their own territories (Daigle, 2020). This concept has also been used to describe the act of resettling other communities, as is the case of people affected by collapsed tailing dams in Minas Gerais (Santos et al., 2020).

Historically, debates have arisen about the environmental impacts caused by large dams built in Brazil, as there should be environmental studies about Sobradinho HPP on the São Francisco River (1972) and Tucuruí on the Tocantins River (1977), financially supported by the World Bank Group. In this context, the World Bank Group played an important role in the dissemination of EIA in Brazil.

Furthermore, important social movements emerged in the early 1980s in Brazil. In mid-1983, the *Central Única dos Trabalhadores* (CUT) was created in the context of several protests in favor of direct elections, and the Landless Workers Movement (MST) was launched in 1984. Finally, in 1989, commissions from different regions have assembled and established a coordinating council to hold a congress in 1991 to define that the Movement of People Affected by Dams (MAB) would lead the agenda for activism to support the population affected by these large projects, thus gaining greater visibility and mobilization after the crimes committed in Mariana and Brumadinho (MAB, 2021).

Among the most recent agendas by MAB (2021), it is worth mentioning the approval of Law No. 23,291/2021, known as "Mar de Lama Nunca Mais", and Bill No. 2,788/2019, establishing the National Policy for the Rights of Affected Populations (PNAB), in addition to social pressures assisting in the introduction of legislation for dams — Law No. 12,334/2010 (Brasil, 2010), which establishes the National Dam Safety Policy (PNSB).

Nonetheless, one of the main positive effects of HPPs is associated with the production of electrical energy to be added to the Brazilian grid. In this sense, an environmental feasibility study must consider positive and negative effects in systemically in environmental studies. However, some argue that, in practice, EIA is often hindered by economic and political concerns, especially in a developing world (Bratman and Dias, 2018).

A concept capable of assisting in debates about socioeconomic impacts caused by HPPs is energy justice, which is grounded in providing distributive justice (assessment of where the main impacts are found), recognition (identification of the source of inequalities) and procedural justice (involvement in decision-making and policy-based solutions including full recognition of those affected) (Uffelen, 2022). Additionally, a few organizations such as the Low Impact Hydropower Institute (LIHI) are devoted to certifying hydropower projects with reduced environmental impacts. However, such certification emphasizes ecological impacts, but the social and economic aspect of hydropower development is practically disregarded (Tahseen and Karney, 2017).

Due to the complexity in quantifying socioeconomic impacts, current literature identifies it as one of the most challenging aspects of hydropower development (Tahseen and Karney, 2017). Therefore, it is necessary to focus on the most vulnerable social groups (Climent-Gil et al., 2018), especially considering the National Energy Plan for 2050, which highlights the hydropower potential located predominantly in areas of high socio-environmental sensitivity in the Amazon region. One way to contribute to this debate is by assessing the socioeconomic impacts considered in EIA of HPPs with high generation capacity in the Amazon region. Thus, this work assesses the socioeconomic impacts on vulnerable communities (riverside, indigenous, quilombolas and other affected populations) during the construction and operation of five large HPPs in the Legal Amazon region.

Methodology

To assess the socioeconomic impacts found during the construction and operation stages of HPP in the Legal Amazon, the following were performed: selection of documents to be analyzed (1st stage); assessment of expected socioeconomic impacts in the construction and operation stages (2nd stage); and assessment of socioeconomic impacts expected to be found in construction and operation stages (3rd stage).

Five HPP documents (EIAs and report) regarding the Legal Amazon were analyzed, one in the state of Pará, one in Rondônia, two in Tocantins, and one on the border of the states of Mato Grosso and Pará. The selection of these studies (1st stage) was carried out based on the installed capacity of the HPPs (available on the website of projects) and the availability of access to documents on the website of an environmental agency named Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). To such an end, five HPPs were selected, whose information is detailed in Table 1, and their respective location are shown in Figure 1.

To assess the socioeconomic impacts anticipated in the construction and operation stages (2nd stage), summaries of HPP documents were accessed and their respective sections or volumes referring to socioeconomic impacts were accessed. For each study, one or more volumes of the document were consulted, depending on how the study was structured, as shown in Table 2. All socioeconomic impacts expected to be found during the construction or operation stages of the HPPs and the respective nature of impacts were compiled as described in the documents.

Finally, regarding the socioeconomic impact assessments (3rd stage), data compiled in the previous stage were organized into a matrix to enable a correlation between the enterprise (HPP), socioeconomic impact statement, the stage of the enterprise life cycle (operation and/or construction) and the impact nature (positive and/or negative). From impact classification, a color system was used to indicate their nature: green (positive impact), red (negative impact) and orange (positive and negative impact). Data compiled from the documents were compared with each other and with academic studies and good practice guidelines in a descriptive way.

Results and Discussion

Potential socioeconomic impacts

A total of 127 potential socioeconomic impacts were identified in the construction and operation stages of the five selected HPPs. Out of these impacts, 71 were predicted in the construction stages and 56 in the operation stages (Supplementary Material). Out of these impacts, 26 were related to indigenous communities (12 in the construction stage and 14 in the operation stage) close to the Belo Monte, Jirau and São Manoel projects (Figure 1).

To discuss the socioeconomic impacts considered for HPPs with high generation capacity in the Legal Amazon, recurring impacts in at least three out of five HPPs in the construction stage and in at least two out of five HPPs in the operation stage were considered. This selection does not regard the impact importance, but the rate at which it is cited in selected studies.

Table 1 – Hydropower plants selected for assessing socioeconomic impacts.

HPP	Intercepted river	State	Installed Capacity (MW)	Start of construction	End of construction
Belo Monte	Xingu	Pará	11,233.1	2011	2016
Jirau	Madeira	Rondônia	3,750	2008	2013
Peixe Angical	Tocantins	Tocantins	498.75	2002	2006
São Manoel	Teles Pires	Mato Grosso e Pará	735.84	2014	2018
São Salvador	Tocantins	Tocantins	243.2	2004	2009

HPP: hydropower plants.

Figure 1 – Location of the hydropower plant under study.
Source: adapted from the Institute of Man and Environment in the Amazon (IMAZON, 2015).

Table 2 – Section/volumes of studies used to compile socioeconomic impacts.

HPP	Section/Volume	Section/Volume title
Belo Monte	Volume 29, 30, 31 Volume 29, 30, 31	Impact Assessment part 1, 2 and 3
Jirau	A Content Analysis Report on EIA/RIMA	Content Analysis Report on Environmental Impact Assessment (EIA) and the Environmental Impact Report (EIR) on Santo Antônio and Jirau Hydropower Plants on the Madeira River, State of Rondônia
Peixe Angical	Volume 5	Impact Assessment
São Manoel	Volume 5	Environmental Impact Assessment - EIA of São Manoel HPP
São Salvador	Part B - Chapter III	Chapter III - Social impact assessment

Thus, 18 impacts were selected, out of which 14 are negative and four are positive. Table 3 presents the socioeconomic impacts of HPPs under study in their construction and operation stages.

In order to facilitate the discussion on selected potential socioeconomic impacts, they are grouped and described below.

Change in migration flow, overwhelmed public administration management and increased incidence of diseases

A change in migration flow refers to a significant increase in people, which reflects a sudden demand for a better structure of social tools.

Table 3 – Socioeconomic impacts assessed during the construction and operation stages of five hydropower plants in the Legal Amazon region.

Socioeconomic impacts		HPP				
		Belo Monte	Jirau	Peixe Angical	São Manoel	São Salvador
Construction stage	Change in migration flow	Negative	Negative	Negative		Negative
	Change in relationship between supply-demand for consumables, goods, and services, as well as boosting the economy	Positive	Positive			Positive
	Increased incidence of respiratory diseases and discomfort to the population	Negative	Negative		Negative	
	Increase in public taxation		Positive	Positive	Positive	
	Increased incidence of other diseases due to greater migration flow and poor conditions such as basic sanitation and environmental changes favoring the proliferation of vectors		Negative	Negative	Negative	
	Real estate speculation			Negative	Negative	Negative
	Arousing expectations by the population	Negative		Negative	Negative	Negative
	Overwhelmed public administration	Negative	Negative		Negative	
	Compulsory population transfer	Negative	Negative	Negative		
	More intense population density in cities close to indigenous lands due to the arrival of project workers and population attracted by it	Negative			Negative	
	Heavier vehicle traffic	Negative			Negative	
Operation stage	Expansion of public tax collection	Positive	Positive	Positive	Positive	
	Increased power supply reliability	Positive				Positive
	Interferences in archaeological, historical-cultural and landscape heritage				Positive and negative	Negative
	Change in uses around reservoirs resulting from their filling and operation of power plants (loss of leisure and tourism areas)		Negative		Negative	
	Proliferation of Zoonoses: Change in the vector-borne disease dynamics and incidence of malaria, black flies, and arboviruses (yellow fever, among others), dengue fever		Negative		Negative	Negative
	Loss of betterments				Negative	Negative
	Reduction in employment and downturn in economic activities in the period following the end of construction		Negative	Negative		

Legend:
Positive
Negative
Positive and negative

Such a change affects the lives of locals residing in these places, as well as the migrating population attracted by the start of project construction (Detoni, 2021).

The issue of SIA lies in how to ensure an anticipation of immigration processes so as to prepare and manage it appropriately, in addition to minimizing negative impacts and maximizing potential benefits (Vanclay et al., 2015). The migration of people to project-affected areas can lead to several social risks if not well managed (Andrade and Santos, 2015). Negative impacts related to migratory processes and population growth in these areas can be triggered, such as an increase in urban violence, traffic violence, consumption and sale of illicit drugs, sexual violence, prostitution, and sexually transmitted diseases (Catolico et al., 2021), in addition to the incidence of endemic diseases (such as malaria), due to greater proliferation of vector-borne diseases (Catolico et al., 2021).

In the case of Belo Monte HPP, a survey on compliance with socio-environmental programs and projects was carried out through a dossier, which revealed partial compliance regarding health infrastructure, education, basic sanitation, and public safety. During the period of peak demand, health and education infrastructures were not yet completely built, leading to constant overcrowding at São Rafael Municipal Hospital and increased demand for places in primary education institutions (Villas-Bôas et al., 2015). As for basic sanitation, water and wastewater treatment plants were unable to operate due to a lack of connection between households to the treatment network. Furthermore, management of Altamira landfill (which should have been built over two years ago) was transferred to the city hall and was operating inappropriately (Villas-Bôas et al., 2015). Regarding public security, there was an increase by almost 80% in cases of violence between 2011 and 2014 (Villas-Bôas et al., 2015).

Compulsory population transfer

Another impact assessed and classified as negative is the compulsory transfer of the population residing in the region of Belo Monte, Jirau and Peixe Angical HPPs. In such cases, there must be a Resettlement Action Plan (RAP) to describe operational process of resettlement in greater detail (Vanclay et al., 2015).

Changing the environment affects the lives of the general population, as it modifies their lifestyle, especially their relationship with their own territory. Previously possible leisure activities such as fishing, swimming in the river, and navigation become dangerous and lead to difficulties in adapting to resettlement, including cases of some families returning to areas close to dams due to difficulties in adapting to resettlement (Giongo et al., 2021). Furthermore, these impacts are more clearly perceived by the most vulnerable communities, since families of farmers and rural workers are compelled to leave their lands, which causes subsistence problems (Parente and Miranda, 2014).

A compulsory population transfer is also associated with loss of family ties (kinship, neighborhood, and friendship relationships); cultural loss (habits, beliefs, customs, and traditions); and sentimental losses (attachment, feeling of belonging to the place) (Catolico et al., 2021).

In the case of Belo Monte HPP, the resettlement process was rather traumatic and disorderly (Villas-Bôas et al., 2015). Successive problems occurred such as: subdivisions built for resettlement with no adequate public services, such as health, education, and transport. Another point worth mentioning was that, initially, the entrepreneur registered 5,141 affected dwellings; however, he only signed a contract to build 4,100 houses (Villas-Bôas et al., 2015). Furthermore, populations residing in rural areas were not resettled in environments similar to their lifestyle (Villas-Bôas et al., 2015). The Collective Urban Resettlement (CUR) of São Joaquim, in addition to being far from the city center, has unpaved roads. Furthermore, there is no public transport, and the only transport able to function properly in the region is school transport; therefore, the remaining population has no access to public transport. Other basic access issues were not addressed properly, such as waste collection, among other urbanization works that were not initiated, in addition to the absence of a zip code, thus preventing the population from having ensured access to a dignified life (Magalhães, 2015).

A similar situation occurred at HPP Jirau. Approximately 2,849 people would be directly affected (Furnas, Construtora Noberto Odebrecht and Leme Engenharia, 2005); however, only the fishermen's cooperative in the region made up of 2,400 people were disregarded in studies (Fearnside, 2014). Therefore, both fishermen and other people living off the river were affected. The Santa Rita settlement, which had previously been resettled by the National Institute for Colonization and Agrarian Reform (INCRA), was occupied by the MST members, and went through the process of change once more so that the dam could be built (Belforte, 2021). Such deterritorialization directly affected locals, as their livelihood mostly depended on agricultural production, such as collecting nuts, *açaí* and wood. To date, these people have not been able to resume their way of life, as the place where they were resettled to was an old farm, which has had soil unsuitable for family farming (Belforte, 2021).

Arousal of expectations among the population and real estate speculation

Expectations are supposed to be aroused the moment the project is announced. Such impact is associated with how the potentially affected community perceives the future effects the project can create. Fear and anxiety, as all perceived impacts, are real social impacts experienced by people which should not be disregarded, but managed effectively (Vanclay et al., 2015).

In the case of HPPs, such expectation is also associated with a potential landscape change. At HPP Luis Eduardo Magalhães (Tocantins), the depletion of beaches created expectations among boatmen, stall owners and traders who depended on this activity as their livelihood (Parente and Miranda, 2014). Such arousal of expectations can in turn cause changes in population habits, in addition to exerting other impacts. In the case of Belo Monte, a strong increase in deforestation rates in the region was observed as a result of such expectation by some of the small and medium-sized producers of deeper land appreciation after project confirmation (Villas-Bôas et al., 2015).

Real estate speculation can occur as a response to the arousal of expectations and migration flow. In these cases, more vulnerable populations might be unable to afford rent for their homes. Furthermore, monetary compensation for affected families might be insufficient to purchase other urban properties, given the real estate speculation caused by project initiation (Villas-Bôas et al., 2015). To avoid speculative or opportunistic behavior by the local population and manage migration, an inventory of houses, other buildings and all assets should be compiled (Vanclay et al., 2015).

Interference with archaeological, historical, cultural and landscape heritage

One of the keys to the continuity and survival of human communities is their historical and cultural resources (The Interorganizational Committee on Guidelines and Principles for Social Impact Assessment — ICGPSIA, 1994). However, there are no measures to minimize or mitigate cultural and archaeological loss in most cases (The World Commission on Dams, 2000). Assessing the actual impact exerted because of these losses of cultural and archaeological assets becomes challenging, since a more extensive and in-depth investigation at each site is seldom carried out. To prevent damage to historical, cultural, and archaeological heritage sites, there should be careful prospecting before the beginning of construction so as to enable the discovery of sites or artifacts and project alterations (Clarke, 2009).

In the stage of HPP operation, the impacts resulting from tampering with archaeological, historical-cultural landscape heritages and

modification of uses around the reservoirs resulting from their filling and operation of HPPs (losses of leisure and tourism areas) are mutually related, as they can make the population feel that they do not belong to their territory.

Modification of uses around reservoirs, proliferation of zoonoses and loss of betterments

Loss of betterments is directly related to real estate speculation and compulsory population transfer. A HPP operation consists in the construction of a dam and the formation of a flooded area, which in turn significantly affects people's lives and culture. Land use must be considered as one of the SIA variables (ICGPSIA, 1994). Natural resources and flooded areas affect communities living off these resources, as they affect their lives and lifestyle (The World Commission on Dams, 2000). Furthermore, social and health implications of land use changes must be considered and discussed (Vanclay et al., 2015).

In the case of HPP Jirau, the activities proposed to replace lost jobs are insufficient, such as the creation of artificial beaches that would encourage tourism in the region (Fearnside, 2014). Water in the reservoir was considered unsuitable for swimming, thus making it impossible to replace fishing with tourism (Fearnside, 2014).

The creation of dams cast another issue to light as it directly affects populations living on riverbanks. In the case of the Tocantins River, the dam made the natural upward and downward movement of riverbanks impossible, thus leading to changes in the absorption of NO_3 brought by the water and exerting direct impacts on the quality of soil on riverbanks, given that it has been traditionally used for agricultural purposes by the population (Swanson et al., 2021). Furthermore, as the soil is unable to absorb nitrogen, its higher concentration in water ended up intensifying eutrophication, in addition to altering water quality (Swanson et al., 2021).

Employment reduction and downturn of economic activities

At the end of the entrepreneur's activities, there is a reduction in employment and downturn of economic activities. These impacts can be worsened in cases of underestimating the population affected or groups that have not been included herein or taken into account at the time of estimates (The World Commission on Dams, 2000).

In the case of HPP Jirau, workers who traveled to work during the construction stage of the HPP, who would later become unemployed, corresponded to approximately 100 thousand people (Fearnside, 2014). Furthermore, these people remained in the city of Porto Velho after the end of the HPP construction, leading to an increase in unemployment and poverty thereof (Fearnside, 2014).

Impacts associated with indigenous communities

The term "Indigenous Peoples" is widely used as a generic term throughout the world, although it is of difficult definition, given that some indigenous groups and other stakeholders (especially in certain regional contexts) prefer a series of broadly equivalent terms, such as: tribal groups, traditional peoples, among others (Vanclay et al., 2015). There are two important international agreements relating to indigenous peoples: the General Conference of the International Labor Organization about Indigenous and Tribal Peoples Convention in Independent Countries in 1989 (C169); and the 2007 United Nations Declaration on the Rights of Indigenous Peoples. These documents emphasize that indigenous peoples are entitled to the same basic human rights as all others residing in the world. However, due to indigenous peoples' special connection to the land and their vulnerability, they deserve special consideration to ensure that their rights are respected (Vanclay et al., 2015). In Brazil, the Indigenous Component Study (ICS) is a fundamental instrument for enforcing these rights established by Interministerial Ordinance No. 60, of March 24, 2015.

The EIAs of Belo Monte and São Manoel HPPs allowed estimating population density in cities close to indigenous lands and an increase in vehicle traffic was also found. Both impacts cause similar problems due to their proximity to indigenous lands, thus leading to pressure on these lands, increased deforestation, diseases and even escalating violence due to land conflicts with communities (Rodrigues, 2018; FIOCRUZ, 2022).

In the case of Belo Monte HPP, members of civil society, researchers and indigenous leaders denounced that the project was developed by underestimating damming impacts, given that it affects the flow and natural reproduction of fish which are a source of food for communities (Villas-Bôas et al., 2015; FIOCRUZ, 2022). Furthermore, negative impacts eventually become more pronounced in the long term, in addition to causing impacts on cultural preferences and traditions, as native fish are eventually replaced by other exotic species able to adapt and reproduce more quickly in reservoirs, such as carp and tilapia (Arantes et al., 2019).

HPP São Manoel failed to carry out prior consultations on sites of works that would affect indigenous communities, given that a demarcation process was expected to be completed over nine years ago (Fearnside, 2019). Furthermore, the construction site was installed in an indigenous cemetery considered sacred, leading to protests, invasions into the site and demands for funeral urns (Fearnside, 2019). Other issues were raised by indigenous people during the construction period, such as the fact that the work took place in a breeding area of migratory fish making up the populations' dietary base (Fearnside, 2019). In December 2018, the Federal Public Ministry of Mato Grosso (MPF/MT) proposed a public lawsuit demanding the revocation of its Operating License due to non-compliance with conditions related to the Kayabi, Apiaká and Munduruku indigenous tribes (Rodrigues, 2018). Typically, costs and impacts on indigenous communities are not adequately compensated, in addition to the fact of disregarding the needs and vulnerabilities of these populations (The World Commission on Dams, 2000).

Increased public taxation, boosting the economy and energy supply reliability

An increase in public tax collection is expected in cases of large projects. Furthermore, economic dynamism is generally reflected in increased municipal Gross Domestic Product (GDP), generation of direct and indirect jobs and new establishments, in addition to growth in tax collection (Catolico et al., 2021). This would be of great value to expand investments in basic infrastructure for populations residing in these regions. However, several cities still suffer from a lack of basic services, which leads to overwhelmed public administration (Villas-Bôas et al., 2015).

Ensuring public trust compels governments, developers, regulators, and operators to fulfill all commitments made to the planning, implementation, and operation of dams (The World Commission on Dams, 2000). In this context, it is up to entrepreneurs to communicate honestly with all actors involved. The concept of energy justice can therefore ensure a reliable and fair energy supply.

Considerations on socioeconomic impacts of hydropower plants in the Legal Amazon and the Environmental Impact Assessment

Although energy is a structuring factor in society capable of affecting the micro- and macro aspects of the economy while handling impacts caused by HPP in the Legal Amazon, these are rather complex (Cavalcante et al., 2021). The expansion of hydropower generation in Brazil is predominantly found (86% in terms of installed capacity) in the Amazon region, which makes it even more relevant as it is considered a very sensitive area from an ecological standpoint (Andrade and Santos, 2015). Therefore, it is essential that activities related to planning and construction of new HPPs occur within a broad and robust EIA process (Andrade and Santos, 2015).

It is argued that the construction of dams in the Amazon is beneficial as a domestic source of clean and renewable energy, which offers an addition to the Brazilian electrical grid (Bratman and Dias, 2018). In this sense, there are studies highlighting its economic and social advantages, such as attracting investments, boosting the local economy and services sector. On the other hand, economic growth attracts migration flows due to the project, which exerts pressure on public services and municipal infrastructures (Catolico et al., 2021). As a result of rapid and concentrated population growth, there is an increase in urban periphery, not only regarding the housing deficit, but also due to an increase in land prices in most urban centers (Catolico et al., 2021).

Thus, these socioeconomic impacts reveal the duality of the construction and operation of a HPP for affected communities since local communities do not reap as many benefits in numerous cases. In this context, energy justice seeks to argue about the costs and benefits of energy production. This concept is applicable to energy consumption and production, regulatory structures, among other issues related to the topic (Jenkins et al., 2016).

Although HPPs represent an important energy source for large cities and industries, they eventually do not offer as many benefits to the population residing around their dams, or even in sites where plants were built (Moran et al., 2018). This represents a serious energy injustice regarding supply, given the impacts suffered by the population. It is worth mentioning that there must be restorative energy justice, in addition to the fact that studies should be carried out appropriately in the context of HPPs so as to ensure knowledge on potential socioeconomic impacts and public participation (Siciliano et al., 2018).

Social impacts have multiple facets, and the need for energy security in the country is found in all discussions. However, as for the relationship between the Brazilian electricity sector and communities affected by these works, it has always prevailed that economic benefits are more important than social damages. This premise causes affected populations to have their cultural, emotional, and material bases extinguished followed by insufficient financial compensations or resettlement that do not match their lifestyle (Bermann, 2007).

Furthermore, another delicate point worth approaching is that HPP projects rarely involve a significant participation from the negatively affected population. An example of such is the Belo Monte HPP, whose project has been in progress for decades. Despite several protests, and several population groups taking a stand against the construction, it was insufficient to stop the work. Although Belo Monte HPP should comply with Article 169 of the International Labor Organization (ILO), requiring that entrepreneurs consult the traditional populations affected by the project, indigenous communities were not previously consulted in the EIS phase (Villas-Bôas et al., 2015).

Another point seldom addressed in studies refers to the cumulative impacts in the region where the project is located. For instance, Peixe Angical HPP is in a region containing four other HPPs (on the Tocantins River), all built within a relatively close time frame (Athayde, 2019). Therefore, these cumulative impacts should have been considered.

The symbolic losses of the population are eventually aggravated by problems regarding incomplete or poorly designed basic structures. Loss of sacred places, contact with the river, ties with the neighborhood and fruit trees bear the loss of identity of a population. Moreover, the impacts of building a dam become even more relevant considering the context of indigenous populations having already been suffering from various forms of violence and changes. Therefore, projects should consider making room for dialogue with these populations, in addition to financial compensation and mitigations of these impacts (Ertzogue, Ferreira and Marques, 2017).

For such a purpose, the manner in which socioeconomic impacts are dealt with must be changed, i.e., not just by making promises about increasing the number of jobs and infrastructure, thus ensuring that the community is able to adapt to changes in their lifestyle, mainly in order for the voices of people belonging to these places to be heard (Mayer, Lopez and Moran, 2022).

An assessment of the socioeconomic impacts and repercussion of these projects evidences the need to expand debates with affected popula-

tions about the construction of a new HPP. Public participation often ends up functioning as a permeable screen through which projects are passed, but it is not substantially changed or blocked (Bratman and Dias, 2018).

Lastly, it is recommended to apply the concept of energy justice in the context of HPPs and its implications for affected populations. Energy justice should be more often present, so that all affected components are adequately evaluated and that life, especially concerning the way of living and the territoriality of a population, has its values recognized. Therefore, carrying out a detailed assessment of the impact of HPPs covering different interests of actors involved is extremely important to guarantee the well-being and distribution of benefits provided to the population (Catolico et al., 2021).

Conclusion

The socioeconomic impacts caused during the construction and operation of a HPP can lead to multiple conflicts between the population affected by the project, public authorities, and enterprises. Given the diverse social challenges and specificities of each region, as well as their population, there are several similarities between socioeconomic impacts raised in five selected studies. What generally happens is that the social issues, such as population transfer, are underestimated, and gains from the HPP operation are overestimated based on its financial compensations for distant actors. Furthermore, social impacts reported in dossiers and scientific articles during the construction stage of HPPs, such as a lack of infrastructure for the affected population, were not previously raised in environmental studies and are, therefore, inadequately mitigated.

It is expected that these observations and information are going to contribute to the process of continuous improvement in the development and implementation of public policies for the implementation of HPPs aiming at regional development and improved social well-being.

Contribution of authors

MIROSEVIC, E.: conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft. ROMÃO, E.L.: conceptualization, methodology, supervision, validation, visualization, writing – review & editing. KASEMODEL, M.C.: conceptualization, methodology, supervision, validation, visualization, writing – review & editing.

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