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Impacts of hydropower development on locals' livelihoods in the Global South

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ABSTRACT

The construction of hydroelectric dams in the Global South and emerging economies is controversial; on one hand, advocates highlight the positive impacts at national and global scales, such as national development and independence from fossil fuels. On the other hand, opponents of dams stress the negative social-ecological impacts on the livelihoods of communities near construction sites, and the lack of local communities participation in the decision making processes. Scholars have published a range of case studies exploring the impacts of dams. However, there is no comprehensive understanding of how hydroelectric dams impact people's livelihoods and capital globally. In this study, we present a comparative medium-N survey exploring the impacts of 33 large-scale dams on people's natural, social, human, financial, and physical capital and the pathways of conditions that explain the changes in these capital in the Global South. To do so, we used the information from a qualitative meta-analysis of the social impacts of dams and fuzzy-set qualitative comparative analysis (fsQCA). Our results show that the types of people's capital are impacted differently by the construction: natural, social, human, and financial capital are negatively impacted, whereas physical capital is often positively impacted. The fsQCA showed three main groups of pathways that explain the changes in capital. First, the study indicates that lack of local communities participation in decision-making processes negatively impacts all capital but physical. Second, regardless of the nation's energy security, megadams generate primarily negative impacts on natural, social, and human capital and positive impacts on physical capital. Third, our results indicate the importance of the World Commission on Dams in raising international awareness about the social-ecological impacts of dams despite a country's energy-security status.

1. Introduction

Hydropower is the world's leading low-carbon electricity source (IEA, 2021a). It will continue to be one of the primary energy sources, particularly in the Global South (also known as the Group of 77 and China) and emerging economies where there is a boom in dam construction (Fan et al., 2022; Moran et al., 2018; Zarfl et al., 2015). National governments and the private sector have incentivized hydroelectric dam construction, arguing it will boost economic growth and energy independence (Fan et al., 2022; Gürbüz, 2006; Namy, 2010; Smyth & Vanclay, 2017), and as a solution for the lack of energy that still millions around the world face (IEA, 2018). However, research has shown that the construction of dams negatively impacts the lives, livelihoods and the ecosystems around them (Cernea, 1997; Cernea & Maldonado, 2018; Scudder, 2005), often not providing them energy access (Aeria, 2016; Siciliano et al., 2018). For instance, Fan et al. (2022) found that recently built dams in Asia, Africa, and Latin America are associated with a reduction in gross domestic product, population, and land cover near construction sites.

The World Bank reported that in 2020, 9% of the world's population, 733 million people, lacked access to electricity, and a significant percentage of that population lives in the Global South (World Bank, 2022). Dams are seen as a path to provide energy to those lacking access. But dam projects are controversial. Their advocates (i.e., dam authorities, governments, and engineering

Abbreviations: WCD, World Commission on Dams; fsQCA, Fuzzy-set Qualitative Comparative Analysis.

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companies) argue that dams bring modernization, technological progress, national development, national prestige, control over water supplies, and energy security (Atkins, 2019; Nüsser, 2003; Nüsser & Baghel, 2017). Dam promoters advocate that energy security is positively associated with better human health, education, and higher incomes (Velez Echeverry et al., 2017; Grogran, 2016; Verneta et al., 2016) which improve well-being. Contrarily, dams' opponents (i.e., activists, affected populations, and social justice organizations) emphasize a range of negative social-ecological and economic impacts on those living close to dams, their livelihoods, and their ecosystems, as well as their lack of participation in decision-making processes (Atkins, 2019; Garcia et al., 2021; Mayer, Garcia et al., 2022; Nüsser, 2003). Some authors have found that the energy access argument is questionable since many rural communities, even some living nearby dams, still rely on polluting diesel generators and limited hours of electricity access (Aeria, 2016; Brown et al., 2022; Green and Baird, 2016; Moran et al 2022; Okuku et al., 2016; Siciliano et al., 2018). Despite these arguments and the extensive literature about the social impacts of dams, there is still no comprehensive understanding of how hydroelectric dams influence changes in people's livelihoods in the Global South.

The construction of hydroelectric dams happens under contexts that include diverse social, institutional, political, and economic conditions: for instance, global pressure for a fast energy transition (IPCC, 2022); a national need to be energy independent (Fan et al., 2022; IHA, 2003; Namy, 2010; Smyth & Vanclay, 2017); a call for implementing participatory processes in dam development decision making (Garcia et al., 2021; WCD, 2000); and a higher awareness of the social-ecological impacts of dams (Arantes et al., 2019; WCD, 2000; Winemiller et al., 2016). In this study, we brought all these conditions together to understand their influence on changing people's capital in areas near dams.

Livelihoods encompass how different people make a living depending on where they live (Scoones, 2009). One way to assess livelihoods is through "capital" or "assets," which are the resources that individuals, households, and communities "combine, substitute and switch" (Scoones, 2009, p. 177) to make a living. In this research, we used capital, in particular natural, social, human, financial, and physical capital, as a tool to synthesize the positive and negative impacts of hydroelectric dams on people's livelihoods. Multiple authors have studied the effects of dams on livelihoods. Still, most studies focus on the impacts on livelihood strategies such as fisheries (Arantes et al., 2021; Castro-Diaz et al., 2018) or agriculture (Calvi et al., 2019; Hausermann, 2018). Others focus their analyses on one type of capital and one dam. For example, Mayer, Lopez et al. (2022) studied the changes in structural and cognitive social capital in both resettled and host communities after the construction of the Belo Monte dam in Brazil, and Kedia (2003) assessed the health impacts (human capital) on resettled communities generated by the construction of Tehri dam in India. Few authors have looked at the concurrent changes in multiple types of capital. Sivongxay et al. (2017) described the changes in natural, financial, human, and physical capital near four hydroelectric dams in Laos. Yet, there is no broad understanding of how hydroelectric dams built in the Global South impact people's livelihoods and their capital.

Scholars have explored the impacts of hydroelectric dams on people's livelihoods from different perspectives and disciplines. However, these multiple methodologies and methods make the comparison across dams challenging, limiting the ability to accumulate knowledge, recommend policies, and provide thoughtful information to diverse stakeholders in the hydropower sector (Kirchherr & Charles, 2016). In this study, we are exploring how the capital of local communities living near hydroelectric dams changed because of dam construction and how their livelihoods are impacted. To do so, we selected 33 large-scale hydroelectric dams in the Global South and emerging economies (Brazil, China, and India) through a qualitative meta-analysis database of peer-reviewed articles exploring the social impacts of hydroelectric dams. Then we used fuzzy-set qualitative comparative analysis (fsQCA) to identify the conditions' pathways that explain the capital change. fsQCA has been used in the past by scholars to compare dams in the context of anti-dam movements (Kirchherr et al., 2016) and to show the deficit in participation of affected communities across different dams (Garcia et al., 2021).

This study is novel because it adds to the literature on the impacts of dams by presenting a comprehensive comparative analysis of how 33 hydroelectric dams built in multiple countries in the Global South impact positively and negatively through a common framing, that of capital: natural, social, human, financial, and physical. It builds off peer-reviewed cases that provide valuable information about the interaction of dam development conditions, such as the participation of local communities, the existence of international awareness of the impacts of dams that occurred with the recommendations from the World Commission on Dams (WCD), the country level of energy security, and the installed capacity of each dam. We also analyzed how these interactions could generate positive or negative changes in people's capital. The results show the immense impacts caused by dam development on communities living near the construction sites and how each capital is affected differently. We shed light on the importance of considering the impacts of hydroelectric dams from a systemic approach, including positive and negative aspects, to reduce the inequalities and injustices this energy system generates. These lessons are of great importance in the current discussion about energy transitions, which will likely increase the construction of renewable energy systems such as hydropower, even in the Global North.

2. Theoretical background

This study aimed to explain the changes generated by hydroelectric dams on people's livelihoods using four causal conditions of dam development associated with the changes in five types of capital: natural, social, human, financial, and physical. The first condition is the participation of local communities, since scholars have highlighted the importance of participatory process in the context of dam development (Garcia et al., 2021; WCD, 2000), and in mitigating the dam's effects on people's livelihoods (Goulet, 2005; Hay et al., 2019). The second condition is the presence of international awareness of the impacts of dams enhanced by the WCD report (Schulz & Adams, 2019; Sneddon & Fox, 2008). The third is whether the country was energy secure when the dam's construction started or had to import energy to satisfy its demand, which is related to the current pressure for fast energy transition and the need to be energy independent (Fan et al., 2022; IHA, 2003; Namy, 2010; Smyth & Vanclay, 2017). And the fourth condition is a project characteristic, the dam's installed capacity, which often reflects its potential benefits (IHA, 2020; Siciliano & Urban, 2017; WCD, 2000).

2.1. Outcomes: capital

We consider livelihoods in terms of access and control of capital (Bebbington, 1999; Ellis, 2000; Scoones, 1998, 2009). Thus, capital, besides being the resources that support individuals', households', and communities' livelihood strategies (Bebbington, 1999; Ellis, 2000), are also the assets providing people with the capabilities to be and act (Bebbington, 1999).

In particular, we look at five types of capital: *Natural* includes natural resources humans use for survival, such as land, water, plants, and animals (Ellis, 2000; Scoones, 1998). *Social* consists of social networks, affiliations, and associations in which people participate and from which they can derive/claim support that contributes to their livelihoods (Ellis, 2000; Scoones, 1998), as well as trust and reciprocity (Flora et al., 2016). *Human* refers to the capabilities and potential of individuals and populations, such as education level and health status (Ellis, 2000; Flora et al., 2016; Scoones, 1998). *Financial* includes the stocks of cash that are accessed to purchase goods and access to credit, like income and savings (Ellis, 2000; Scoones, 1998). *Physical* comprises human-built infrastructure and assets brought to existence by economic production processes like houses, tools, machines, and land improvements (Ellis, 2000; Flora et al., 2016). All these capitals interact and contribute to sustainable livelihoods (Bebbington, 1999; Flora et al., 2016) and vary by individual, household, geographical area, and other social characteristics (Bebbington, 1999; Scoones, 2009). Access and control over more capital imply greater opportunities to switch between activities to sustain livelihoods (DFID, 1999).

Our research is an opportunity to provide a broad perspective on the social impacts of dams on capital, not by trying to quantify the effects but by describing how they are affected differently by the construction of dams. Thus, we are exploring the effects of dams on capital and the pathways of conditions influencing the change in capital based on what researchers have found in their studies.

2.2. Causal conditions to explain changes in capital

2.2.1. Participation

In the context of hydroelectric dams, researchers have shown that the impacts generated by their construction depend to some degree on the participation of local actors in a fair and equitable decision-making process or procedural justice (Siciliano & Urban, 2017). Procedural justice is concerned with decision-making practices and calls for equitable procedures that engage all stakeholders (Jenkins et al., 2016). In the case of hydroelectric dams, dam authorities and governments often do not consider principles of procedural justice (Garcia et al., 2021; Mayer et al., 2021; Mayer, Garcia et al., 2022) because they do not acknowledge the needs of local populations, and they repurpose control and access of capital resources that support local people's livelihoods, for example, food, forests and water, for building the project and feeding its workers (Siciliano & Urban, 2017).

Since the 1970s, researchers, practitioners, and even WCD have suggested including affected populations in decision making for dam development to mitigate the impacts on people's livelihoods (Goulet, 2005; Hay et al., 2019). For instance, Scudder (2005) noted that involving resettlers requires not just their active participation in decision making but also the involvement of their expertise and consideration of their lifestyles. Participation should start during the assessment process because it is when the social, environmental, and economic contexts are considered. However, procedures such as consultation or negotiation with local actors are rarely conducted in dam construction projects (Fainguelernt, 2011, Hay et al., 2019, Mayer, Garcia et al., 2022). Some would argue that environmental impact assessments and social impact assessments ensure the participation of local communities, but evidence shows that these assessments are often done poorly, sometimes even by the same companies that build the dams, people living in these territories are often not involved/consulted, and governments have started the construction of dams without the completion of these assessments (Fainguelernt, 2011; Gerlak et al., 2019).

The relationship between access to capital and local's participation works like a loop. When individuals participate in decision-making processes, their access to capital increases, and when individuals have access to a variety of capital, their participation and bargaining power also increase (Matsue et al., 2014; Radel, 2012). Thus, we expect the lack of participation (LackPAR) in decision making will decrease people's capital.

2.2.2. International awareness of a dam's impacts

Something that might have tamed the impacts of dam development since 1998 was the creation of WCD. The commission was seen as a response to the controversies around dam construction and its impacts (Scudder, 2001) and as a way to bring together the dam's opponents and supporters (Fujikura & Nakayama, 2009). It comprised actors from different backgrounds (local communities, governments, academia, industry) and countries (Schulz & Adams, 2019). In 2000, WCD presented a final report highlighting seven strategic priorities for sustainable dam construction and including local actors in decision-making processes. The commission elicited responses from the anti-dam movements and reactions from representatives of major dam-building nations (Sneddon & Fox, 2008). The report embraced participatory decision making in planning, designing, and operating dams (Schulz & Adams, 2019).

Despite initial support, big dam-funding agencies like the World Bank and the Asian Development Bank did not adopt WCD's guidelines. They argued that the recommendations for participatory decision making interfere with the rights of sovereign states to pursue development (Sneddon & Fox, 2008). Likewise, countries with plans for high-capacity hydropower, such as India, China, and Brazil, did not endorse the report because they felt the guidelines would limit their energy development goals (Fujikura & Nakayama, 2009). However, other funding agencies, such as the African Development Bank and the German KfW Development Bank, have followed the recommendations (Scheumann & Hensengerth, 2014; Schulz & Adams, 2019). In addition, WCD has been very important, since it provided a way to legitimize the social movements around dams, improved awareness about the need for more participatory processes and brought to the conversation the social and ecological impacts of dams in peoples' livelihoods (Schulz & Adams, 2019; Sneddon & Fox, 2008).

Lack of international awareness of hydroelectric dam impacts before the WCD (LackINT) is the second causal condition of this research. We expected dams constructed after the commission's establishment to have better guidance to protect people's livelihoods and, therefore, have fewer negative impacts on their capital.

2.2.3. Energy security

Hydropower is an attractive way of generating energy vis a vis climate change (Gerlak et al., 2019), because dams are advertised as an alternative source to fossil fuels (Namy, 2010; Oud, 2002). Hydropower development organizations claim the need for "significantly more hydropower, to be built at a much faster rate if it is to tackle climate change" (IHA, 2020, p. 8). However, this statement is debatable since, in the tropics, hydroelectric dams generate methane, carbon, and other greenhouse gases (Barros et al., 2011; De Araújo et al., 2019; Scherer & Pfister, 2016), which are drivers of climate change.

Dams are promoted as a key component of national economic development (Nüsser & Baghel, 2017) since they supply cheap electricity (da Costa, 2014). Their supporters argue the need to build dams to increase the countries' energy security (Atkins, 2019), particularly in Global South nations, where there is still a lack of access to electricity (Siciliano et al., 2015; World Bank, 2022).

The polysemic concept of energy security appears precisely in the discussions on climate change and energy (Chester, 2010). In this research, we understand that a country is energy secure when it has enough resources to meet its energy demand (Bruckner et al., 2014), with no energy supply interruptions, and when it is not dependent on other countries (Chester, 2010). This one of the reasons why the most biodiverse water basins in the world like Congo, Mekong, or the Amazon, are exploiting their hydropower potential building dams to reduce energy insecurity in their territories (Winemiller et al 2016). Such is the case of Brazil, where more than 67% of domestic energy depends on hydropower (IEA, 2021b). A country with a vulnerable or less energy-secure system will have a high share of energy imports, making it susceptible to energy price volatility (Global Network, 2010).

Nations commonly propose energy-security policies focused on strategies to secure low-cost and reliable electricity generation and transport supplies, reducing energy imports (Global Network, 2010). We expect that less energy-secure countries (import more energy than export) will generate more negative impacts on peoples' capital. These countries' policies mainly focus on reducing energy imports by developing low-cost energy sources. Hydropower is portrayed as a low-cost energy source because, in most cases, economic benefits tend to be overestimated and social-ecological impacts and construction costs are underestimated (Moran et al., 2018; Scudder, 2005). The variable we used in the analysis was energy security (LessES) based on *net energy imports*, estimated as the percentage of energy use less production.

2.2.4. Installed capacity

Installed capacity is a project-specific condition that indicates the quantity of electricity measured in megawatts (MW) the dam generates. The dam size usually reflects its potential benefits (WCD, 2000), such as increasing energy access (IHA, 2020; Siciliano & Urban, 2017). This supposed installed capacity is often not achieved after the dam's construction because of climate variability, as is the case with the Belo Monte in Brazil (Stickler et al., 2013). Governments and dam authorities promote hydroelectric dams by pointing to their installed capacity rather than their effective capacity during low-water periods (Winemiller et al., 2016). A recent global study of 631 dams confirmed that in regions where dams with large installed capacity are built, there is a reduction in the gross domestic product, and a reduction of land cover (Fan et al., 2022). Thus, we assumed that the larger the installed capacity (LargeIC) of a dam, the more negative impacts it will have on people's capital.

3. Research design

To explore the configurations among the causal conditions presented in Section 2.2 in relation to the changes generated by hydroelectric dams on people's capital, we used secondary sources of information and our database of a qualitative meta-analysis of peer-reviewed papers exploring the social impacts of hydroelectric dams. For data analysis, we used fsQCA.

3.1. Data collection

We conducted a qualitative meta-analysis to explore the social impacts of hydroelectric dams in the Global South. This method involves summarizing the depth and complexity of case studies according to a standard coding scheme designed by the research team. We first conducted a literature search using Google Scholar following these criteria: peer-reviewed articles (indexed) written in English, published between January 1980 and May 2019, focusing on the social impacts of large-scale hydroelectric dams[1] in the Global South. We selected 1980 as the starting date because it was the year The World Bank established the first international standard on resettlement (Vanclay, 2017). This screening yielded 129 peer-reviewed papers studying 87 dams. Then we developed a codebook and a coding protocol. The coding process involved two stages. First, all four coders collaboratively coded a selection of papers to become familiar with the codebook and the coding process. Then each coder coded a separate batch of studies using NVivo 12 software.

We used the database of the qualitative meta-analysis for information about the various types of capital and local communities' participation in dam decision-making processes. We obtained information about the dam's installed capacity in MW and the year construction began from the qualitative meta-analysis and verified with other sources such as the *Global Atlas of Environmental Justice* (EJAtlas, 2019). For each dam, we collected information on the country's net energy imports from World Bank (2015).

3.1.1. Data aggregation at the dam level

We selected 147 case studies from 89 articles (see Appendix 1) representing 33 dams in 18 countries. A case study describes what was happening with one population/group in a specific period because of a dam; one paper could include more than one case study. For example, in our research, an article describing the impacts of a dam on a host community and one that is resettled was codified as two case studies. This approach allowed us to consider the heterogeneity of communities impacted by dams. For this process, we used the *collapse* command in Stata 16 software to merge the case studies' information per dam, giving us the average values of the different cases per dam. We chose these 33 dams from our meta-analysis because we had data on them for all types of capital and the causal conditions (except for energy security).

Table 1 presents information about the 33 dams included in the analysis: name, country, year of construction, installed capacity, and if the country was a net energy importer by the time construction started.

Our study has some limitations. First, our qualitative meta-analysis dataset only includes papers written in English; we acknowledge that scholars are conducting and publishing high-quality research about the social-ecological impacts of dams in other local languages. Second, the 33 dams included in our analysis were selected because they were in the meta-analysis dataset and scholars have explored all five types of capital for each dam. This means that some critical large dams were left out due to lack of information.

3.2. Data analysis

In fsQCA, the outcome is understood as the phenomenon to be explained, and causal conditions as the characteristics that are associated with the outcome in question. fsQCA aims to determine which combinations of factors (causal conditions) are most closely associated with the outcome. In this research, the changes in each capital (natural, social, human, financial, and physical) due to dam construction are different outcomes. The causal conditions were the same for all outcomes: local communities' participation, international awareness of a dam's impacts, energy security, and installed capacity. fsQCA allows the analysis of small or intermediate *n* of purposively selected cases. It is a method that creates a bridge between qualitative and quantitative approaches to measurement because it is both case-oriented (fsQCA compares cases

[1] Based on the definition of the International commission on large dams (Icold), large-scale dams have a wall higher than 15 m. We chose this definition because it has been used by various scholars studying the social impacts of dams, such as Scudder (2005).

Table 1
Dams included in the analysis.

Dam	Country	Year construction started	Installed capacity (MW)	Net energy importer at start of construction
A luoi	Vietnam	2007	170	No
Aswan	Egypt	1960	2100	Not Available
Ataturk	Turkey	1983	2400	Yes
Bagre	Burkina Faso	1989	16	Not Available
Bakun	Malaysia	1996	2400	No
Batang Ai	Malaysia	1982	100	No
Belo Monte	Brazil	2011	11,233	Yes
Bili Bili	Indonesia	1991	19.25	No
Bui	Ghana	2009	400	Yes
Chixoy	Guatemala	1976	280.983	Yes
Cirata	Indonesia	1984	1008	No
Gilgel Gibe I	Ethiopia	1988	184	Yes
Gilgel Gibe III	Ethiopia	2006	1870	Yes
Gitaru	Kenya	1975	225	Yes
Kamburu	Kenya	1971	93	Yes
Kamchay	Cambodia	2006	193.2	Yes
Kaptai	Bangladesh	1957	230	Not Available
Kiambere	Kenya	1983	165	Yes
Kindaruma	Kenya	1968	72	Not Available
Kotmale	Sri Lanka	1979	201	Yes
Masinga	Kenya	1978	40	Yes
Nam Theun 2	Laos	2005	1075	Not Available
Ralco	Chile	1998	690	Yes
Saguling	Indonesia	1983	700	No
Sardar Sarovar	India	1987	1450	Yes
Sobradinho	Brazil	1973	1050	Yes
Son La	Vietnam	2005	2400	No
Tehri	India	1978	1000	Yes
Theun Hinboun	Laos	1994	210	Not Available
Three Gorges	China	1994	22,500	No
Wonorejo	Indonesia	1992	6.2	No
Xenamnoy	Laos	2013	410	Not Available
Xepian	Laos	2013	410	Not Available

as representations of configurations) and variable-oriented (fsQCA pays attention to specific individual conditions) (Marx et al., 2014).

For the analysis, we calibrated both the outcomes and causal conditions, then tested the necessity and sufficiency of each causal condition for every outcome with the software fsQCA 3.0. A causal condition is necessary if it must be present for the outcome to occur, whereas a causal condition is sufficient if it can produce a specific outcome (Ragin, 2014). For the analysis of necessity, we selected a consistency threshold of 0.9 or higher, as suggested by Schneider and Wagemann (2012). For sufficiency, as Ragin (2005) recommended, we selected a consistency level of above 0.75.

3.2.1. Calibration

Calibration, in fsQCA, is an analytical process by which researchers transform qualitative or quantitative data into crisp or fuzzy sets (Basurto & Speer, 2012; Fiss, 2011; Schneider & Wagemann, 2012). For the outcomes, we first created indices for each capital from variables of the qualitative meta-analysis (see Table 2 and Appendix 2 for a description of each variable). The indices ranged from −7 to 5; the lower the index, the more the variables belonging to that capital decreased (Table 2). Thus, a dam with six negative variables and one positive in a specific capital will have a value of −5.

Then we calibrated each capital in each dam as a particular outcome based on the index value. We used direct calibration, which requires the researcher to select the values of a scale that correspond to the breakpoints of the set (Ragin, 2008). This type of calibration allows for replication and validation (Pappas & Woodside, 2021). We calibrated the index scores into a three-value scheme—0, 0.5, and 1—to indicate full non-membership, the crossover point, and full membership (see Table 3). Then, for each capital, if a dam had more positive variables than negative ones, it was calibrated as 0; if it had the same number of positive and negative variables as 0.5, and if it had more negative variables than positive, it was calibrated as 1.

For our first condition, *Participation* (LackPAR), we used a four-value scheme based on scales from non-participation to citizen control (Arnstein, 1969; Pretty, 1995; White, 2011). We used four variables from the meta-analysis for calibrating this condition: participation, consultation and information, choice, and negotiation (see Appendix 3). The calibration ranges from *No public participation* (full membership = 1) when locals could not engage in any level of participation to *Some participation occurred* (full non-membership = 0) when local communities could choose or negotiate in decision making. The calibration values between the extremes were *Poor participation occurred* (partly in membership = 0.67) when locals were consulted or participated in the decision-making process but did not have the opportunity to choose or negotiate and *Low participation occurred* (partly out membership = 0.33) when local communities were engaged in at least two levels of participation.

We calibrated *International awareness (*LackINT), the second condition, in a two-value scheme: after the publication of the WCD report in 2000 (full non-membership = 0) and before its publication (full membership = 1).

The third causal condition, *Energy security* (LessES), is a proxy of the country's energy security during the initial year of dam construction. We used a two-value scheme to calibrate this causal condition: Energy secure or net exporter countries (full non-membership = 0) and less energy secure or net energy importer countries (full membership = 1). A country is a net energy importer if energy use is higher than the production in a year. Countries with no information available were calibrated as the crossover point: 0.5, which in fsQCA is the value of maximum ambiguity and represents cases that are categorized as neither full membership nor full non-membership (Ragin, 2008).

Table 2
Capital indices.

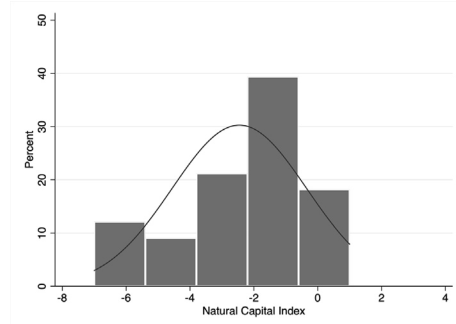
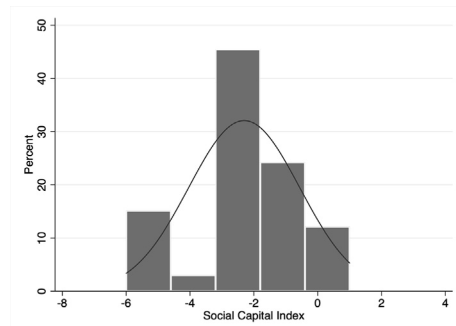
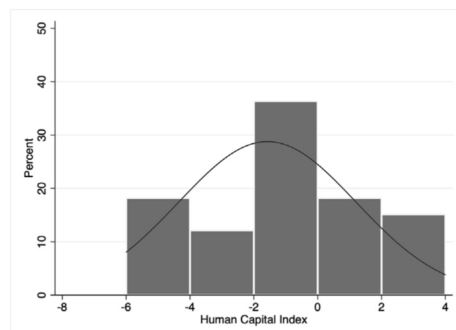
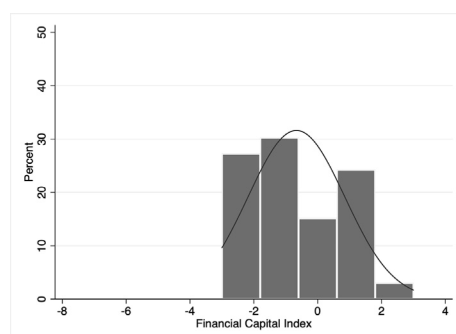
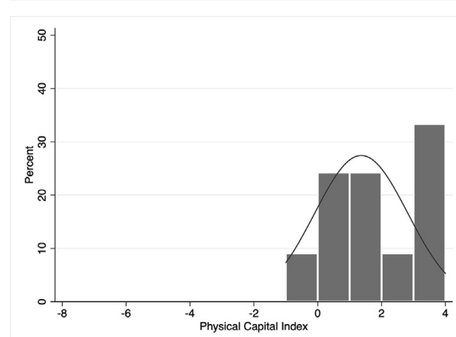
Outcome	Variable	Index distribution
Natural capital	Capital natural Soils Fish quantity Fisheries access Natural areas and products access Natural products quantity Water quality Water access Livestock amount Compensation natural capital	
Social capital	Capital social Community trust Cultural activities Friends and family connections Site neighbors Immigrants Conflict	
Human capital	Capital human Food access Food security Health Health access School Sanitation Standard of living Self-reported well-being Compensation human	
Financial capital	Capital financial Income Income inequality change Crop yield Employment Monetary compensation	
Physical capital	Capital physical Electricity access Compensation communities Physical compensations (e.g. house)	

Table 3
Calibration of outcomes.

Value	Outcome's Calibration		Description
1	Index value ≤ -1	Full membership	Mostly negative impacts
0.5	Index value = 0	Crossover point	The same number of positive and negative impacts
0	Index value ≥ 1	Full non-membership	Mostly positive impacts

For the last condition, *Installed capacity* (LargeIC), we used a four-value scheme to differentiate between the smaller dams and megadams. We assigned a value for each percentile from smaller dams (full non-membership), fairly large dams (partly out membership), large dams (partly in membership) to megadams (full membership).

Table 4 contains information about the calibration of the causal conditions (See Appendix 4 for expanded information about the calibration process).

4. Results and discussion

We start by describing the distribution of the impacts on each capital reported in all 147 studies used in this research. Then we present the fsQCA configurations that explain the change in each capital for the 33 dams.

4.1. How does capital change after dam construction?

Fig. 1 presents the percentage of the 147 cases that studied the impacts of hydroelectric dams in at least one variable of each capital. As shown, not all cases considered all capital; however, this was not problematic since our study was conducted at the dam level. Fig. 2 shows the distribution of positive and negative impacts among those cases that considered variables of different types of capital.

Fig. 1 shows that 82% of the case studies described at least once an aspect of change in natural capital; among those, it is noticeable that most of the case studies report negative impacts except for physical capital (Fig. 2). It is very important to consider the effects of dams on natural capital because, in rural communities, this capital is the basis for supporting all the other capitals (Flora et al., 2016). Scholars reported that local actors had lost access to common-pool resources such as rivers, forests, and pasture land (Abrampah, 2017; Bisht, 2009). Another common issue was the decrease in soil quality, which was prevalent in the case of resettlers who received land of worse quality, including infertile soils compared to what they had before the resettlement, preventing them from planting quality crops and threatening their food security (Aeria, 2016; Urban et al., 2015).

Only 58% of the case studies referred to at least one variable of social capital, demonstrating that this capital was less studied in the literature (Fig. 1). Still, 95% of the impacts were negative when it was reported. These impacts include the loss of traditional ceremonies due to resettlement (González-Parra & Simon, 2008; Nguyen et al., 2017) and the loss of social networks because households were often resettled in different locations than their friends and relatives (Leturcq, 2016). Among the few positive impacts on social capital, researchers have shown that, in some cases, host communities have increased their participation in associations after resettlement (Bui & Schreinemachers, 2011).

Human capital was included in 79% of the case studies; among those, 75% reported primarily negative impacts. For instance, scholars informed an increase in disease transmission (Gyau-Boakye, 2001; Kedia, 2003), hunger, malnutrition (Hall, 1994), and depression (Hausermann, 2018; Xi, 2016). However, some local communities also increased their access to health (Mishra & Kahssay, 2015), education (Fujikura & Nakayama, 2013), and sanitation services (Yoshida et al., 2013).

Aspects of financial capital are frequently mentioned in the literature. At least one aspect of this capital was described in 83% of the case studies (Fig. 1), including income, savings, and cash compensations provided by dam authorities. Financial capital had both positive (37%) and negative (63%) aspects (Fig. 2). For instance, resettled households experienced a decrease in their income potentiated by the loss of their natural resources, which were sources of food and cash (Bui & Schreinemachers, 2011). Furthermore, their livelihoods were impacted negatively by a drop in income and high housing prices in resettlement areas (Howe & Kamaruddin, 2016). In some cases, families were displaced but not resettled into new houses; some received cash compensation and were responsible for finding a new place to live. The most common type of compensation dam authorities provided to affected communities was cash, which increased financial capital in the short run. Still, if that was all people received, it certainly was not enough to restore their livelihoods (Cernea, 1997).

Finally, just 62% of the case studies made at least one reference to physical capital (Fig. 1), including houses, roads, and other physical infrastructure. Not surprisingly, physical capital was the least negatively affected capital in these cases. Only 17% of the case studies described negative issues, whereas 82 % indicated positive aspects such as improved housing, roads, schools, health centers, and markets (Hensengerth, 2018; Jusi, 2006). Some of these aspects not only generated benefits to the local area but were necessary for the operation of dam builders (i.e., roads or hospitals). Nonetheless, in most cases, resettled communities lost their houses and other physical assets due to resettlement (Faure, 2003).

Fig. 3 summarizes the context of capital at the dam level. This figure reflects the distribution of positive and negative impacts after collapsing the information from all cases per dam. Among the 33 hydroelectric dams in the analysis, 27 mainly had negative impacts on natural capital, 29 on social, 22 on human, 19 on financial, and three on physical capital. On the other hand, 22 of the dams had primarily positive impacts on physical capital.

This section has offered a broad description of how hydroelectric dams generate multidimensional impacts on people's capital. These results support our assumption that the construction of dams will impact people's capital differently because each capital supports different aspects of their livelihoods. In the next section, we present the fsQCA configurations, which provide a deeper understanding of the conditions that led to the changes in capital due to hydroelectric dam development.

4.2. fsQCA configurations

In this section, we describe the configurations of conditions that explain the presence of primarily negative impacts in natural, social, human, and financial capital and mostly positive impacts in physical capital. In the analysis of necessity, we found that none of the causal conditions is necessary for the presence of the outcomes, which means that none of the causal conditions must be present for any capital to change. Results for all conditions in each outcome are presented in Appendix 5.

Table 5 shows the 13 configurations of causal conditions or pathways that are sufficient to explain the presence of primarily negative impacts in natural, social, human, and financial capital and the presence of mostly positive impacts in physical capital (see Table 5 and Appendix 5 for extended information about the solutions). The table includes all sufficient pathways and their coverage or empirical relevance and consistency. Each pathway's raw coverage (RC) represents the proportion of dam projects explained

Table 4
Causal conditions calibration.

Causal condition	Value	Calibration		Source
Participation (LackPAR)	Full membership	1	*No public participation occurred*	Qualitative meta-analysis
	Partly in membership	0.67	*Poor participation occurred*	
	Partly out membership	0.33	*Low participation occurred*	
	Full non-membership	0	*Some participation occurred*	
International awareness (LackINT)	Full membership	1	Construction started before publication of the WCD report	WCD (2000), qualitative meta-analysis, and EJAtlas (2019)
	Full non-membership	0	Construction started after publication of the WCD report	
Energy security (LessES)	Full membership	1	Less energy-secure country (net energy importer)	World Bank (2015)
	Crossover point	0.5	Country is neither a net energy importer nor a net energy exporter	
	Full non-membership	0	Energy-secure country (net energy exporter)	
Installed capacity (LargeIC)	Full membership	1	1870 MW or more mega dam	The qualitative meta-analysis and EJAtlas (2019)
	Partly in membership	0.67	1075–1869 MW large dam	
	Partly out membership	0.33	400–1074 MW fairly large dam	
	Full non-membership	0	Less than 400 MW smaller dam	

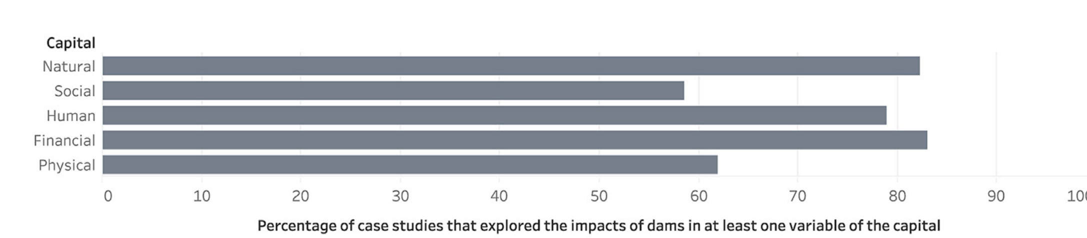


Fig. 1. Percentage of case studies that explored the impacts of dams in at least one capital variable.

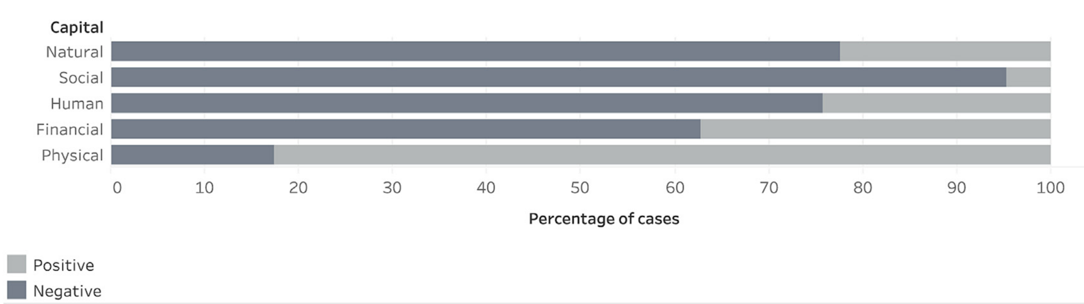


Fig. 2. Distribution of capital indexes at the case-study level.

by the pathway, including those in other pathways. The unique coverage (UC) represents the proportion of dam projects explained by that pathway. The consistency (C) score is a value that assesses the sufficiency of each pathway. For example, the pathway LackPAR for natural capital explains that 80% RC of the dams had mostly negative impacts on this capital and are included in other pathways. LackPAR has UC of 0.15, which indicates that this pathway alone covers 15% of the dams not included in other pathways, and it has C of 0.95. High consistency suggests that the configuration is sufficient to generate the outcome. In this study, high consistency indicates the presence of mostly negative or positive impacts in a capital.

First, we briefly describe the solutions for each capital; then we explore in depth how different pathways explain the changes in the various types of capital. The solution for the decline of natural capital has three pathways (1, 8, and 10 in Table 5). The first configuration indicates that dams with poor or lack of local communities participation (LackPAR) explain the presence of mostly negative impacts in this capital. The second configuration (LargeIC * ~ LessES) indicates that large and megadams in energy-secure countries also generate mostly negative impacts on natural capital. The last pathway shows that dams constructed with a lack of international awareness about dams' social impacts (LackINT) sufficiently explain the presence of mostly negative impacts on natural capital.

The solution for social capital has three pathways (1, 7, and 11 in Table 5) sufficient to decrease social capital. The first pathway (1) is shared with natural capital; this indicates that dams with

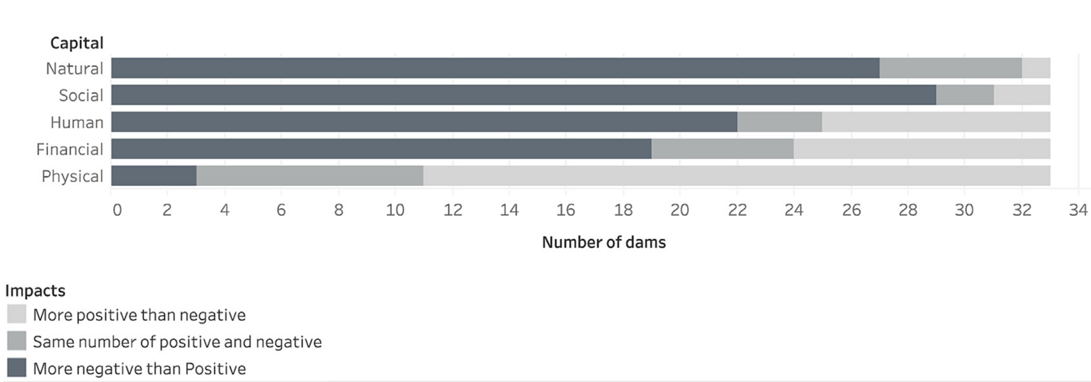


Fig. 3. Distribution of positive and negative impacts across 33 large-scale dams.

poor or lack of local communities participation (LackPAR) explain the presence of primarily negative impacts on social capital. The other two pathways (7 and 11) show that dams built in less energy-secure countries combined with a larger installed capacity (LargeIC * LessES) or built with a lack of international awareness about the social impacts of dams (LackINT* LessES) are sufficient to explain the presence of primarily negative impacts on social capital.

For human capital, the solution has three pathways (3, 6, and 7 in Table 5). Pathways 3 and 6 show that dams built with poor or lack of local communities participation that were constructed before or after the publication of the WCD report (2000) and in energy-secure or less energy-secure countries (LackPAR* LackINT * LessES + LackPAR* ~ LackINT* ~ LessES) are sufficient for explaining the presence of primarily negative impacts on human capital. Pathway 7 shows that large dams and megadams built in less energy-secure countries (LargeIC * LessES) are sufficient for the presence of primarily negative impacts.

The solution for financial capital has two pathways (2 and 4 in Table 5). Both pathways indicate that dams with poor or lack of local communities participation and built in a context of lack of international awareness about the social impacts of dams in combination with lower large installed capacity (LackPAR * LackINT * ~ LargeIC) or built in energy-secure countries (LackPAR * LackINT *~ LessES) are sufficient for explaining the presence of primarily negative impacts on financial capital.

The final solution, which describes the presence of positive impacts on physical capital, has four pathways (5, 9, 12, and 13 in Table 5). Pathway 5 indicates that dams built with lower or lack of local communities participation built after the publication of the WCD report (2000) are sufficient for the presence of primarily positive impacts on this capital (LackPAR* ~LackINT). Pathway 9 shows that large dams and megadams with some level of local communities participation are sufficient for the presence of mostly positive impacts (LargeIC * ~LackPAR). The last two configurations (12 and 13) illustrate that dams built after the WCD report (2000) in energy-secure countries (LackINT* ~ LessES) or with some level of local communities participation (LackINT * ~LackPAR) are sufficient for the presence of mostly positive impacts on physical capital.

As seen in Table 5, none of the pathways explains the change across all capital. There are three groups of configurations within all of the solutions that indicate the presence of mostly negative impacts on natural, social, human, and financial capital and mostly positive impacts on physical capital: participation of local communities and international awareness, megadams and energy security, and international awareness and energy security.

4.2.1. Local communities participation and international awareness

One of the most recognized contributions of the WCD report (2000) is how it acknowledges the need of participatory processes across all stages of dam construction (Schulz & Adams, 2019). Participation, as a concept, has been used by dam developers as a buzzword to indicate their projects are fulfilling the requirements. However, their "participation" processes are far from addressing procedural injustices. Mayer, Garcia et al. (2022) have described the participation processes in dam development as "pretend participation," since the mechanisms provided by developers are completely inadequate. Table 5 shows six pathways (1–6) that include the interaction between local communities participation and international awareness to explain the changes in capital. Our results prove that poor or lack of local communities participation is related to primarily negative impacts on natural, social, human, and financial capital, and mostly positive impacts on physical capital. Thus, our results support the expectation that when individuals or local communities do not participate in decision making, most of their various types of capital will be negatively impacted. However, as described in this section, not all types of capital are affected in the same way; the lack of participation in combination with other conditions has different effects on each capital.

The first pathway, LackPAR, is sufficient to explain the presence of mostly negative impacts on natural and social capital. Its consistency for both was 0.95, which implies that this condition is highly likely to be sufficient to explain both outcomes. This pathway includes 20 dams: A luoi, Bagre, Bakun, Batang Ai, Belo Monte, Bui, Chixoy, Cirata, Gilgel Gibe III, Gitaru, Kamburu, Kamchay, Kaptai, Kiambere, Kindaruma, Masinga, Saguling, Sardar Sarovar, Sobradinho, and, Tehri. These cases show that poor or lack of local communities participation is sufficient for the presence of mostly negative impacts on natural and social capital. For example, the inhabitants of a community located downstream of Belo Monte in Brazil were not included in decision making, and they lost fish species and access to the river (Castro-Diaz et al., 2018). Resettlers did not choose to move (Randell, 2016), and the process generated a separation from their families and acquaintances (Leturcq, 2016). Likewise, Kedia (2004) described that in the case of Tehri in India, communities were forced to resettle, and they lost their land and access to their forest. Furthermore, after relocation, they lost social cohesion and cultural practices (Naithani & Saha, 2019).

The lack of local communities participation, in combination with a lack of international awareness, is sufficient for the presence of mostly negative impacts on human capital (pathway 3) and financial capital (pathways 2 and 4). These pathways include 19 dams: Ataturk, Bakun Bagre, BatangAi, Chixoy, Cirata, Gitaru, Kamburu, Kaptai, Kiambere, Kindaruma, Masinga, Saguling, Sardar

Table 5
Configurations of causal conditions.

Pathway		Natural capital	Social capital	Human capital	Financial capital	~Physical capital
1	LackPAR	RC: 0.8 UC: 0.15 C: 0.95 Cases: 20	RC: 0.78 UC: 0.28 C: 0.95 Cases: 20			
2	LackPAR* LackINT * ~LargeIC				RC: 0.48 UC: 0.29 C: 0.93 Cases: 10	
3	LackPAR * LackINT * LessES			RC: 0.446 UC:0.262 C:0.926 Cases:9		
4	LackPAR* LackINT * ~LessES				RC:0.34 UC:0.115 C:0.95 Cases:5	
5	LackPAR* ~ LackINT					RC:0.23 UC:0.19 C:1 Cases:5
6	LackPAR* ~ LackINT * ~ LessES			RC:0.08 UC:0.056 C:1 Cases:1		
7	LargeIC * LessES		RC:0.36 UC:0.05 C:1 Cases:8	RC:0.361 UC:0.14 C:0.77 Cases:8		
8	LargeIC * ~ LessES	RC:0.23 UC:0.05 C:0.97 Cases: 5				
9	LargeIC * ~LackPAR					RC:0.205 UC:0.09 C:0.94 Cases:6
10	LackINT	RC: 0.75 UC:0.11 C:0.95 Cases: 20				
11	LackINT* LessES		RC:0.45 UC:0.04 C:1 Cases:11			
12	LackINT* ~ LessES					RC:0.32 UC:0.24 C:0.89 Cases:7
13	LackINT* ~LackPAR					RC:0.16 UC:0.03 C:1 Cases:5

Note: *, and; ~ absence; RC, raw coverage; UC, unique coverage; C, consistency; Cases, number of cases per pathway.

Sarovar, Sobradinho, Tehri, Theun Hinboun, Three Gorges. For example, the Bakun in Malaysia, for which construction began in 1996 (before the 2000 WCD report), did not conduct prior consultation with local indigenous communities, which violates the United Nations Declaration on Indigenous Peoples (Aeria, 2016). In other communities, the government provided information about the benefits of the dam (Siciliano & Urban, 2017). Still, there was no negotiation process. After the dam's construction, communities did not have the economic means to access their farmlands, which reduced their protein intake and food security (Choy, 2004; Siciliano & Urban, 2017).

The last group of participation conditions (pathways 5 and 6) indicates that dams lacking participation policies and built in a context of international awareness of the impacts of dams also generate mostly negative impacts on human capital and primarily positive impacts on physical capital. Five dams are included in these pathways: A luoi, Belo Monte, Bui, Gilgel Gibe III, and Kamchay. The construction of A luoi in Vietnam started in 2007, after the 2000 WCD report. The participation process of locals was poor because they did not play any role in the decision-making process. Ty et al. (2013) reported that the province and district decided to build the dam, and locals were informed they would be evicted and resettled due to the construction. Resettled communities claimed that they were concerned about their food security since there was a reduction in the satisfaction of nutritional needs. Also, the authors described how the resettlement area had a hospital building but no doctors or health workers. This reflects a typical situation; in this case, there was a positive impact on physical capital with the construction of the hospital but no access to the services, negatively impacting human capital.

4.2.2. Megadams and energy security

Table 5 displays the second group of configurations of causal conditions (pathways 7, 8, 9) led by installed capacity (LargeIC). The results show that megadams generate mostly negative impacts on natural, social, and human capital and positive impacts on physical capital regardless of the nation's energy security level. Our results support the assumption that the larger the dam's installed capacity, the more negative impacts it will have on people's livelihoods, or at least in natural, social, and human capital.

First, we found that the largest dams in our analysis built in less energy-secure countries (LargeIC * LessES) generate sufficient conditions for the presence of more negative impacts on social and human capital. This pathway (7) includes eight dams: Ataturk, Belo Monte, Bui, Gilgel Gibe III, Ralco, Sardar Sarovar, Sobradinho, and Tehri. A well-known case among these dams is Sobradinho, a dam with 1050 MW of installed capacity, built during the 1970s under a Brazilian military dictatorship and in a context when Brazil depended on energy imports. The dam was conceived to respond to the country's growing urban and electricity requirements and to reduce petroleum imports (Hall, 1994). Hall (1994) reported that 4150 km^2 were flooded for its construction, and around 120,000 people were displaced without a resettlement program. Additionally, because of the lack of planning and processes of expropriation used, local actors suffered from psychological stress and widespread hunger and malnutrition, which reflect negative impacts on human capital. Cernea and Maldonado (2018) described the case of Sobradinho as a social disaster that acted as a stimulus for generating radical changes, such as the implementation of the World Bank's first international standard on resettlement in 1980 (see also Mathur, 2011; Vanclay, 2017).

Megadams in energy-secure countries generate negative impacts on natural capital (LargeIC * ∼LessES), as in the cases of Bakun, Cirata, Saguling, Son La, and Three Gorges. All these dams are located in Asia and financed by Asian agencies such as the China Export-Import Bank, the Overseas Economic Cooperation Funds of Japan, the Asian Development Bank, and the China Development Bank. This pathway (8) does not support our assumption that countries with less share of energy imports will generate fewer negative impacts on peoples' capital. Still, it would be essential to investigate where the energy produced by these dams will end up going, because it will likely go to another country. Here we are showing cases of Asian hydroelectric megadams built in energy-secure countries that caused mostly negative impacts on natural capital.

For example, Saguling was built in an energy-secure country and negatively impacted natural capital. It was constructed in 1983 in Indonesia, the largest energy producer in Southeast Asia (IEA, 2021b), to increase the reliability of the electricity system, reserve petroleum, and improve the irrigation system, among others (Nakayama, 1998). In the case of natural capital, farmers lost more than 4713 ha of productive farmland (Nakayama, 1998), fish species declined (Sunardi et al., 2013), and pollution levels increased due to the population increase in the resettlement areas (Manatunge et al., 2009).

Another case presented in this pathway is the Three Gorges Dam, the largest dam in the world, which has displaced the largest number of people, around 1.13 million (Wang et al., 2013; Wilmsen, 2016). Its construction began in 1994 in the Yangtze River (China). This dam was expected to generate 10% of the electricity demand of China (Salazar, 2000) and reduce flooding and control navigation (Yan, 2010). Scholars have reported a variety of impacts generated by this megadam. To mention some, the loss of land for farming (Heggelund, 2006; Wilmsen & van Hulten, 2017); lower quality of soils after resettlement (Tan et al., 2005); loss of aquatic mammals like river dolphins, and loss of riparian areas (Beck et al., 2012).

The third configuration (pathway 9) within this group indicates that large dams and megadams with some level of local communities participation are sufficient for the presence of mostly positive impacts on physical capital (LargeIC * ∼LackPAR). This pathway includes six dams: Nam Theun2, Ralco, Aswan, Son La, Xenamnoy, and Xepian. The Aswan High Dam, with 2100 MW of installed capacity, was built in the 1960s in Egypt. It had some level of local's participation since, before the resettlement process, the government held meetings with community delegates (Weist, 1995). For its construction, new roads were built, which increased local actors' access to urban facilities such as health centers, police stations, transportation systems, markets, and schools (Weist, 1995).

4.2.3. International awareness and energy security

The last group of configurations (pathways 10, 11, 12, and 13) reflects the effects of international awareness about the social-ecological impacts of large-scale hydroelectric dams in local communities. The pathways show that the effect of international awareness in protecting peoples' livelihoods maintains despite the context of energy security. Our results support the assumption that dams built after the publication of the 2000 WCD report, in a context with more international awareness about the social impacts of dams, have better protocols to protect people's livelihoods and, therefore, fewer negative impacts on capital.

Pathways 10 and 11 (LackINT + LackINT*LessES) indicate that dams built in less energy-secure countries before the WCD report generate mostly negative impacts on natural and social capital. These pathways support our assumption that dams built without international awareness about the social impacts of dams in less energy-secure countries generate more negative impacts on capital. Twenty hydroelectric dams are included in these pathways: Aswan, Ataturk, Bagre, Bakun, BatangAi, Bili Bili, Chixoy, Cirata, Gilgel Gibe I, Gitaru, Kamburu, Kaptai, Kiambere, Kindaruma, Kotmale, Masinga, Saguling, Sardar Sarovar, Sobradinho, and Tehri. For example, Gitaru dam was constructed in 1975 in Kenya while the country depended on energy imports for its supply. Gitaru has an installed capacity of 225 MW, and as a result of its construction, areas were flooded, which mainly generated negative impacts on natural and social capital. For instance, after the dam's construction, there was a decrease in arable land and crop yields, forcing landowners to build irrigation systems increasing their production cost. Contrarily, in areas located downstream from the dam, the flooding of the reservoir increased the drying of floodplains and decreased riverine forests and access to gathering activities (Okuku et al., 2016). Okuku et al. (2016) also reported social disintegration in the communities impacted by the dam's construction due to the lack of roads and an increase in conflicts between different groups.

Finally, dams built before the the WCD report in a fairly energy-secure country or with better participation policies (LackINT*∼LessES + LackINT*∼LackPAR) generated mostly positive impacts on physical capital. Pathways 12 and 13 include ten hydroelectric dams: Aswan, Bakun, Batang Ai, Bili Bili, Cirata, Gilgel Gibe I, Kotmale, Saguling, Three Gorges, and Wonorejo. To illustrate, during the resettlement process for Wonorejo dam in Indonesia, built under a context of energy security, families whose houses were going to be flooded received support from local authorities to negotiate cash compensation. After resettlement, families reported their houses were larger than before, and public facilities, such as roads, were better than those in their previous settlements (Sisinggih et al., 2013).

5. Conclusions

The social impacts of hydroelectric dams have been studied from different perspectives. On one side, dam advocates highlight positive impacts, whereas dam opponents present negative ones. In this study, we explored hydroelectric dams' positive and negative impacts on capital, specifically how they impact the livelihoods of communities living near construction sites. Our research complements the literature on the social impacts of dams by presenting a comparative analysis of 33 large-scale hydroelectric dams bult in the Global South. So far, most of the literature focuses on one or multiple dams in one country, and among those, the majority assess one type of capital. Therefore, the results of our analysis bring into the literature a comprehensive and global view of the social impacts of dams by assessing multiple types of capital across dams in Africa, Asia, and Latin America.

The analysis showed that financial, human, and natural capital impacts are frequently studied. In contrast, the literature should further explore social and physical issues. Our results suggest that peoples' capital are impacted differently by the construction of hydroelectric dams. Natural, social, human, and financial capital are negatively impacted, whereas physical capital is often positively impacted, mainly because dam construction companies need better infrastructure like roads to conduct their operations successfully. Other infrastructure, such as hospitals and schools, are often promised during negotiations at the regional level. In many cases, these are built in host communities or are part of the new resettlements created for people displaced by the construction or where the dam workers live. However, it is worth mentioning that physical capital does not ensure the provision of services. As Mayer, Lopez et al. (2022) found, the construction of a school or a health center does not guarantee the presence of individuals with the skills to provide the services, such as teachers or health practitioners.

Our analysis showed that none of the conditions we explored is necessary to explain changes in all types of capital but that different pathways explain changes in some. This reveals how complex it is to assess changes in people's livelihoods, since each capital supports different aspects of livelihoods, but also that people and communities intertwine their capital to live. In the same argument, future research needs to explore how hydroelectric dams' impacts on one capital are related to other capital over time. For instance, negative impacts on natural capital, such as the reduction in land fertility or land scarcity, could generate negative impacts on human capital like food insecurity. Studying this requires longitudinal research, and not only in one period of time because the impacts and responses to dam development are dynamic; they depend on social-ecological and economic contexts and change over time (Castro-Diaz, 2022; Kirchherr & Charles, 2016; Scudder, 2005). Along those lines, we call for future research to investigate the differences between control and access to capital after dam construction since the availability of capital does not mean access to such capital (as this depends on means like technology, know-how, authority, power, etc.). Similarly, access would require control to benefit local communities (Ribot & Peluso, 2003).

The literature, including the studies in our qualitative meta-analysis, portrayed persistent procedural justice problems in dam development. However, they did not explain how this injustice is related to the dam's impact on people's livelihoods. Usually, scholars noted the urgent need to include affected populations in decision making to reduce impacts on their livelihoods (Goulet, 2005; Hay et al., 2019) without portraying a comprehensive understanding of this relationship. Our medium-N study indicates how the lack of participation of local communities in decision-making processes influences negative impacts on all but physical capital. This result is critical, since their active participation, power, and recognition will mitigate and reduce the negative impacts of energy development in their lives. Thus, to pursue equitable and just processes in energy development projects, policy-makers and practitioners should allow local people's participation in decision making.

When a dam is to be built, governments need to improve the design and implementation of environmental and social impact assessments. One way to do that is by assessing the livelihoods of populations living near the construction area and include their voices. In the past, those studies are often not done properly (Moran et al., 2018), and when they are conducted, they do not include the input of downstream populations. Governments and dam builders need to recognize that the impacts of dams are multidimensional and over a long period of time, and that all populations living near dams are affected in one way or another. In this paper, we show that dams cause diverse positive and negative effects on people's capital. Allowing people's participation in all steps of the project could provide the knowledge and tools to ensure at least the restoration of local livelihoods to the conditions before the dam's construction.

All dams included in our analysis have a large installed capacity, a characteristic used by governments to promote the potential benefits of a dam for the nation while overlooking the potential local social-ecological and economic impacts. We presented how the construction of megadams in less energy-secure countries negatively impacts social and human capital, while causing positive effects on physical capital. We also described how megadams built in energy-secure countries generate negative impacts on natural capital. This is consistent with the results found by Fan et al. (2022), showing how large-scale dams negatively impact land cover near construction. However, in our case, this capital also included the loss of quality land, fisheries, and the effects on people when they lost those ecosystems, In sum, regardless of the energy security status of a nation, the larger the dam's installed capacity, the more negative impacts the dam will have on people's capital, except for physical.

We found that regardless of the energy-security status of a country, dams generate negative impacts in all capital except physical at the local level which reflects the influence of governments and dam authorities in endorsing dam construction due to its benefits at national and global scales. This result also suggests that governments and dam construction companies are continually overlooking the impacts at the local level. In the Global South and emerging economies, hydropower is presented as a clean energy source that will meet nations' energy needs while reducing dependence on fossil fuels. However, considering the immense impacts of megadams and the need for energy security, it is necessary to rethink dams and other energy systems.

Despite the controversies generated by the publication of the WCD report (2000) and the lack of adoption of its recommendations and guidelines by some agencies and governments, our results show that dams built after the report generated fewer negative impacts on people's capital. Our results indicate the importance of the role played by WCD in raising international awareness about the social-ecological impacts of dams despite a country's energy-security status. WCD also helped affected communities to legitimize their concerns (Sneddon & Fox, 2008) for protecting their livelihoods through the environmental justice movement. Well-organized social movements strengthen the mobilization against large dams by providing locals with a political voice (Shah et al., 2021).

More common efforts should be made among academics, activists, and local communities' organizations to shed light on the social impacts of dams, to find alternatives to large-scale hydroelectric dams, and address energy injustices. In particular, the injustices faced by communities living nearby dams, who paradoxically, still lack access to electricity (Urban et al., 2015; Castro-Diaz, 2022). We believe that alternative development paths are required, some that incorporate local populations' social, ecological, and economic characteristics, such as decentralized microgrids (Brown et al., 2022). We argue for inclusive and transdisciplinary approaches to co-design sustainable, decentralized, and just energy systems, such as the one described by the convergence framework introduced by Moran et al (2022). This framework emphasizes the importance of communities' self-governance and self-determination, which enhances local actors' empowerment (Moran et al., 2022).

CRediT authorship contribution statement

Laura Castro-Diaz: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Visualization. **María Alejandra García:** Conceptualization, Data curation, Methodology, Writing – original draft. **Sergio Villamayor-Tomas:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Maria Claudia Lopez:** Conceptualization, Methodology, Writing – original draft, Supervision, Funding acquisition, Project administration.

Data availability

Data will be made available on request.

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 A. Supplementary data

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