



# COST-BENEFIT ANALYSIS OF SMALL HYDROELECTRIC PLANTS IN THE UPPER PARAGUAY BASIN

The socioeconomic unsustainability of hydroelectric projects in light of the  
official method of the federal government

Aerial view of the Pantanal Matogrossense National Park with the Amolar Mountains in the background. Border of Mato Grosso and Mato Grosso do Sul.

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# INTRODUCTION

Faced with the global climate emergency, the transition to renewable energy sources is an essential strategy for reducing greenhouse gas (GHG) emissions. However, the promotion of alternatives considered “clean” is not always accompanied by due attention to their socio-environmental impacts and their real contribution to collective well-being. Often, the push to implement renewable projects ignores fundamental analysis, such as the socioeconomic cost-benefit assessment.

This is the case of Brazil, which has granted significant subsidies for the construction of Small Hydroelectric Power Plants (SHPs) in the Upper Paraguay River Basin (UPB), a region that covers the states of Mato Grosso and Mato Grosso do Sul and comprises the entire territory of the Pantanal. Currently, there are 58 SHPs in operation and another 65 under study, many of which advance without clear information on costs and benefits to society. This study by WWF-Brazil seeks to precisely fill this gap.

Although classified as “small”, these hydroelectric plants cause significant changes in the flow regime of rivers, water quality, connectivity of aquatic habitats and sediment flow — directly affecting the local ecosystem and the communities that depend on it.

**The construction of SHPs in the Upper Paraguay Basin (UPB) represents an estimated net loss of BRL 7 billion for Brazilian society, even compared to non-hydro renewable alternatives such as solar, wind and biomass sources.**

In addition to environmental impacts, SHPs are private enterprises driven by a favorable framework of public incentives, such as financing lines, soft regulations and tax benefits. Unlike larger plants, they are not subject to bidding, being authorized through simplified processes. They also have relevant exemptions, such as the discount on energy transport tariffs and the exemption from Financial Compensation for the Use of Water Resources (CFURH).

Despite their significant impacts, Small Hydroelectric Power Plants (SHPs) offer little or no effective contribution to mitigate them, and are still driven by a set of incentives that favor their adoption from a private point of view. But what is the **balance for society**? What are the **real benefits** and what are the **still invisible costs**? WWF-Brazil **sought these answers**.

A study commissioned by the institution helps answer these questions based on the official methodology of Socioeconomic Cost-Benefit Analysis (CBA). The results are negatively significant:

More than not fulfilling their promises, **SHPs deepen inequalities, concentrate gains and disseminate losses to all of society** — especially to the populations that live and depend directly on the Pantanal.

Below, this publication anticipates scenarios and presents an unprecedented comparative analysis, based on public data and consistent evidence. The results show the limitations and contradictions of the current model of expansion by SHPs in the UPB and point out concrete directions for an energy transition that balances development, social justice, and care for the environment.

Amolar Mountains, located in the municipalities of Corumbá (Mato Grosso do Sul) and Cáceres (Mato Grosso), on the border with Bolívia, Brazil.



# WWF-BRAZIL AND THE INFRASTRUCTURE AGENDA

WWF-Brazil is a Brazilian NGO that for 28 years has been working collectively with civil society partners, universities, governments and companies throughout the country to fight socio-environmental degradation and protect the lives of people and nature. We are connected in an interdependent network that seeks urgent solutions to the climate emergency. Its mission is to combat the trajectories of environmental degradation and to build a future in which humans live in harmony with nature, with the preservation

of biodiversity and the rational use of natural resources, for the benefit of current and future generations.

In this perspective, WWF-Brazil establishes as one of its strategic pillars the promotion of infrastructures that respond to the contemporary challenges of development and sustainability, committing itself to boosting development that harmonizes with the communities and that brings positive effects to the Brazilian society.

## WE NEED RELIABLE AND EFFICIENT INFRASTRUCTURE

A reliable and efficient infrastructure network in quantity and quality is essential to sustain a country's economic, social and environmental development, which requires significant public and private investments in new assets and renewal of existing ones. In the Brazilian case, the remaining gaps in terms of inventory and quality of infrastructure will require increasing rates of investment in the sector in the coming decades.

[The New Climate Economy \(2016\)](#)<sup>1</sup> report estimates that global infrastructure investments **need to move from the current \$3.4 trillion to \$6 trillion annually in 2030.**

Juana Candia Ortiz, a fisherwoman in Bahía Negra (Paraguay), holding a piranha. Bahía Negra, Alto Paraguay.



# THE CHOICE OF CBA AS ANALYSIS METHOD

To evaluate the socioeconomic feasibility of the implementation of SHPs in the Upper Paraguay Basin (UPB), WWF-Brazil adopted the Socioeconomic Cost-Benefit Analysis (CBA) as the central method of evaluation. The choice reflects the commitment to a broader and more transparent approach to infrastructure decision-making, capable of capturing the real social, economic and environmental costs and benefits of the projects.

Internationally recognized and applied by countries such as Chile, the United Kingdom, Australia, South Korea and South Africa, as well as multilateral institutions, the CBA provides a robust framework for comparing investment alternatives from the perspective of collective well-being. By expressing costs and benefits in a common monetary metric, the method allows to assess whether the gains generated by a project justify the costs — including intangible externalities and impacts that often escape traditional analysis.

The Cost-Benefit Analysis (CBA) has been gaining strength in Brazil. Still in the early stages of adoption in the country, it was recently incorporated by the federal government into the [Model of Five Dimensions \(M5D\)](#),<sup>2</sup> which aims at the multidimensional evaluation of infrastructure investments.

To technically guide this application, the Federal Government published the [General Guide for Socioeconomic Cost-Benefit Analysis of Infrastructure Investment Projects](#).<sup>3</sup>

**WWF-Brazil believes that including CBA from the early stages of project analysis is essential to overcome the prevailing logic of private financial return and bring the decision-making process closer to a public perspective, focused on sustainability and collective well-being.**

This approach becomes even more relevant when applied to the reality of the SHPs planned for the UPB. The region, marked by high environmental vulnerability and intense interaction between ecosystems and traditional ways of life, requires analytical tools able to reveal hidden impacts to society.

Previous studies indicate that public subsidies to SHPs distort their private profitability and transfer diffuse costs to society. These plants generate significant negative externalities, compromising fishing, tourism and economic activities sustained by local ways of life. In addition, they put pressure on already fragile ecosystems and threaten the region's biodiversity.

Added to this are the effects of climate change, which have caused a reduction in river flows, directly affecting the generation capacity of these plants. Data from the National Water Agency (ANA) confirm this trend, which aggravates the uncertainty regarding the future returns of these projects.

**Given this scenario, applying the CBA allows to verify, in a transparent and reasoned way, whether the planned investments are really justified compared to other energy generation options — especially when considering the net return to society as a whole.**

The CBA application, especially when it occurs in the strategic phase (upstream planning), when it is called Preliminary CBA, helps in the design and prioritization of projects, as it allows considering risk effects (such as those imposed by climate change), testing different project designs and technological assumptions, measuring the effects of ecosystem services and dealing with demand perspectives and sensitivities to important variables. Projects evaluated by a Preliminary CBA have a higher degree of maturity and robustness, increasing their chances of success in delivering the expected socioeconomic results.

## WHAT THE CBA ALLOWS TO OBSERVE

The analysis conducted by WWF-Brazil followed the guidance of the CBA Guide and was based on criteria that reinforce its legitimacy as a strategic assessment tool. Among the main points, the following stand out:

- 1 Comparison with a counterfactual scenario**, with hypothetical alternatives that would deliver the same amount of energy, with the same reliability;
- 2 Projection of incremental effects** throughout the project life cycle, including direct costs (Capex and Opex), externalities and intangible benefits;
- 3 Expression of data in common monetary metric**, allowing the calculation of the net return to the company;
- 4 Analysis of self-sufficient units** (completed projects until the generation of benefits, that is, energy where there is demand), which include connection to the general electricity network;
- 5 Valuation of benefits** based on users willingness to pay;
- 6 Identification, quantification and valuation of negative externalities**, that is, **impacts on third parties (environment and society)** not economically compensated.



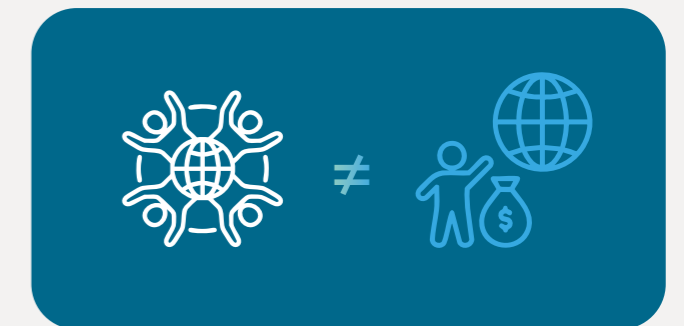
Boat for ecotourism in the Pantanal, Mato Grosso do Sul, Brazil.

## FROM THE PERSPECTIVE OF BRAZILIAN SOCIETY AND NOT OF THE ENTREPRENEUR

Socioeconomic evaluation differs from financial evaluation (or private, from the perspective of the entrepreneur), when comparing projects – sometimes quite different – that meet the demands of society.

In this sense, the logic of evaluating social interest prevails before choosing the best way to attend to it. The CBA is a method that allows this evaluation to be systematized, ranking which alternatives add greater benefits with lower costs.

This comprehensive and impartial view outweighs the interests of the entrepreneur when considering the non-monetary benefits (such as improvements in public health, reduction of accidents, appreciation of natural and cultural heritage, among others) and the externalities (emission of greenhouse gases (GHG), variation of ecosystem services, among others), which even not being traded in markets, are relevant to society. In addition, socioeconomic CBA considers social



costs when discounting taxes and subsidies, as well as fees and tariffs, as they are mere transfers between economic agents (families, users, firms and government) from the same society.

Still, in the case of SHPs in the UPB, even from a strictly financial perspective, the calculations show that, although they have positive internal rates of return (IRR), this attractiveness is strongly conditioned to the maintenance of public incentives and tax exemptions. And, without these mechanisms, many projects analyzed would no longer be financially viable.

Although the planning of electric expansion in Brazil is structured by instruments such as the Ten-Year Energy Expansion Plan (PDE) and the National Energy Plan (PNE), these documents are based on Technical-Economic Feasibility Studies (TEFSs), which do not always include a comprehensive cost-benefit analysis.

The CBA emerges, therefore, as an essential complementary instrument, especially for addressing alternatives to the enterprise — and not just variants within the same project. This is particularly necessary in contexts of high socio-environmental sensitivity, such as the UPB, where systemic impacts on climate, land use and hydrological dynamics are still underestimated in energy decisions.

In addition, the CBA makes it possible to incorporate risks not captured by traditional models, such as climate risk, and to more realistically assess the social opportunity cost of following through with certain investments.

The methodology was even recommended by the Federal Court of Accounts (TCU) both for the evaluation of public investment projects, **THROUGH DIFFERENT AGREEMENTS**, as well as for the external control of concessions and public-private partnerships, through TCU Ordinance No. 119/2024. In the regulatory field, Federal Decree No. 10.411/2020, which regulates the Regulatory Impact Analysis (RIA), also recommends the CBA as the preferred methodology for measuring the economic impacts of public policies.

**By applying the CBA to the SHPs of the UPB, WWF-Brazil contributes with robust technical evidence to guide public policies, energy planning decisions and the definition of rules for auctions. The tool also offers comparative parameters between different generation sources, allowing the government to identify which projects promote real net gains for society.**

This approach strengthens the capacity of the State to align its investments in energy infrastructure and the goals of sustainability, equity and climate resilience — overcoming restricted visions of economic viability and reaffirming the role of energy as a vector of inclusive and responsible development.

To make this evaluation possible, data produced by the National Water and Basic Sanitation Agency (ANA) were used, within the scope of the *Studies to Evaluate the Effects of the Implementation of Hydroelectric Projects in the Hydrographic Region of Paraguay*,<sup>4</sup> carried out between 2016 and 2020. These studies offered a solid empirical basis, gathering hydrological, sedimentological, socioeconomic information and on impacts already caused by existing projects.

In addition to the ANA databases, the study also incorporated data and evidence from specialized technical literature. The application of the CBA followed the guidelines of the *General Guide for Socioeconomic Cost-Benefit Analysis of Infrastructure Investment Projects*,<sup>5</sup> prepared by the federal government.

The combination of these public and reliable inputs allowed to estimate relevant externalities associated with the construction of new SHPs — such as the impacts on fishing and tourism, which are today two of the main economic vectors of the Pantanal region.

## A CONTRIBUTION TO THE DEBATE ON INFRASTRUCTURE INVESTMENTS

**More than assessing whether SHPs in the UPB are beneficial to society or not, the objective of WWF-Brazil with this study is to offer a concrete contribution to the methodological and procedural debate on infrastructure investment decisions in the country.** It is about demonstrating, through a real case, the importance of the CBA as an available and robust public instrument to support choices with greater legitimacy and rationality.

**Projects evaluated based on the CBA tend to have a higher degree of maturity, greater clarity about risks and uncertainties, in addition to better conditions for delivering the expected socioeconomic results.**

Expanding the CBA use in Brazil is essential to build more effective public policies that are compatible with contemporary challenges.

This is ultimately an attempt to strengthen the bridge between strategic planning and execution, from an integrated approach that takes into account not only technical and financial feasibility, but also socio-environmental and territorial impacts, climate risks, technological factors and sustainable development projections for the territories.

Some of the most important rulings of the Federal Court of Accounts (TCU) mentioning CBA and/or MCA as a method for evaluating public investment projects:

**TCU Ruling 2272/2019 and 2835/2020** – Systemic evaluation of large hydropower generation projects (as a result, the Civil House and the Ministry of Mines and Energy decided to use CBA as a systemic evaluation methodology)

**TCU Ruling 2579/2021 and 1462/2022** – Recommend the use of CBA (in transport planning), which was also used in the 2021 Fiscobras Report as a reference for infrastructure project planning

TCU-Plenary, **Ruling 2478/2023**

TCU-Plenary, **Ruling 29/2023**

TCU-Plenary, **Ruling 245/2023**

TCU-Plenary, **Ruling 1022/2023**

TCU-Plenary, **Ruling 2519/2023**

TCU-Plenary, **Ruling 157/2024**

# SHPS AND THE ELECTRICITY SECTOR

Long before the climate emergency gained prominence in the public and political agendas, the use of Brazilian water potential was already seen as a structuring axis for national development. This model was consolidated with the construction of large hydroelectric plants (LHPs) initially concentrated in the South and Southeast, and, from the 1990s, also in more sensitive regions, from a socio-environmental point of view, such as the Amazon.

The implementation of the Santo Antônio (2012) and Jirau (2013) plants, on the Madeira River, and then Belo Monte (2016), on the Xingu River, marked a turning point. The scale of the socio-

environmental impacts of these works — added to the resistance organized by social movements, indigenous peoples and civil society organizations — has expanded the public debate over the limits of this large-scale centralized energy generation model.

In this context, Small Hydroelectric Power Plants (SHPs) began to be presented as a viable alternative: a way to continue exploring the national hydroelectric potential, but with alleged more moderate impacts and less dependence on state action. This perception — fueled by its name and size — favored its silent and pulverized expansion along several Brazilian rivers.

## UNDERSTAND THE SCALE OF HYDROELECTRIC PLANTS IN BRAZIL



### MHPs

MINI HYDROELECTRIC POWER PLANTS  
UP TO 5 MW

⚡ Enough energy to power about **3.500 homes per month**

⚖️ It does not need a concession or authorization from ANEEL, only a water use grant



### SHP

SMALL HYDROELECTRIC PLANT  
5 A 30 MW

⚡ **Up to 21.000 homes per month** or nearly a midsize city

⚖️ Authorization from ANEEL (no bidding)

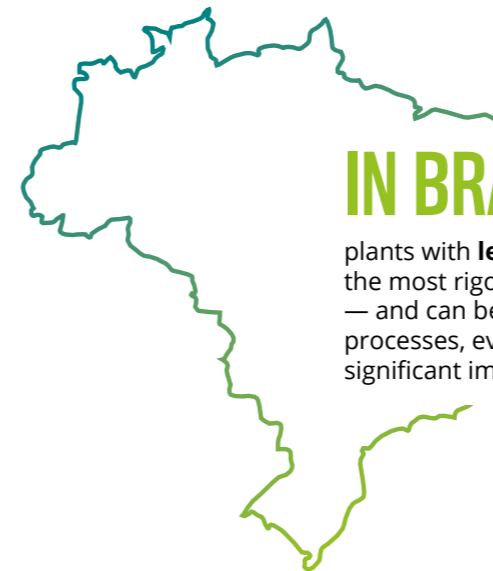


### HPP

HYDROELECTRIC PLANT  
ABOVE 30 MW

⚡ **More than 21.000 homes per month**, possibly reaching millions (e.g. Itaipu = 14.000 MW)

⚖️ Concession via mandatory bidding



## IN BRAZIL

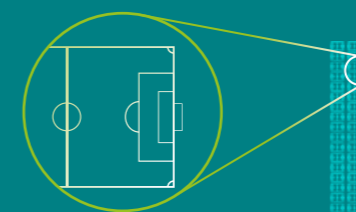
plants with **less than 50 MW** escape the most rigorous concession model — and can be authorized by simplified processes, even when they cause significant impacts.



## IN OTHER COUNTRIES

the international standard for defining “small” is usually **10 MW**. That is: Brazil calls “small” what many countries already consider “medium” or “large”.

## TO COMPARE



1 official football field occupies about **0.7 HECTARE**



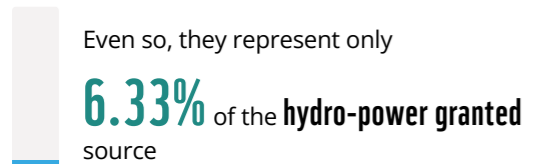
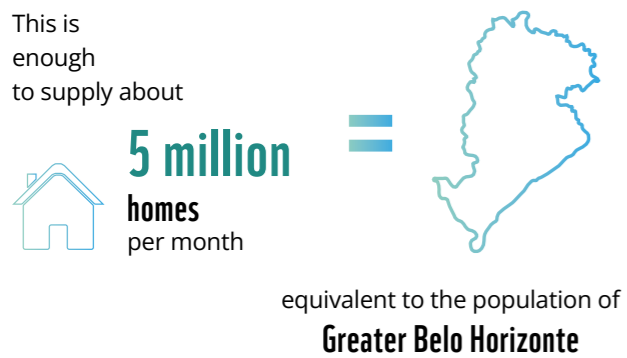
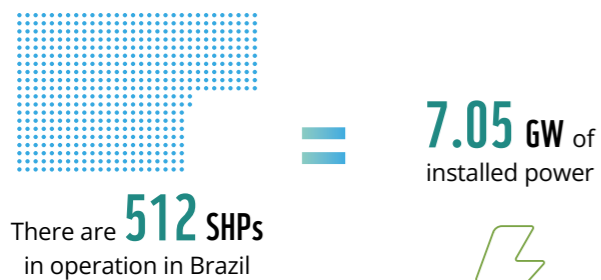
A SHP can require **50 TO 1.500 HECTARES** of flooded area

the equivalent of **+THAN 2000 SUBMERGED FOOTBALL FIELDS**

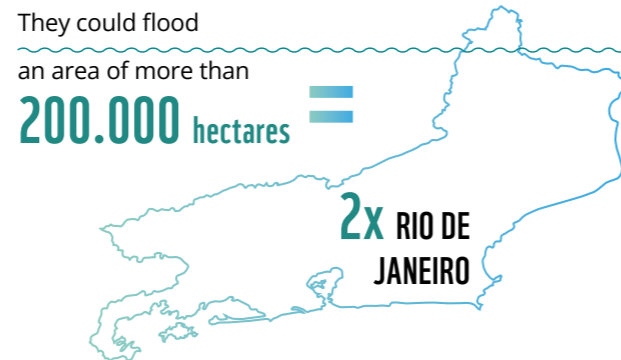
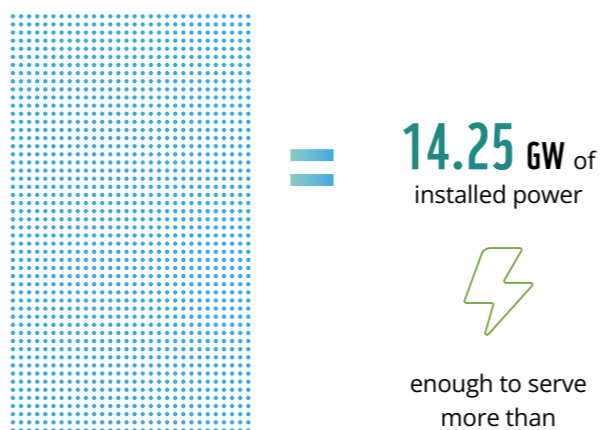
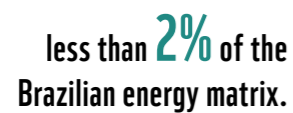
In the last 20 years, the number of SHPs in operation has grown by more than 40%, while their installed capacity has been multiplied by six.

Although called “small”, these plants present a wide variety of construction arrangements — with or without a reservoir, with or without watercourse deviation — and do not always operate in a manner compatible with the stability of the national electrical system.

# SHPS IN BRAZIL: MANY PROJECTS, LITTLE ENERGY, MAJOR IMPACTS



In other words, they occupy territory, receive incentives and cause impact, but contribute with



Most of these SHPs are outside the operational control of the National Energy System Operator (NESO). About 87% work completely independently, without any centralized scheduling or dispatch. Only 13% are programmed by the NESO, but even these are not dispatched — that is, they can affect the stability of the system without contributing to its reliability.

Despite this, many SHPs operate in order to meet, within their limitations, the peaks of daily energy demand of the National Interconnected System (SIN), promoting sudden and intermittent river discharges. According to ANA, this sudden variation in river flow directly affects aquatic ecosystems and multiple water uses.

**As most of these plants operate in the Free Contracting Environment (ACL), their decisions are guided exclusively by private market strategies — which disconnects them from the logic of national energy planning.** The growth of this type of generation, therefore, imposes new pressures on the need for dispatchable sources in the Regulated Contracting Environment (ACR), where the reliability of the energy supply to society is guaranteed.

## Dispatchable vs. non-dispatchable sources



**Dispatchable sources:** those whose power generation can be controlled and adjusted according to the demand of the electrical system, in real time. They can be switched on, off or programmatically modulated. Examples: hydroelectric plants with reservoir, thermoelectric plants (gas, coal, biomass), nuclear power plants.



**Non-dispatchable sources:** these are intermittent or variable, which cannot be directly controlled as they depend on external conditions, such as climate and light. Its production cannot be guaranteed at any time. Examples: solar photovoltaic, wind.

Energy storage (such as batteries or hydraulic reservoirs) is a complementary technology, not an intrinsic characteristic of the source. That is, a dispatchable source may or may not be associated with storage, and vice versa.



An aerial view of the Paraguay River at Fecho dos Morros in Porto Murtinho – MS.


# SHPS IN THE UPPER PARAGUAY BASIN AND THE PRESSURE ON THE PANTANAL


## HYDROPOWER PLANTS IN THE UPB


The Upper Paraguay River Basin (UPB) currently houses **58 hydroelectric plants** in operation, of which

-   
**23 MHPs**  
Mini Hydroelectric Power Plants
-   
**29 SHPs**  
Small Hydroelectric Plants
-   
**6 HPPs**  
Hydroelectric Power Plants

In addition to what is already in operation, there are **65 other projects proposed** for the UPB, namely:

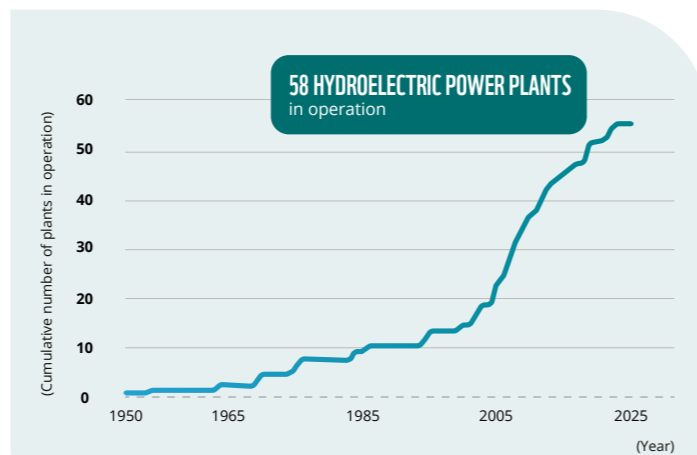
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**4** under implementation phase
- 

**36** under project phase
- 

**25** under preliminary studies

Cumulative number of hydroelectric plants installed in the BAP (1950–2025)



Evolution of the cumulative number of hydroelectric plants in operation in the BAP between 1950 and 2025. An accelerated growth is observed starting in the 2000s.

Of this total, 54 projects are located in the state of Mato Grosso. Together, these plants total 1.26 GW of granted power, distributed as follows:

- 457.61 MW**  
(with an average of **15.78 MW** per plant);
- 49.61 MW**  
(with an average of **2.16 MW** per plant);

Although they are numerically the majority, SHPs and MHPs contribute with only **18.04%** and **1.96%**, respectively, of the total power granted in the UPB — considering all sources of electricity generation. **In other words, they take up space, demand infrastructure and generate impact, but deliver a modest fraction of the energy produced in the region.**

## CHARACTERISTICS OF THE UPB

The UPB is divided into **two main reliefs: PLATEAU and PLAIN**

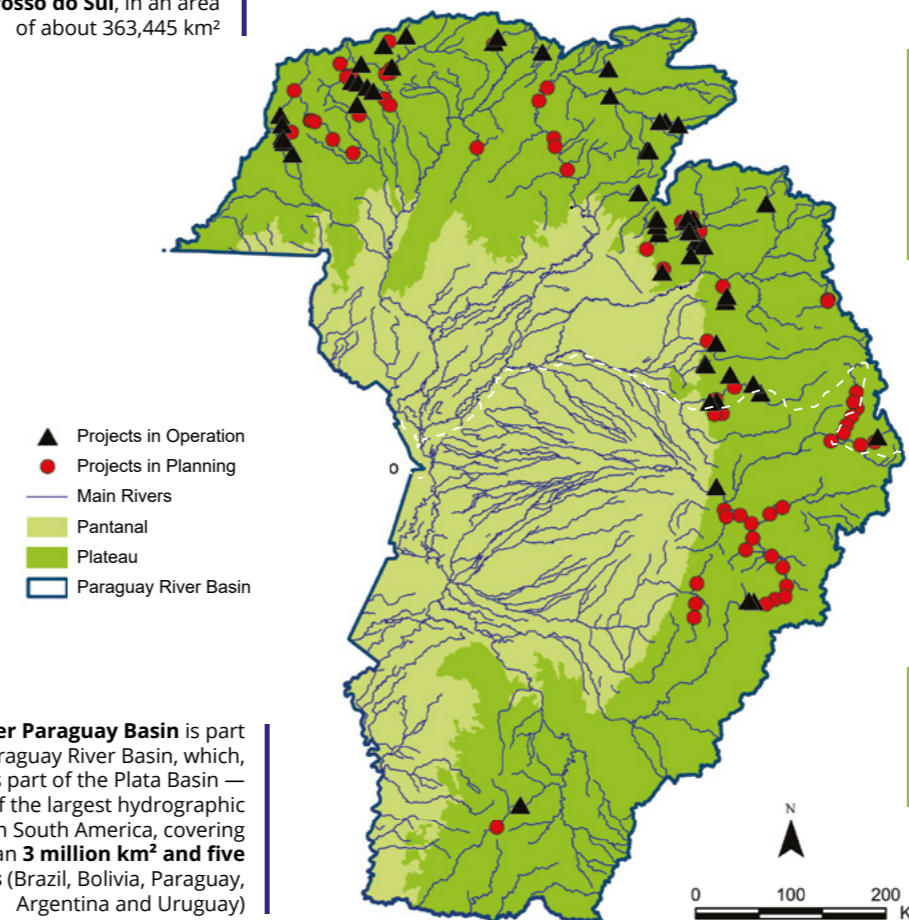
In Brazil, the Upper Paraguay River Basin is present in the states of **Mato Grosso and Mato Grosso do Sul**, in an area of about 363,445 km<sup>2</sup>

### CERRADO

This portion of the plateau is formed mainly by areas of the Cerrado, a biome recognized for its **biodiversity and strategic role as cradle of waters**. It is precisely in this territory that hydroelectric projects are concentrated

### THE PLATEAU

with altitudes that can reach **1,100 meters**, is responsible for the supply of water and sediments that feed the plain, where the Pantanal is located — a region of low altitudes and high humidity



The **Upper Paraguay Basin** is part of the Paraguay River Basin, which, in turn, is part of the Plata Basin — one of the largest hydrographic systems in South America, covering more than **3 million km<sup>2</sup>** and **five countries** (Brazil, Bolivia, Paraguay, Argentina and Uruguay)

The activities developed in these higher parts of the basin directly **influence the ecological functioning of the floodable areas** that characterize the Pantanal

## ECONOMIC PROFILE OF THE UPB AND LOSSES CAUSED BY EXISTING SHPS

In the Upper Paraguay River Basin (UPB), fishing represents much more than an economic activity: it is an essential socio-cultural and food pillar for millions of people. The abundance of migratory species, such as pintado, cachara, jaú, dourado and pacu, supports productive chains, traditional ways of life and a significant part of regional tourism.

According to ANA's *Studies to Evaluate the Effects of the Implementation of Hydroelectric Projects in the Hydrographic Region of Paraguay*, this importance is expressed concretely in three fishing modalities, in addition to the nutritional value associated with the consumption of fish.

### ARTISANAL PROFESSIONAL FISHING

directly supports **7.7mil** fishermen and **14mil** family members

accounts for about **5.000 TONS** of fish per year, 90% of which are migratory fish

migratory fish are sold at prices **1.7 times** higher than non-migratory,

other associated activities (such as piloting, bait collection, ranch janitorial and meal offering) add up to an additional

**BRL 89.06 million per year**

generating **BRL 90.44 million** on first sale

about **465 TONS** are self-consumed by fishing communities

**44%** of fishermen have never worked elsewhere

### FISHING TOURISM

attracts **138.5 thousand** tourists per year

moving **BRL 151 million**

it is estimated that another **41.000 tourists** also sensitive to the quality of rivers

inject another **BRL 38 million** into the economy

the infrastructure includes

**185** lodging facilities **22** boat-hotels

with about **4.000 beds** aimed at fishing tourism

### NATIVE DIFFUSE AMATEUR FISHING

practiced by **1.4 million** people (56% of the population of the UPB), as leisure and food supplement

generates about **7.2 million** fisheries per year

**13.8 thousand** tons of fish, **82% of which are migratory**

**1 in 4** residents declares that fishing is "very important" in their lives

It represents, for many, the only form of **LEISURE** and a fundamental way of **SUBSISTENCE**

the social welfare associated with this activity is estimated at **BRL 3.16 billion** per year

Despite this significant economic and social weight, the planning and implementation of new hydraulic projects in the region have not considered the socioeconomic losses already caused by existing infrastructures.

ANA studies reveal that 85% of the variation in Pantanal fishing production is associated with the availability of spawning areas. An increase of only 1 km in the extent of these habitats could mean an increase of 229 kg of fish per year.

However, the SHPs in operation have already significantly compromised this dynamics: 35 hydroelectric installations blocked between 5.3% and 9.4% of the fish migration routes in the UPB, aggravating a situation that already included natural obstacles. The result is the fragmentation of habitats essential for the reproduction of migratory species.

### NUTRITIONAL QUALITY OF FISH



only considering migratory species, the UPB offers the equivalent of

**70 million** 100g portions of fish per year

Freshwater fish have **HIGHER NUTRIENT DENSITY** than other animal proteins

The nutritional differential of Pantanal fishing represents an estimated value of

**BRL 45.43 million** per year in micronutrients for society.



© Nalare Jinkins / WWF - Brasil

The negative externalities generated by these plants currently total between **BRL 152.95 million** and **BRL 198.19 million** per year, which represents **10% to 13%** of the average GDP of the municipalities in the Brazilian portion of the UPB. In a 20-year horizon, this accumulated loss regarding fishing, tourism, food security and social welfare reaches **BRL 3.51 billion**.

As we will see in the next section, the planned expansion of SHPs could quadruple these damages, posing a concrete threat to the region's economic and socio-environmental sustainability.

# FINANCIAL ANALYSIS OF THE PROJECTS: DO SHPS STAND ALONE?

**Much is argued that Small Hydroelectric Plants (SHPs) represent an economic opportunity for investors — but to what extent does this argument hold up, especially when the protection network of public incentives that supports the sector is removed?**

Before presenting the results of the Cost-Benefit Analysis (CBA), this section provides a strictly financial evaluation of the hydroelectric projects planned for the UPB. The objective is to understand whether the projects are economically sustainable, even from the perspective of the private investor.

The analysis considers the main cost components, estimated revenues based on energy auctions and simulates scenarios with and without the public incentives currently offered to the sector. The results show that the financial viability of SHPs depends heavily on the maintenance of subsidies, exemptions and regulatory facilities. Without these benefits, most projects become little or no attractive from an economic standpoint — which reinforces the criticism to the current policy of stimulating the expansion of this type of plant in the region.

At this point, it is already possible to affirm that the hydroecological dynamics of the Upper Paraguay Basin should be a central element in the decision-making processes of the regional electricity sector — both in hydroelectric inventories and in environmental licensing. This is because the implementation of dams, regardless of size, significantly changes the flow regime, water quality, habitat connectivity and sediment flow. These impacts directly compromise the ecological functionality of the Pantanal plain.

**However, the losses generated by the expansion of SHPs in the UPB are not only due to the negative ecological effects. They also result from a set of public subsidies that transfer to society the costs of low-efficiency energy generation and high environmental impact.**

Since 2001, the CONAMA Resolution No. 279 has instituted a simplified environmental licensing process for projects considered to have “little potential for environmental impact”. This classification, which includes SHPs, originally limited the projects to 30 MW of installed capacity and reservoirs of up to 13 km<sup>2</sup> — an area 2.6 times higher than the average of Municipal Full Protected Areas in the Cerrado and Pantanal biomes.

In addition, SHPs are subject only to authorizations (not concessions via bidding, as in the case of HPPs). The MHPs do not even need authorization from ANEEL — just communicate their existence.

The regulatory favoritism gained strength with Law No. 14.182/2021, which established the compulsory contracting of SHPs through the reserve of 50% of the demand in the A-5 and A-6 energy auctions. The A-5 auction, whose public session is scheduled for the second half of 2025, recorded a record number of registered projects: 241 in total, of which 184 are SHPs. Of the 2,999 MW of power registered in the auction, 86% correspond to SHP projects.

These facilities are added to direct tax and financial incentives, such as:

## DISCOUNTS ON TRANSMISSION (TUST) AND DISTRIBUTION (TUSD) TARIFFS

**BRL 72/kW.year** SHPs pay      **BRL 96.5/kW.year** paid by sources such as solar, wind and biomass

the cost is covered by consumers of the national electricity system, generating a cross-subsidy of

**BRL 24.5/kW.YEAR** in favor of SHPs

**FINANCIAL COMPENSATION FOR THE USE OF WATER RESOURCES (CFURH)** — although they generate relevant hydrological impacts, SHPs do not contribute with

**6.75%** of the produced energy value,

as other hydroelectric plants do.



**These subsidies artificially reduce the private costs of the projects, creating an appearance of economic viability that does not hold under real market conditions.**

To assess the weight of these incentives, WWF-Brazil commissioned a purely financial analysis of the hydroelectric projects proposed for the Upper Paraguay Basin. The following were considered:

**Capex** (own capital and financing);

**Opex** (operating expenses);

**charges and taxes** (with the effects of the subsidies);

**network connection costs** (Capex + Opex);

**cash flow of 3 years of construction and 30 years of operation**, with a discount rate of 8%.

Revenues were estimated based

**BRL 380/MWh**

on the ceiling value of the A-5 auction,

**BRL 344.05/MWh**

and also with the discounted average value of the last exclusive auction of SHPs.

Present value BRL million	Considering subsidies (minor expenses)		Disregarding subsidies (major expenses)	
	BRL 380 /MWh	BRL 344 /MWh	BRL 380 /MWh	BRL 344 /MWh
<b>Revenues</b>	<b>12.184</b>	<b>11.031</b>	<b>12.184</b>	<b>11.031</b>
<b>Expenses (total)</b>	<b>10.351</b>	<b>10.351</b>	<b>10.758</b>	<b>10.758</b>
Capex (entrepreneur)	5.870	5.870	5.870	5.870
Capex (amortization and interest)	1.784	1.784	1.784	1.784
Opex	399	399	399	399
Charges and taxes	1.065	1.065	1.472	1.472
LT (Capex + Opex)	1.232	1.232	1.232	1.232
<b>NPV (BRL million)</b>	<b>1.833</b>	<b>680</b>	<b>1.425</b>	<b>273</b>
<b>IRR (%)</b>	<b>10,58%</b>	<b>8,98%</b>	<b>10,02%</b>	<b>8,40%</b>
<b>Profitability (%)</b>	<b>17,71%</b>	<b>6,57%</b>	<b>13,25%</b>	<b>2,53%</b>

Financial analysis of the SHPs complex in the UPB

The table above presents the results of four simulations with variations regarding price of energy and presence of subsidies. In the incentives maintained scenarios, the return rate of projects ranged between 8.98% and 10.58%, values that exceed the cost of capital (8%), but that do not yet constitute attractive returns — which is expected in a low-risk sector.

However, when subsidies are withdrawn, profitability drops dramatically. In the reduced price and no incentives scenario, the return rate plummets to 2.53%.

Another way to highlight the weight of subsidies is to simulate an increase in financing interest rates: it would be enough for the rate to rise from 7.97% of the TJLP to 13.86% per year (still below the market average) to eliminate all positive return, even in the subsidies and maximum price scenario.

In the no-subsidies and reduced price scenario, a rate of 10.79% is already enough to make the project unfeasible.

**Subsidizing a project is only justified when it generates social value. In the case of the SHPs of the UPB, the opposite occurs: the subsidies feed the proliferation of enterprises that destruct social value.**

As seen earlier, the current situation already imposes about BRL 175 million per year in losses only to the fishing activity in the region — part of it directly attributable to the misguided policy of incentives to the sector.

# SOCIOECONOMIC CBA OF SHPS IN THE UPPER PARAGUAY BASIN

According to the CBA method (as well as the CBA Guide), the assessment of the socioeconomic viability of a project is given by its incremental effect, that is, **the evaluated alternative (in this case, the SHPs in the UPB)** compared to other ways of meeting the same underlying social objectives. Thus, a combination of alternative generating sources was established, composed exclusively of **non-hydro renewables (called “mix”)**.

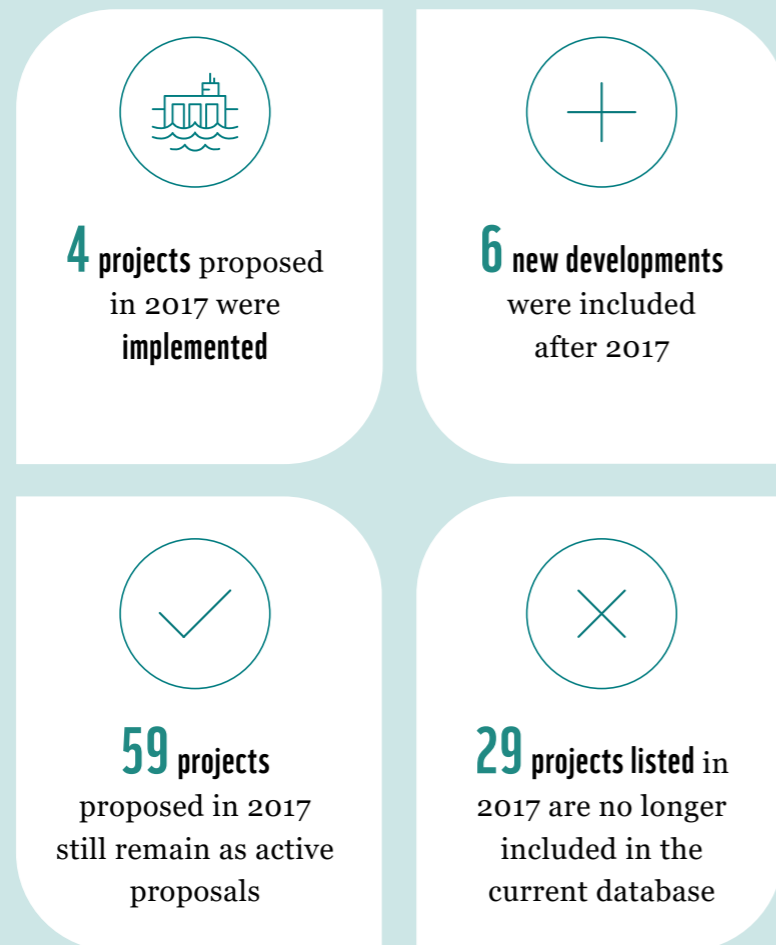
Juana Candia Ortiz, a fisherwoman in Bahía Negra (Paraguay), returning home after fishing. Bahía Negra, Alto Paraguay, Paraguay.

## PROJECT SCENARIO (SHPs IN THE UPB)

The analysis starts from the characterization of the projects proposed for the Upper Paraguay Basin, according to data from the National Electric Energy Agency (ANEEL) and the studies developed by the National Water and Basic Sanitation Agency (ANA).

Currently, there are 65 hydroelectric projects proposed for the UPB, 62 of which for Small Hydroelectric Plants (SHPs), according to data from the [ANEEL SIGEL](#).<sup>6</sup> However, the reference year adopted in the ANA studies — 2017 — identified 92 planned projects.

The comparison between the two moments reveals the following:



ANA’s modeling of hydrosedimentological and hydrological impacts — essential for the quantification of environmental externalities — was based on the set of projects proposed in 2017.

**As 59 of these projects are still active today, this group was defined as the focus of the analysis, forming the so-called “project scenario”, also called “complex of SHPs in the UPB”.**

## BASE SCENARIO (MIX OF NON-HYDRO RENEWABLES)

The 59 hydroelectric projects considered in this study total an installed capacity of 744.63 MW, which represents only 1.1% of the total projected by the EPE for the expansion of electricity generation in the country by 2034.

Based on a capacity factor of 55% — in line with both national energy planning and information from the sector itself — it is estimated that this set of plants would have a firm power of 409.55 MW. This is equivalent to an annual generation of 3,587,627 MWh.

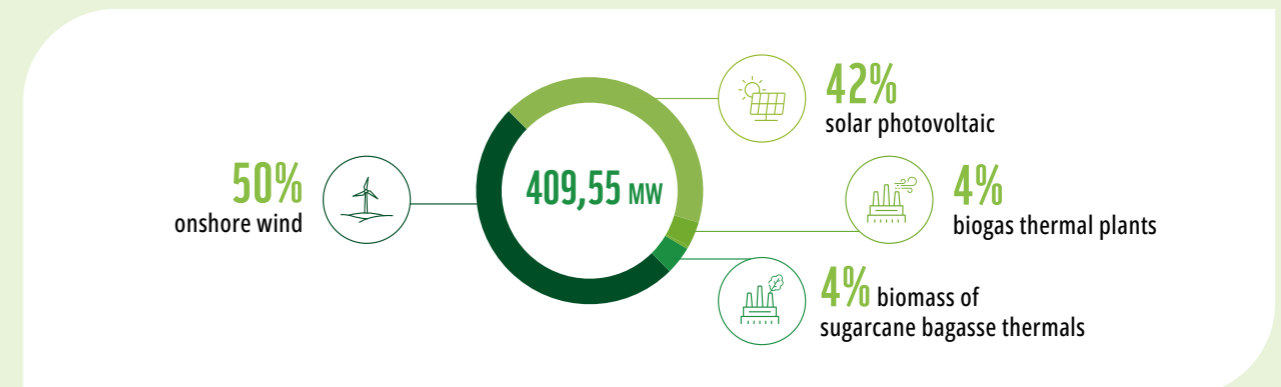
To enable its operation, it would be necessary to install about 2,445 km of transmission lines, connecting the projects to the National Interconnected System (SIN). Although many SHPs can operate as self-producers, most of those already in operation in the Upper Paraguay Basin (97%) are connected to the SIN and sell energy. In the case of MHPs, 87% work exclusively as

self-producers, without injection of surpluses into the network — and, therefore, do not require connection to the SIN.

Regardless of size, the construction of hydraulic dams causes changes in the flow regime, water quality, connectivity between aquatic habitats and sediment flow. These impacts on the Pantanal have already been evidenced in studies conducted by ANA.

Thus, the so-called “base scenario” adopted as reference for this analysis assumes that no new SHP should be implemented in the UPB. In this case, the expansion of electricity generation would take place through other non-water renewable sources, following the guidelines of the Ten-Year Energy Plan (PDE) 2034.

The composition considered was:



**This alternative scenario was designed to generate exactly the same firm power of the SHPs (409,55 MW), ensuring comparability between the models.**

To this end, the counterfactual assumes the beginning of the operation of renewable sources one year before the SHPs (due to the shorter implementation time) and incorporates a reinvestment (Repex) with residual value in the 30th year, compensating for the shorter life of these sources in relation to hydroelectric plants.

As in the case of SHPs, it is also considered that the alternative generation would take place in self-sufficient units, which implies evaluating their

need to connect to the SIN. Although this scenario has a higher total installed capacity (1,133.14 MW), the length of transmission lines required would be significantly lower: 316 km.

**In proportional terms, SHPs demand about 18 times more transmission lines than wind, 21 times more than solar and almost twice the requirement of biomass thermal plants.**



Fish traps in Porto da Manga, Mato Grosso do Sul.

© André Siqueira / ECOA Collection

The CBA result is given by the net comparison between the balance of benefits, costs and externalities of the project scenario versus the same balance of the base scenario.

When the monetized, aggregated and expressed in present value flows are finally compared, they produce the net benefit to society metric.

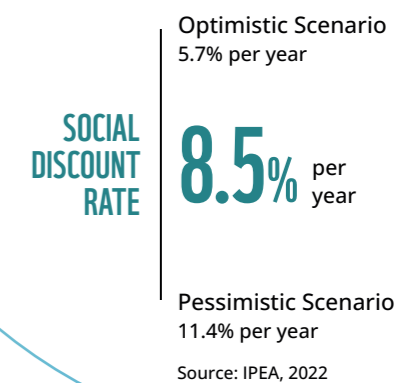
**Given the particularity of the electricity sector, the most advantageous option from a social point of view (of greater net benefit) between one or the other has the set of costs and externalities as a defining element.**

**Therefore, the scenario that has the lowest costs for the same level of benefits is the best option.**

Among the main feasibility indicators of a cost-benefit analysis, the **Comparative Net Social Present Value ( $\Delta$ VSPL) stands out**. This is the difference between the VSPL of the project scenario (SHPs) and the base scenario (mix of non-hydro renewables) and can be defined as the sum of the net benefits and costs calculated in each period over the entire horizon of the analysis, brought to present value through the **SOCIAL DISCOUNT RATE (TSD)**. In other words, the comparative net social present value is the sum of the discounted net flows, for which a negative value means that the project is socially unfeasible when compared to the base scenario.

Thus, according to the CBA Guide, to obtain the  $\Delta$ VSPL, it is necessary to calculate the flow of benefits, costs and externalities (positive and negative) over the established life of the project and its alternative. For it to be a socioeconomic (and not financial) assessment, the values are also required to be at **SOCIAL PRICES**.

Another relevant indicator in the CBA analysis is the benefit to cost ratio (B/C). When the result of the B/C ratio is less than 1, that is, the costs are greater than the benefits, the project must be discarded. Costs greater than benefits represent the subtraction of limited resources that could be used in alternative projects. In the case of  $\Delta$ VSPL, negative results indicate the disposal of the analyzed project to the detriment of the alternative.



#### SOCIAL DISCOUNT RATE (TSD):

To reduce the flow of costs, benefits, and externalities, which extends over 30 years, into a single present value that can be compared with other investment options (net present value), it must be discounted by a rate that represents the opportunity cost of alternative resource allocation. In the case of CBA, the Social Discount Rate (TSD) is used, estimated specifically for the evaluation of infrastructure investments, as defined by the Federal Government.

The TSD is 8.5% per year, with a threshold of 5.7% per year in an optimistic scenario and 11.4% per year in a pessimistic one. It is worth noting that the PDE 2031 (EPE, 2022) uses a discount rate of 8%, which, although not strictly the social rate, is very close.

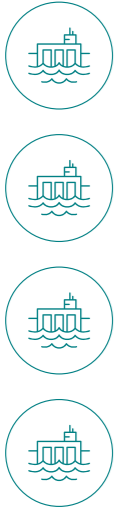
#### SOCIAL PRICES AND APPLICATION OF CONVERSION FACTORS:

When adopting society's perspective, CBA uses social prices (also called shadow prices), not necessarily market prices (observed prices). Social prices:

- i) correct the distortions embedded in market prices, which include taxes, subsidies, fees, and tariffs (transfers between economic agents of the same society);
- ii) consider users' willingness to pay for improvements in well-being; and
- iii) include externalities, whether positive or negative.

# COMPOSITION OF THE COMPARATIVE NET SOCIAL PRESENT VALUE ( $\Delta$ VSP)

## SHPS IN THE UPB



### BENEFITS

**BRL 11.36 bi**

Economic value of **3,59 million MWh/year**

### DIRECT COSTS

**BRL 7.22 bi**

- Capex (investment)
- Opex (operation and maintenance)
- Subsidy (TUST/TUSD and CFURH)
- Connection (annualized value reflects Capex and Opex)
- Repex (equals lifetime 30 years)
- Residual value (equal lifetime at 30 years of SHPs)

### EXTERNALITIES

**BRL 6.34 bi**

- GHG emissions (life cycle)
- Degradation of Ecosystem Services
- Direct Impacts on Fishing Activity
- Effects on Chain and Local Economy
- Discontinuity of traditional way of life

=

FLOW OF DISCOUNTED BRL  
30 years of operation

**-BRL 2.20 bi**

Net Social Present Value (NPSV)

Comparative Net Social Value ( $\Delta$ VPSN)

**-BRL 7.04 bi**

**+BRL 4.84 bi**

Net Social Present Value (NPSV)

Social discount rate **8.5/year**  
(IPEA 2022)

## NON-HYDRO RENEWABLE ENERGY MIX



**BRL 11.36 bi**

Economic value of **3,59 million MWh/year**

**BRL 6.02 bi**

- Capex (investment)
- Opex (operation and maintenance)
- Subsidy (TUST/TUSD and CFURH)
- Connection (annualized value reflects Capex and Opex)
- Repex (equals lifetime 30 years)
- Residual value (equal lifetime at 30 years of SHPs)

**BRL 0.50 bi**

- GHG emissions (life cycle)
- Air pollution (life cycle)
- Land use deamenities and noise

=

## BENEFIT ESTIMATES

### BENEFITS

Estimating economic benefits requires analyzing the variations in social welfare generated incrementally by the project.

The most common way is through the willingness to pay (DAP), which measures the maximum amount that people would be willing to pay for a given result considered desirable.

This estimate is made in place of financial revenues (collection of service fees, for example), as they do not necessarily express the incremental variations in social welfare to be measured.

It should be noted that investments in the sector can generate benefits from the increase in the availability of electricity to the system (additional), as well as non-incremental benefits, which correspond to:

the production of electricity for the **integration of energy markets;**

**replacing** the power supply;

**increasing efficiency** in the system; or

increased **safety** and **reliability** of electricity supply.

Due to the incorporation of renewable sources in the energy matrix, projects that do not generate energy, but that add more flexibility to the system, end up generating, indirectly, more energy — such as reversible hydroelectric plants or storage units.

In the case of the SHPs complex in the UPB, the result is clearly the production of the energy supply increase effect.

**In this sense, both scenarios consider the same increase in energy supply (3,587,627**

**MWh/year) at a unit social value of BRL 376.23/MWh, obtained after deducting subsidies, direct taxes and distributors' profits from the tariff paid by consumers.**

**Thus, the social benefit generated by either scenario is BRL 1.35 billion per year, or 11.36 billion in net present value over 30 years.**

However, climate change poses a significant risk to SHPs. The reduction in river flow directly impacts energy generation capacity and, consequently, socioeconomic benefits.

**Many SHP projects are based on old hydrological series (40 to 80 years), which do not reflect the current climate reality of temperature rise and precipitation reduction in the Upper Paraguay Basin.**

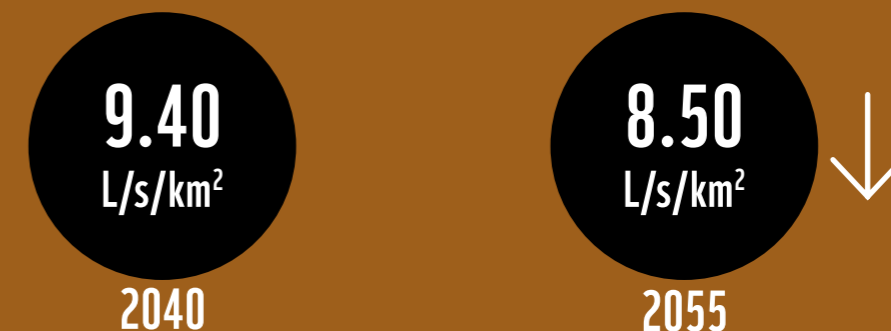
Among the projects proposed for the UPB that declare the period considered for the flow estimates, which are the basis for calculating the potential energy of the project, 14 projects (37%) make use of hydrological series from more than 75 years ago, starting in 1931; and another 14 projects (37%) use hydrological series from 40 to 50 years ago, most starting in 1966. Only one of the projects uses a series representative of the current “climate normal” — from 31 years ago, between 1990 and 2021.

However, the specialized literature brings ample scientific evidence that the past hydrological series represent less and less the reality of a world in which the average earth temperature rises year after year relentlessly.

### FORECASTS OF FLOW CHANGE IN THE UPB

According to ANA, the currently observed flow rate of about 10.15 L/s/km<sup>2</sup> is likely to be reduced in future periods, regardless of greenhouse gas emission scenarios.

Average flow projection of



Climate change should therefore be responsible for a 16% reduction in the average flow rate by 2055, which may lead to a drop in the socioeconomic benefits generated by SHPs from BRL 1.35 billion in 2030 to BRL 1.14 billion in 2055.

It is no longer possible to consider hydrological series from 40, 50 and even 80 years ago to design hydroelectric projects, especially when considering that SHPs do not have accumulation reservoirs: their operation is fully susceptible to the fluctuations in the flows of the rivers that feed them.

**In this context, the implementation of non-hydro renewable sources is more resilient to climate change, due to the geographical complementarity of these sources.**

DIRECT COSTS

The Cost-Benefit Analysis estimates the economic costs of a project based on total investments (Capex) and operating and maintenance expenses (Opex), **adjusted to social prices**.

This adjustment eliminates distortions of market prices and seeks to reflect the true **opportunity cost to society**. The following is a comparison between the two scenarios analyzed.

PROJECT SCENARIO

Capex

Based on the EPE parameters (2024), the cost of implementing the 59 SHPs in the project scenario was estimated at **BRL 6.678 billion (market price)**. After applying the conversion factors for social prices, the total value is **BRL 6.212 billion**. The execution is scheduled for three years (2026 to 2028), with typical distribution: 50% in the 1st year, 30% in the 2nd and 20% in the 3rd.

Opex

The annual operation of the SHPs results in a market cost of **BRL 44.68 million**, and a social cost of **BRL 42.08 million**. Added to this amount are the specific subsidies to SHPs, which represent opportunity costs:

**BRL 17.87 million/year**

related to the discount on energy transport tariffs (TUST/TUSD)

**BRL 25.40 million/year**

related to the CFURH exemption

**Total annual cost of operations and subsidies: BRL 85.35 million (social price).**

Connection

The infrastructure for connecting the SHPs to the network requires the construction of **2.445 km** of transmission lines. The annualized cost of the connection is **BRL 137.90 million (market)** and **BRL 128.94 million (social)**.

BASE SCENARIO – NON-HYDRIC RENEWABLE SOURCES

Capex

The base scenario foresees the replacement of the firm energy of the SHPs by a mix of sources (wind, solar, biomass and biogas). The total investment is **BRL 5.605 billion (market)** and **BRL 5.354 billion (social price)**. The implementation schedule is two years, with 60% of the investment in the first year and 40% in the second. As the average life of the sources is lower than that of the SHPs (22 years), there is a provision for reinvestment (Repex) to ensure equivalence over the 30-year horizon.

Opex

Based on the specific parameters for each source, the annual operating cost is **BRL 122.61 million (market)**. Applying the conversion factors, there is a social cost of **BRL 115.01 million/year**.

Connection

The need for connection infrastructure in the base scenario is significantly lower: **316 km**. The annualized cost of the connection is **BRL 17.80 million (market)** and **BRL 16.65 million (social)**.

SUMMARY OF COSTS

Cost Type	SHPs (Project)	Alternate Sources (Base)
Total Capex BRL billion	6.212	5.354
Annual Opex BRL million	42.08	115.01
Subsidies (TUST + CFURH) BRL million	43.27	0.00
<b>Total Opex + Subsidies</b> BRL million	<b>85.35</b>	<b>115.01</b>
Annual Connection BRL million	128.94	16.65

# EXTERNALITIES ESTIMATE

## EXTERNALITIES

Externalities are the **effects (costs or benefits) generated by a project** that fall on third parties, without compensation, and that are not captured in direct costs or financial benefits.

### PROJECT SCENARIO

To quantify the externalities of the project scenario, the evidence brought by **ANA in its Studies to Evaluate the Effects of the Implementation of Hydroelectric Projects in the Hydrographic Region of Paraguay** was used.









Based on the simulation of the prospective effect of the **59 hydroelectric projects**, ANA studies bring the following externalities arising from the change in hydrological ecosystem services:

**The sum of these 13 quantified externalities for the SHPs in the UPB, in addition to the greenhouse gas emissions in their life cycle, results in a loss of BRL 6.34 billion in net present value, which represents 88% of the direct costs of implementing the project itself.**

### BASE SCENARIO NON-HYDRO RENEWABLE ENERGY SOURCES

Regarding the externalities associated with renewable sources in the base scenario, it is important to recognize that these also generate impacts, although of a different nature from those caused by SHPs. In the model considered, **59 SHPs** would be replaced by **23 non-hydric projects**, with equivalent capacity over **30 years**.

Although these sources have a generic location, since they represent a counterfactual scenario, the specialized literature offers consolidated parameters that allow a robust estimation of three relevant externalities:

					BRL(millions)
	<b>GHG EMISSIONS<sup>1</sup></b> (life cycle)				<b>2.057</b>
	<b>DIRECT IMPACTS ON FISHING ACTIVITY</b> (Direct Impacts on Fishing Activity)	<ol style="list-style-type: none"> <li>Reduction in diffuse fishing activities with a loss of <b>BRL 502.60 million</b> per year, affecting <b>1.4 million</b> people in the UPB</li> <li>Reduction in direct income of professional artisanal fishermen, with a loss of <b>BRL 53.72 million</b> per year, due to the fragmentation of migratory fish habitats</li> <li>Reduction in family income in activities directly associated with fishing, with a loss of <b>BRL 35.83 million</b> per year</li> <li>Reduction of fish for self-consumption by professional artisanal fishermen (drop of 465.22 tons/year), with a loss of <b>BRL 1.83 million</b> per year;</li> </ol>			<b>593.982</b>
	<b>EFFECTS ON LOCAL CHAIN AND ECONOMY</b> (Indirect losses and related sectors)	<ol style="list-style-type: none"> <li>Reduction in nutritional quality due to lower fish consumption, with a loss of <b>BRL 29.29 million per year</b> due to the replacement of fish with less nutritious proteins</li> <li>Reduction in electricity generation capacity, estimated at <b>BRL 10.29 million per year</b> due to sediment retention</li> <li>Reduction of carbon sequestration from plain pastures, with a loss of 112.60 thousandt CO<sub>2</sub>e/year, valued at <b>BRL 4.97 million per year</b></li> <li>Reduction in the carrying capacity of the cattle herd in the plain, with an annual loss of 2.79 thousand animals, equivalent to <b>BRL 3.03 million per year</b> in production;</li> </ol>			<b>47.585</b>
	<b>DEGRADATION OF ECOSYSTEM SERVICES</b> (Perda de funções naturais com impacto econômico)	<ol style="list-style-type: none"> <li>Reduction in fishing tourism will result in the loss of <b>BRL 54.55 million per year</b> in direct spending</li> <li>Reduction in nature tourism, with a loss of <b>BRL 25 million per year</b></li> <li>Reduction in local economic chains of fishing tourism, with a loss of <b>BRL 12.27 million per year</b></li> <li>Reduction in local economic chains of professional artisanal fishing, with a loss of <b>BRL 4.23 million per year</b></li> </ol>			<b>96.053</b>
	<b>SOCIOCULTURAL IMPACTS</b> (Intangible values and identity)	<ol style="list-style-type: none"> <li>Discontinuity of the traditional way of life, valued at <b>BRL 8.29 million per year</b></li> </ol>			<b>8.294</b>
	<b>GHG EMISSIONS<sup>1</sup></b> (life cycle)				<b>2.440</b>
	<b>AIR POLLUTION<sup>2</sup></b> (life cycle)				<b>31.088</b>
	<b>LAND USE DEAMENITIES<sup>2</sup> AND NOISE</b>				<b>23.971</b>

<sup>1</sup> Both scenarios share a common externality: **greenhouse gas (GHG) emissions** throughout the life cycle of generation sources.

<sup>2</sup> In this case, the estimated social cost is BRL 2.057 million per year for SHPs and BRL 2.440 million for non-hydro renewables.

# WHAT THE DATA REVEAL

The CBA result is given by the net comparison between the balance of benefits, costs and externalities of the project scenario versus the same balance of the base scenario.

When the monetized, aggregated and expressed in present value flows are finally compared, they produce the net benefit to society metric.

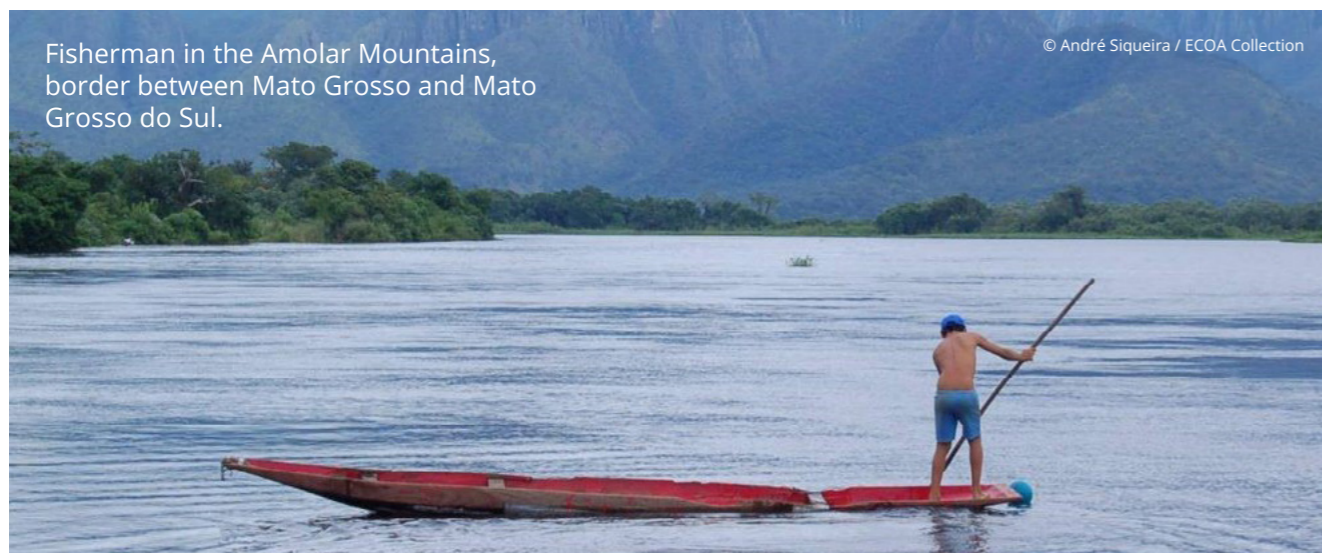
In the electricity sector, the choice between two alternatives must consider not only the direct costs, but also the externalities involved. Thus, the best option from a social point of view will be the one that generates the greatest net benefit, that is, that presents the lowest total costs for the same level of benefit.

To interpret the results, the following indicators are used:

**Comparative Net Social Present Value ( $\Delta$ VSPL), which indicates whether the project generates net social benefits in relation to the base scenario**

**Economic Rate of Return (ERR), which expresses the intrinsic profitability of the project and must be compared to the Social Discount Rate (SDR)**

**Benefit/Cost Index (B/C), a dimensionless indicator given by the ratio between the present value of benefits and costs**



## THE LOSS FIGURES

The numbers generated by applying the CBA method speak for themselves.

### NET SOCIAL PRESENT VALUE

**SHPs complex in the UPB,** the construction of the 59 SHPs in the Upper Paraguay Basin generates a **loss of BRL 2.20 billion** ↓ in net present value as a result of the various and significant externalities.

+

**Mix of non-hydro renewables,** the choice of non-hydro renewables has a **positive return of BRL 4.84 billion**, ↑ even considering the externalities of air pollution and land use deamenities and noise.

**COMPARATIVE RESULT BETWEEN SCENARIOS:**

**-BRL 7.04 billion** ↓

That is, insisting on the construction of new SHPs will not only result in considerable losses, but also Brazilian society would no longer have a very positive return if it opted for non-hydro renewable sources.

**In short, the choice of non-hydro sources instead of SHPs in the Upper Paraguay Basin avoids a loss of approximately BRL 7.05 billion.**

**The amount is enough to generate twice as much electricity (install twice the mix of non-hydro renewables) and still save BRL 531.88 million.**

In addition, it should be noted that the direct costs of the base scenario are also lower than those of the SHPs, even before considering the externalities.

**Therefore, investing in the complex of 59 SHPs in the Upper Paraguay Basin is an option that, by itself, before even considering the externalities, is simply not justified in view of the existing options for non-hydro renewable energy generation.**

## ECONOMIC RATE OF RETURN

Expresses the intrinsic profitability of the project and must be compared to the Social Discount Rate (SDR).

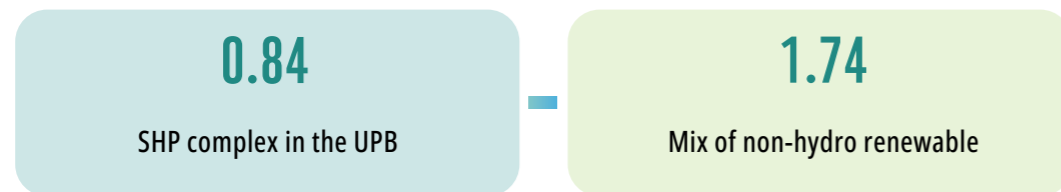
In addition to a negative net social present value, the economic rate of return does not cover the opportunity cost:



## BENEFIT/COST INDEX

Dimensionless indicator given by the ratio between the present value of benefits and costs.

When analyzing the ratio between the present value of benefits and costs in both scenarios, the following (dimensionless) indicators are reached:



COMPARATIVE RESULT: 0.48

These figures indicate that:

the option for SHPs in the UPB generates **losses** in the order of **16%** of the investment made;

other **renewable sources** generate **74%** more **benefits** than costs;

in comparative terms, for every

**BRL 1.00**  
that is no longer invested in non-hydro renewables to be directed to the SHPs in the UPB

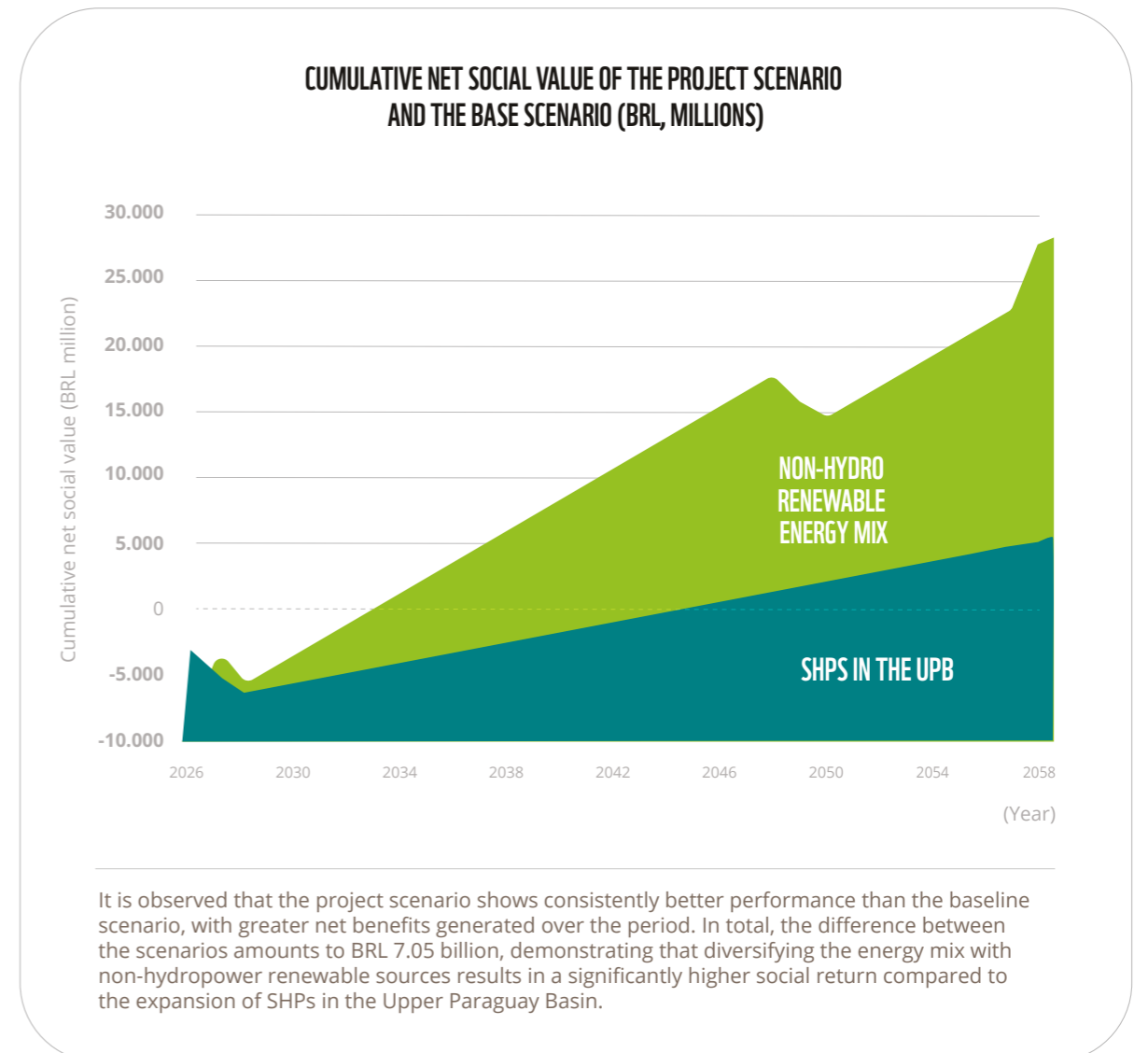


Brazilian society is charged  
**BRL 0.52**

Since the present social value considers the allocation of benefits, costs and externalities over a 33-year analysis horizon, the behavior of the accumulated curves can be observed below.

**Therefore, the base scenario (mix of non-hydro renewables) is consistently superior to the project scenario (SHPs in the UPB).**

Cumulative Net Social Value (2030–2058) – Baseline Scenario vs. Project Scenario



## CLIMATE CHANGE

In addition, climate change and consequent change in river flow, as projected by ANA, will result in less water availability for hydroelectric plants — both those already built and those projected — impacting the intended socioeconomic benefits.

It should be noted that other renewable energy projects are also vulnerable to climate change, but **the adoption of a mix of alternatives and geographical complementarity increase climate resilience. Opposing seasonal patterns generate synergy between the sources, with more intense winds in the**

**semi-arid region during the drought (May-November) and greater solar irradiance in the rainy season (December-April).**

**In contrast, the entire complex of SHPs in the Upper Paraguay Basin is subject to the same hydrological risk.**

Based on the flow projections for the Paraguayan hydrographic region, published by ANA in 2024, 9.999 simulations of variability in the power generation capacity of the SHPs complex in the UPB were made.

These simulations change the benefits of hydraulic generation, which further worsens the Net Social Present Value:

SHP complex  
**WITH NO CLIMATE RISK**

loss of

**BRL 2.20 billion**

in net present value



SHP complex  
**WITH CLIMATE RISK**

median loss of

**BRL 2.745 billion**

in net present value



**Therefore, the loss when opting for the complex of SHPs in the UPB to the detriment of the mix of non-hydro renewables, which is BRL 7.05 billion, is also increased by the climate risk, rising to BRL 7.61 billion in the median of the simulated results — there is a 50% chance of this social loss reaching between BRL 7.35 billion and BRL 7.86 billion.**

Thus, the probability is very high that the project scenario (construction of SHPs) does not generate as much economic benefits as the base scenario (mix of non-hydro renewables) over 30 years of

useful life. Failure to consider the climate risk, therefore, means to increase the burden imposed on society with the choice of SHPs.

## IMPACTS ON FISHING AND SOCIOECONOMIC BALANCE IN THE UPB

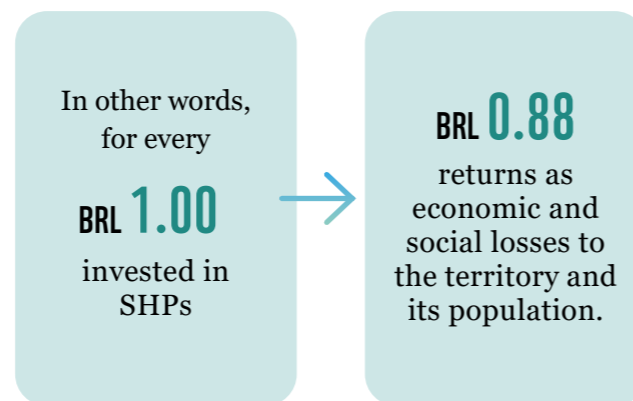
Elizete Garcia da Costa “Zeze” uses her net to catch crabs and small fish on the banks of the Paraguay River. She has been doing this for over 30 years.

Porto da Manga,  
Mato Grosso do Sul.



© Jaime Rojo / WWF-US

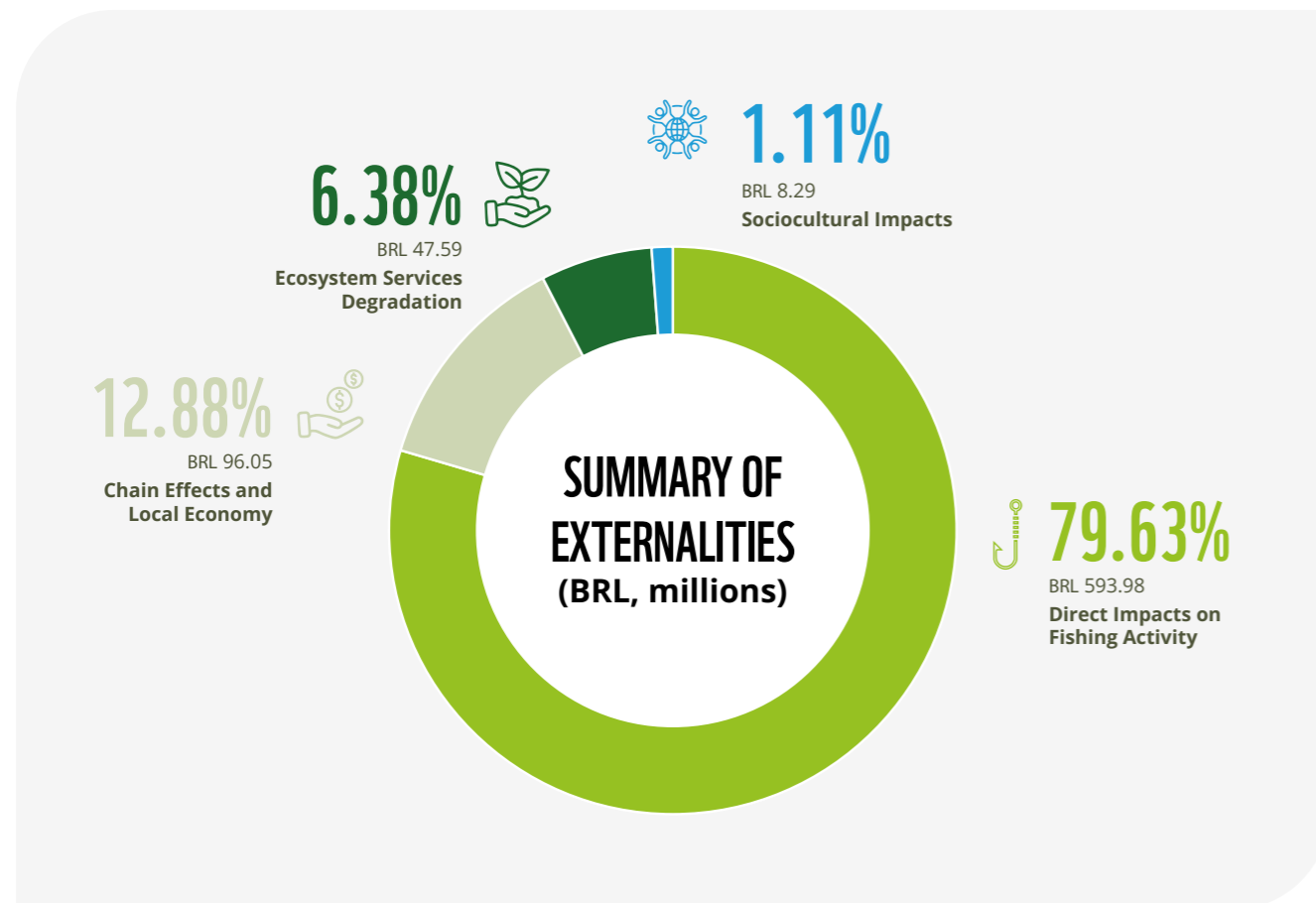
The Cost-Benefit Analysis (CBA) of the implementation scenario of the 59 Small Hydroelectric Plants (SHPs) in the Upper Paraguay Basin (UPB) incorporated 14 externalities that could be quantified and valued based on a robust methodology. The result points to an aggregate loss of BRL 6.34 billion in net present value, which represents approximately 88% of the direct costs of implementing the projects.



The adverse effects on fishing are significant both in economic terms and in relation to the well-being of populations directly and indirectly dependent on the region's fishing resources.

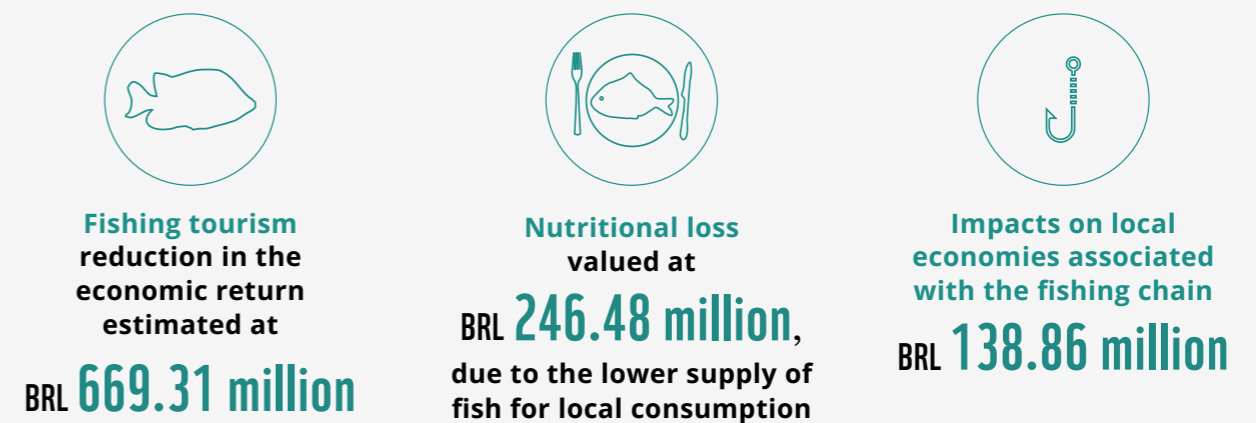
Native amateur diffuse fishing, practiced by more than 617,000 people in the UPB, is the most affected group, accounting for 67% of total losses (BRL 4.23 billion). The main cause of this loss is the reduction of migratory fish stocks due to the fragmentation of aquatic habitats caused by the dams. This represents an average individual loss of BRL 744.37 per affected person.

Professional artisanal fishing, a traditional and formalized economic activity in the region, also suffers significant impacts. **The direct loss associated with the interruption of river connectivity and the consequent reduction in fish availability is estimated at BRL 838.62 million, directly affecting 7,700 fishermen and their 14,000 family members — with an average impact of BRL 38.76 thousand per family. These values include the loss of direct income, food for self-consumption, increased family income and compromised way of life.**



**The main source of these losses is related to the fishing activity. Only the category “Direct Impacts on Fishing Activity”, referring to the effects produced on fishermen and production chain, accounts for 79.63% of the total value of the externalities considered.**

In addition, the effects on economic chains linked to fishing result in other relevant externalities:



Other externalities, although smaller in absolute value, complement the loss scenario — such as the impacts related to sediment retention and environmental quality degradation, estimated at BRL 184.96 million.

The results show that the impacts on fishing — especially those related to migratory fish — are the main source of losses associated with the SHPs scenario. This reinforces the structural incompatibility between the expansion of these hydroelectric projects and the maintenance of the local socioeconomic base of the Upper Paraguay Basin



## SUBSIDIES TO SHPS: LOSS DISTRIBUTION

SHPs receive exclusive subsidies in relation to the non-hydro renewable energy sources that make up the base scenario. Since the subsidy to SHPs is paid by society as a whole, it is an item included in the socioeconomic cost-benefit analysis.

**In the specific case of the set of 59 SHPs in the UPB, it is observed that the subsidies, of BRL 364 million in present value, are slightly higher than the operating costs themselves (BRL 354 million). Thus, the operating costs of SHPs are artificially low thanks to the subsidies.**

If any project is subsidized, but presents net socioeconomic benefits (positive comparative VSPL), there is a situation that allows the compensation of those who bear the subsidy in the first place.

That is, the positive result represents the generation of benefits in addition to costs, which include subsidies — and this is the logic of declaring them in the CBA.

For the SHP complex in the UPB, on the other hand, the negative comparative VSPL (in BRL 7.05 billion, without considering the climate risk) indicates that the subsidies become another way of distributing losses to society, such as an externality.

**In addition, the granting of subsidies artificially inflates the private return of SHPs, favoring the pressure for their installation even in evidently inadequate places, such as the UPB.**

# CONCLUSIONS AND RECOMMENDATIONS

The expansion of SHPs in the Upper Paraguay Basin generated profits for a few private actors, while spreading diffuse losses to thousands of users of the valuable water resources of the basin, which includes the Pantanal, the largest wetland on the planet.

Although necessary, the expansion of electricity generation cannot take place indiscriminately, under a logic of strictly sectoral evaluation. In the UPB, it is evident the need to consider the unique hydroecological dynamics that occurs between the plateau and the plain, and that supports a biome of peculiar traditional characteristics and uses.

**Hydroelectric plants already installed in the UPB cause, annually, socioeconomic losses in the order of 10-13% of the average GDP of the municipalities in the Brazilian portion of the basin due to the negative impact generated on fishing resources.**

In this context, it is clear that the advancement of multiple new hydroelectric projects, facilitated by regulatory rules and financial incentives, must be evaluated beyond financial return, under a socioeconomic assessment that allows identifying not only direct costs and benefits, but also indirect and long-term effects, such as habitat fragmentation, alteration of traditional ways of life and the resilience of the Pantanal in the face of climate change.

**The Cost-Benefit Analysis (CBA) carried out for the set of 59 SHPs proposed for the UPB unequivocally reveals their socioeconomic unfeasibility in the face of the alternative scenario composed of non-hydro renewable sources (solar, wind and biomass).**

**The direct costs of SHPs (BRL 7.22 billion) exceed those of the “base scenario” (BRL 6.01 billion), while the negative externalities associated with hydroelectric plants (BRL 6.34 billion) are more than twelve times higher than those of the non-hydro renewable mix (BRL 0.5 billion).**

Part of the unfeasibility of SHPs in the UPB is due to geographical dispersion, which entails high network connection costs. In addition, the implementation of SHPs in the UPB entails externalities of great magnitude for the Pantanal and its inhabitants, largely motivated by the extreme reduction of migratory fish populations.

**The loss of BRL 4.23 billion is noteworthy in diffuse fishing, affecting almost a quarter of the local population (617,000 people), as well as the direct damage to the way of life of 7,700 professional fishermen and at least 14,000 other people, their families, resulting in losses of BRL 838 million.**



Água Branca Waterfall in Pedro Gomes – MS.

**Exclusive subsidies to SHPs, which total BRL 364 million, only transfer costs to society, aggravating a less efficient energy matrix and more vulnerable to hydrological uncertainties.**

The intensification of climate change represents a serious additional risk: projections point to a median reduction of 16% in the average flow rate of the UPB by 2055, which would proportionally decrease the generation and benefits of SHPs, in addition to causing greater variability. The historical flow series used in the planning of hydroelectric plants are seriously outdated and do not reflect the new hydrological regime that is already underway.

**Climate risk simulations indicate that the damage to society increases by 25% compared to the initial standard.**

Given these results, the need to disregard the installation of new SHPs in the UPB in a timely manner becomes evident, prioritizing non-hydro renewable sources and distributed generation projects, which demonstrate greater resilience and lower social cost.

**The redirection of subsidies to environmental restoration and social compensation programs for the impacted groups can mitigate the costs already imposed on the Pantanal society.**

The installation of new SHPs in the Upper Paraguay Basin represents an environmental, economic and social setback incompatible with the national commitments of resilience, conservation, sustainable development and energy security.

**The transition to a more modern, distributed, clean and efficient system is not only a viable path, but a pressing need for the future of the Pantanal and of Brazil.**



Renewable energy with photovoltaic panels and wind turbines generating electricity at a solar power plant.

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## REFERENCES

This document is based on the study commissioned by WWF-Brazil, entitled *“The (un)sustainability of Small Hydroelectric Power Plants (SHPs) in the Upper Paraguay River Basin (UPB)”*, prepared by economist Daniel Thá, from Kralingen Consultoria Ltda.

For a more in-depth understanding of the context and conclusions presented,

[access the full study here.](#)

[access here](#)

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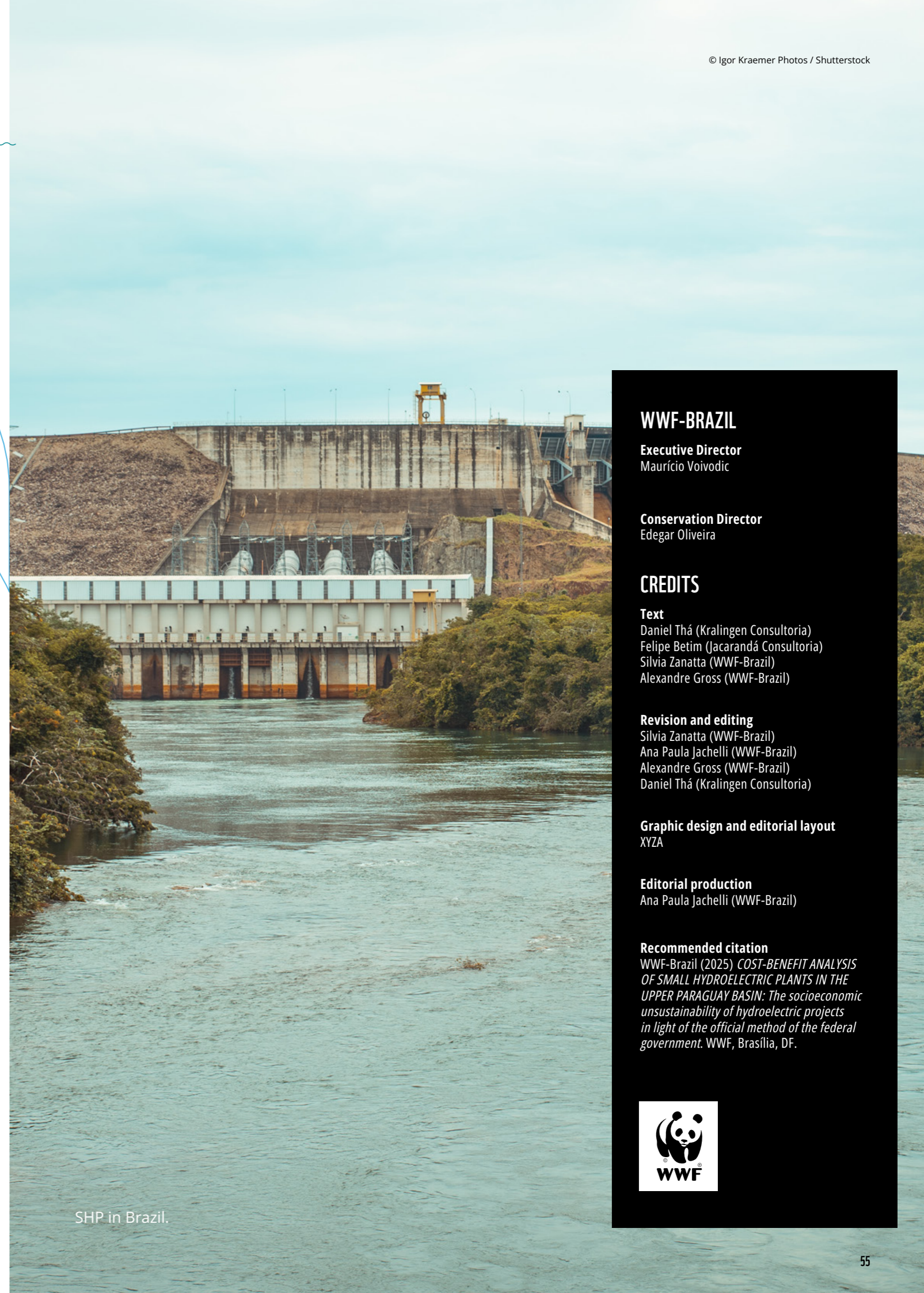
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<sup>6</sup>ANEEL, 2025.



SHP in Brazil.

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