Hydropower for the Age of Deep-Decarbonization: a Case Study of the Brazilian Water-Energy Nexus

CIGRE Knowledge Sharing - Power Systems Operation, Protection and Control

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1. Introduction

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Motivation

Hydropower regaining attention

- Developing/Emerging Countries: Climate mitigation and energy access[1]
- Developed Countries: Grid stability and flexibility[2][3]

Multi-purpose operation of reservoir-based hydropower

- “Water-Energy Nexus”[4][5]

Brazil, one of the most hydropower-dependent countries

- > 56% [6] of electricity depends on hydro and challenges arise during droughts

Research Gaps

Water-energy nexus studies in Brazil

lacks national-level synthesis of institutional responses during droughts[14][15][16]

2. Methodology

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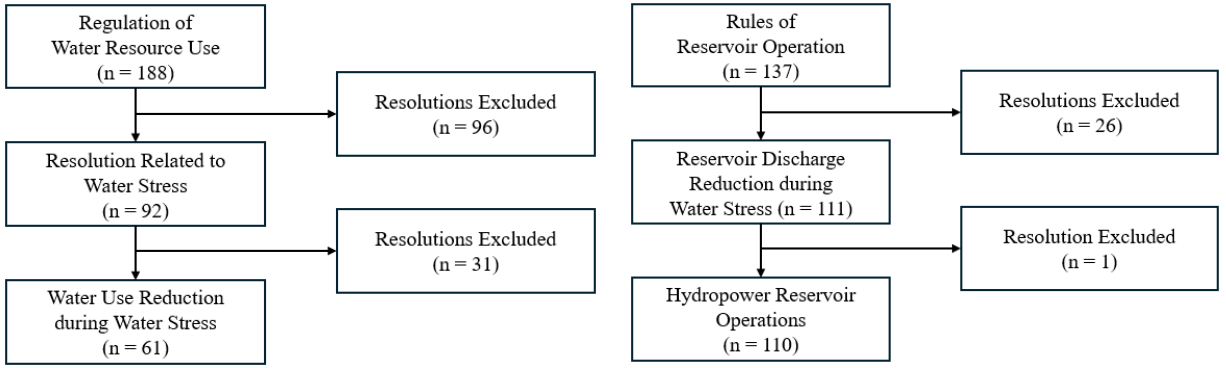
Hydrologic Resolution Analysis

1. **Extracting drought-response resolutions:**

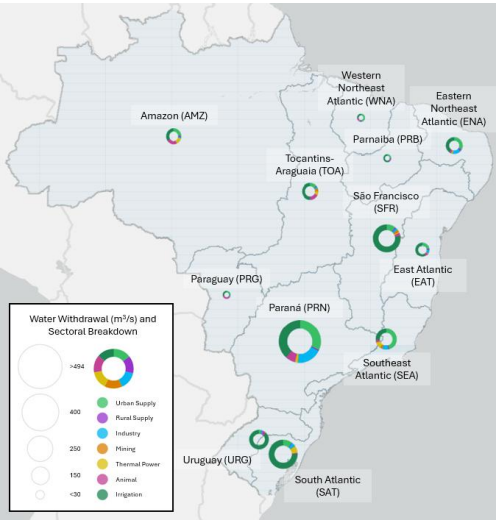
Water allocation reduction/limitation (n = 61)

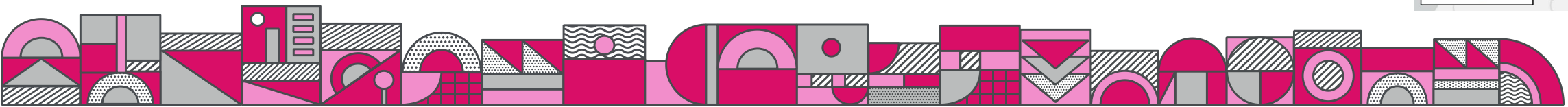
Hydropower reservoir operations (n = 110)



2. **Mapping to hydrographic regions**

3. **Analyzing the evolution of emergency river basin management**





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3. Analysis and Results

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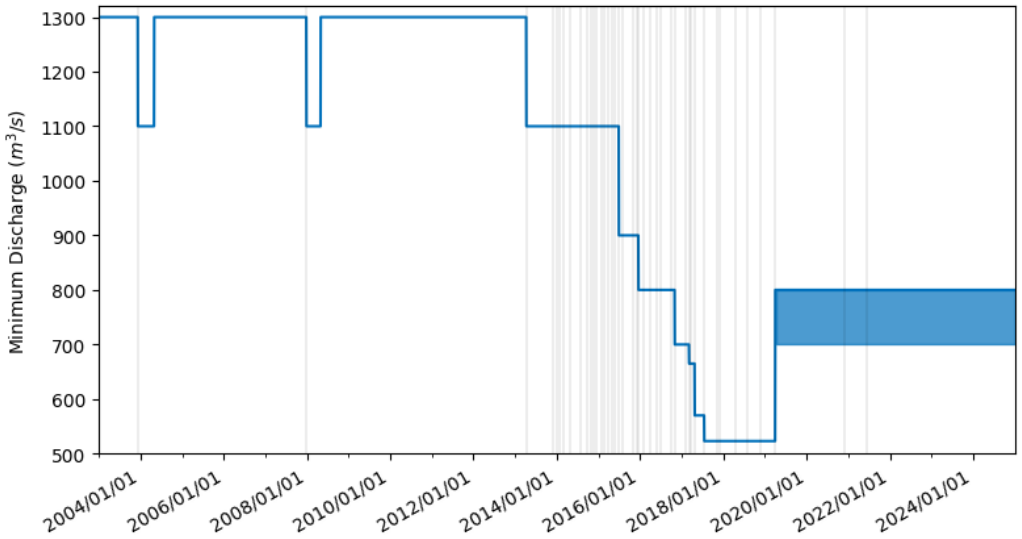
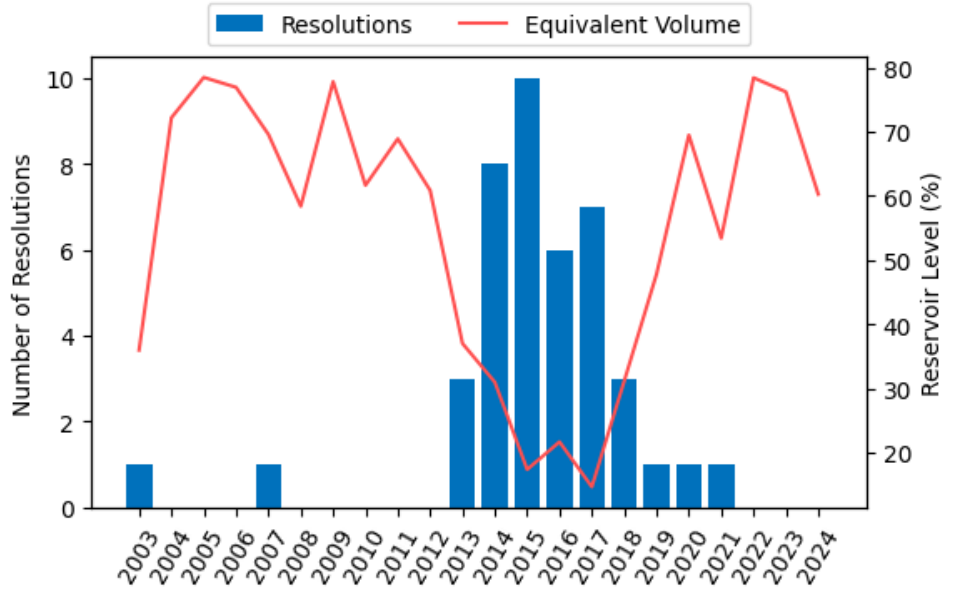
Reduction of Minimum Discharge

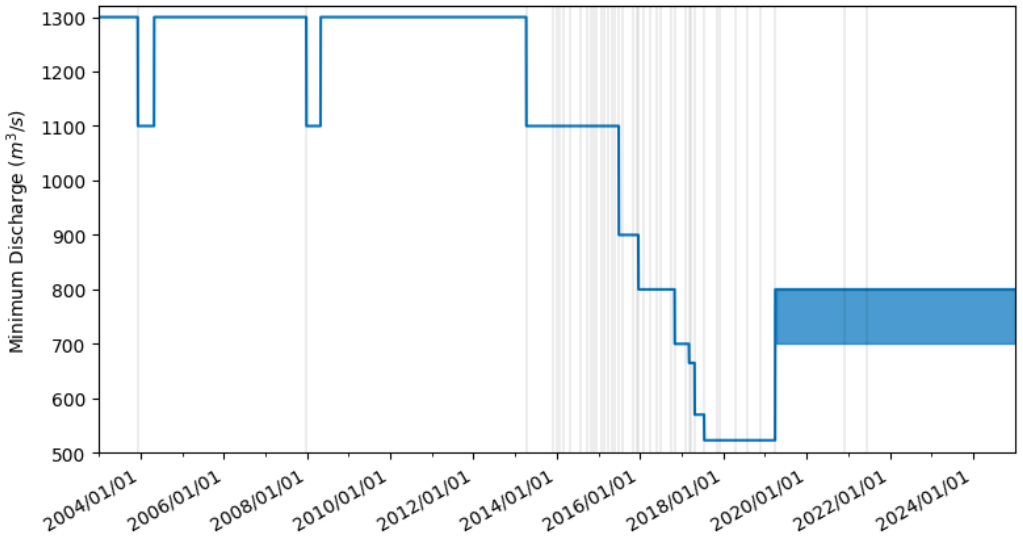


Reduction of Minimum Discharge Rates for the Sobradinho Reservoir.



Resolution Issuance and the Reservoir Level. Data Source: [19][20]

Normalized Emergency Operation



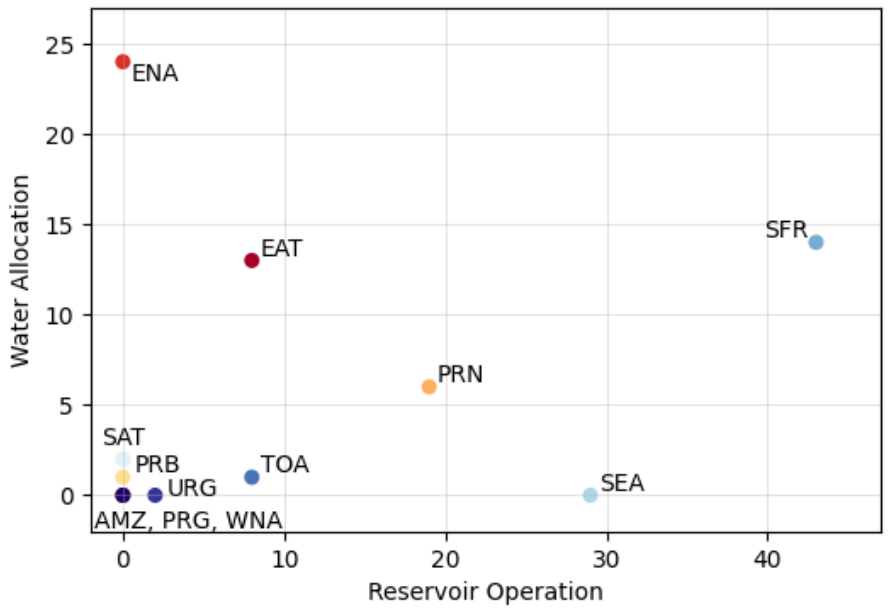
Threshold of Storage Capacity, Minimum Water Discharge	Três Marias	Sobradinho	Xingo (Operated according to the storage level of Sobradinho)
Normal	≥ 60%, 150 m^3/s	≥ 60%, 800 m^3/s	≥ 60%, 1100 m^3/s
Attention	30 - 60%, 150 m^3/s	20 – 60%, 800 m^3/s	20 – 60%, 800 m^3/s
Restriction	< 30%, 100 m^3/s	< 20%, 700 m^3/s	< 20%, 700 m^3/s

Color-band Water Allocation Scheme

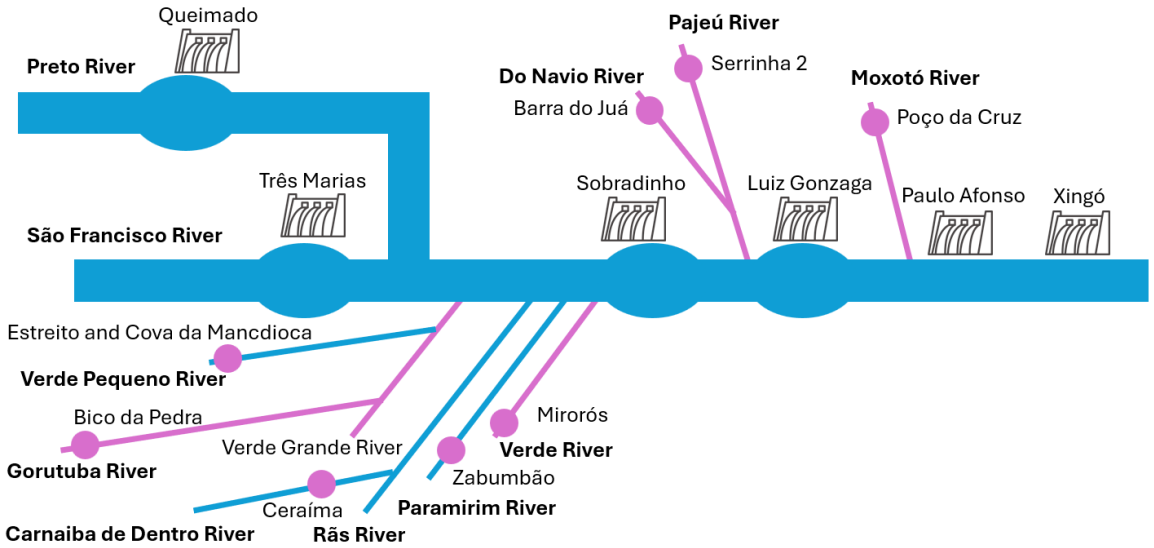
Color-band Water Use Reduction Scheme of the Cruzeta Water System (June).
Adapted from: ANA (2019b).

Hydrologic State	Volume (hm^3)	Reservoir Level (m)	Use	Condition of Use
Green	22	123.28	All Uses	100%
Yellow	11.80 - 22	121.20 - 123.80	Public Water Supply	100%
			Other Uses	0 - 100%
Red	- 11.80	- 121.20	Public Water Supply	- 100%
			Other Uses	0%

Unharmonized Nexus Governance



Regional mismatch between reservoir operation and water allocation resolutions



Intra-regional mismatch: mainstream vs. tributaries

4. Future Works

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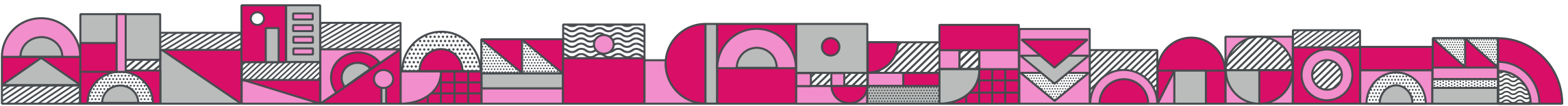

Thank you for listening

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