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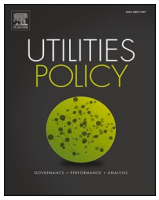

Full-length article

Are Brazilian water auction prices affordable for vulnerable families?

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ABSTRACT

A recent regulatory framework reform implemented in Brazil aims to universalize water and sanitation services by 2033. For financing and speeding up the construction of infrastructure, the new law encourages private sector participation through auctions promoted with the support of the Brazilian National Development Bank. However, the first auctions, with billions of dollars in price and investment effects, have raised concerns among practitioners over the impact on vulnerable families. We analyze the concessions in Alagoas and Rio de Janeiro states in Brazil to demonstrate how low-income families will struggle to pay their bills based on auction prices via the tariff, which may invite discontent. This research can inform subsequent water and sanitation auctions by highlighting that awards should not be based exclusively on auction prices, and affordability assessments should be mandatory.

1. Introduction

Approximately 84.2% of Brazil's population has access to potable water (BRASIL, 2022), corresponding to more than 33 million people lacking safe drinking water. The sanitation situation is even worse, with a 55.8% coverage rate for wastewater collection and 51.2% for wastewater treatment. Besides the lack of adequate access to water and sanitation (WSS) services, particularly the latter, substantial disparities are observed among the Brazilian regions and between rural and urban areas. For example, 60.5% of the wastewater is treated in the West Center macro-region, whereas only 20.6% is treated in the Northern area (BRASIL, 2022). Moreover, the quality of service is not of a high standard, with 40.3% of water losses, intermittent services, and several inefficiencies (BRASIL, 2022).

Aware of such a challenging scenario, the Brazilian government has reformed its main regulatory framework through law No. 14,026 of July 15, 2020 toward encouraging private sector participation by improving WSS regulation, adopting the neutrality principle between public and private operators, and implementing regional blocks (groups of cities, neighboring or not, mandatorily designed by each state) to increase their financial attractiveness (Marques, 2021). The Brazilian government's preference for private ownership is understandable. Private capital is fundamental to speeding up the WSS universalization, especially when the government does not have the financial capital to deploy the investments required and public utilities have not shown the capacity to leverage and implement the necessary projects.

Efficiency, flexibility, adaptability, and less bureaucracy are potential advantages of the WSS private ownership (Marques, 2008), and Public-Private Partnerships (PPP) arrangements are widely used to enhance infrastructure projects, potentially increasing social welfare. However, the empirical experience has brought concern about how the privatization processes have been conducted. Conflicts, litigation, and renegotiation of the contracts leading to tariff increases, redistribution of risks, or early termination are frequent and observed in several examples worldwide (Bel et al., 2010; Guasch, 2004). A study on Latin American contracts found that renegotiations often favor the concessionaire, with 62% leading to tariff increases, 38% to extensions of concession terms, and 62% to reductions in mandatory investments (Guasch, 2004). A study of 50 concessions awarded in Chile between 1993 and 2006 found that renegotiations included additional works (an increase of one-third of investments), and 84% of the USD 2.3 billion awarded in bilateral renegotiations corresponded to their compensation (Engel et al., 2009). Brazil has undertaken a major WSS privatization program, but the process has drawn considerable criticism, especially the auction price as the unique tender criterion and its potential impact on WSS tariff in the medium and long term.

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Infrastructure projects that rely on users' tariffs may cause affordability issues and deserve a specific assessment according to local socioeconomic factors. Besides the lack of physical access, society has become aware of the growing affordability topic since pressures on tariffs for funding the infrastructure sector have increased (Goddard et al., 2021; Mack and Wrase, 2017; Reynaud, 2016). Researchers and practitioners have suggested a variety of approaches for the evaluation of WSS affordability, such as analyses for different income groups and volumes of water, considering the living cost of the locality (Andres et al., 2020; García-Valiñas et al., 2010; Gawel et al., 2013; Kessides et al., 2009; Komarulzaman et al., 2019; Martins et al., 2016; Vanhille et al., 2018). See for a revision of the literature on affordability (Fagundes et al., 2023).

This paper aims to contribute to the discussion about the importance of water affordability analysis in areas where the services rely (or intend to) exclusively on tariffs. Using the recent auctions promoted by the Brazilian National Development Bank (BNDES) in Alagoas and Rio de Janeiro states, the potential impact of auction prices on families' income was studied to evaluate their sustainability. Although considered a remarkable success by national stakeholders, the perception that the water sector is such a social and politically sensitive area has led the authors to question if those recent auctions should have been more carefully prepared and conducted along with deeper social studies and discussions with experts from social and economic areas. They also defend that the auction model based exclusively on the auction price turns itself perverse and should not be adopted in this context. Finally, they posit that a post-auction assessment should be conducted to avoid an abnormal price (either auction price or average tariff proposed), a study of the population's affordability is a necessary condition for the projects, the auction price paid cannot be diverted to other sectors, and winners' auction price should not be included in regulatory costs.

This study contributes to the literature by highlighting the risk of the absence of affordability analyses in infrastructure tenders that involve tariffs. The research also demonstrates that public tenders based exclusively on auction price might not be sustainable over time in low- and middle-income localities since users will struggle to pay WSS bills and that an affordability analysis should be mandatory before and after the auctions. The analysis can be of value to decision-makers in Brazil and countries where private sector participation is desirable and viable. It is structured as follows: Section 2 briefly discusses the recent reform in the Brazilian regulatory framework and the private sector participation in the water sector; Section 3 describes the case studies; Section 4 reports the affordability analysis results. Finally, Section 5 provides the concluding remarks and suggestions for future research.

2. The Brazilian regulatory framework and private participation

Except for Metropolitan Areas, which have shared governance, WSS ownership belongs to municipalities in Brazil. They can provide those services directly or indirectly through local entities, or delegate them to the private sector (through PPP contracts) or to the state-owned companies (Narzetti and Marques, 2021). Until the recent reform, only contracts with private providers demanded previous competitive bidding, leading to a scenario where state-owned WSS companies offer service to more than 70% of the total population. Several cities have more than one provider, as shown in Table 1, which means that in 32% of the cities, municipal utilities run the services, but private operators also do so in 9.1% of them (many times, as the wastewater utility). The private sector participation is still timid, with about 1.303 local water providers and 3310 local wastewater utilities (BRASIL, 2022).

Table 1
Types of providers in the Brazilian water sector.

Types of providers	Cities (%)[a]	Population (%)[a]
State-owned	71.7	74.0
Municipal	32.0	24.8
Private	9.1	21.7

[a] Some cities have more than one provider.
Source: ABCON (2022).

In 2020, the sector underwent a legislative reform, setting national targets of 99% for water supply coverage and 90% for sanitation by 2033 since current services are still uneven and far from ideal, as observed in Figs. 1 and 2. The key legislative changes were the reshaping of the National Water Agency (ANA) competencies, including enactment of guidelines for subnational regulators, the obligation of public bidding for new contracts between state-owned companies and municipalities, and incentives to leverage integrated and regional solutions aiming at the promotion of economies of scale and financial rationality of providers trough regional blocks of cities (Narzetti and Marques, 2022).

In Brazil, private sector participation is mostly through public service concessions and sponsored or administrative PPP. The difference among them refers to the funding mechanism. Customers partially fund sponsored PPPs through tariffs, administrative PPP projects are funded by the contractor (the public entity responsible for the PPP arrangement), and public service concessions are fully funded by customers' tariffs. The country's regulatory system also has its peculiarities. First, the municipality can choose its regulatory authority, either municipal, state, or regional. Before Law No. 14,026, all the subnational water regulators (90, according to the national government[1]) had complete independence to work as they wished, relying on the basic rules of Law No. 11,447 of 2007, such as pricing setting, technical standards, and WSS plan monitoring. For PPP arrangements, the contract regulation is applied with general technical standards. For example, tariff-setting methodologies and coverage goals are set in the PPPs contracts, but administrative processes and quality standards follow the regulator's procedures. Also, the regulators are responsible for deciding whether a PPP contract needs a revision (based on the previous requests for economic and financial rebalancing and on the contract's risk sharing). Considering the complexity and the technical level disparity between subnational regulators, Law No. 14,026 designed ANA to be responsible for establishing national guidelines for those subnational authorities aiming at regulatory quality improvements all over Brazil.

The Federal Government demanded the structuring and modeling of new projects for public investment banks such as BNDES and *Caixa Econômica Federal* to increase and standardize PPP arrangements. Since then, BNDES has become a key player in privatization, helping Brazilian states and municipalities prepare PPP arrangements, from preliminary studies to contract signing. As a result of the first year of sector reform, the private sector participation increased 31%, from 389 to 515 cities (from 5.2% to 9.2% of Brazilian cities), from 31.6 million to 47.3 million people (from 14.5% to 22.2%) (ABCON, 2022), representing a success of one of the main objectives of the new WSS law – increasing private sector engagement. According to the BNDES,[2] the projection for the next two years is more than BRL 24 billion (US$ 4.6 billion[3]) in investments, increasing the proportion of the population with a private provider to 36% until 2030 (ABCON, 2022).

3. Case studies

Private sector participation has increased since the reform of the WSS regulatory framework with concession contracts on water, wastewater, and solid waste services. Our analysis will focus on Block A of Alagoas state and Blocks 1, 2, and 4 of Rio de Janeiro state since Brazilian water stakeholders considered them a great success, mainly due to their auction prices. In both cases, the auction winner selection was based on the

[1] Available at https://www.gov.br/ana/pt-br/assuntos/saneamento-basico/agencias-infranacionais (accessed on 30/12/2023).
[2] https://hubdeprojetos.bndes.gov.br/pt/projetos/nossos-projetos.
[3] Exchange rate of 29/03/2023.

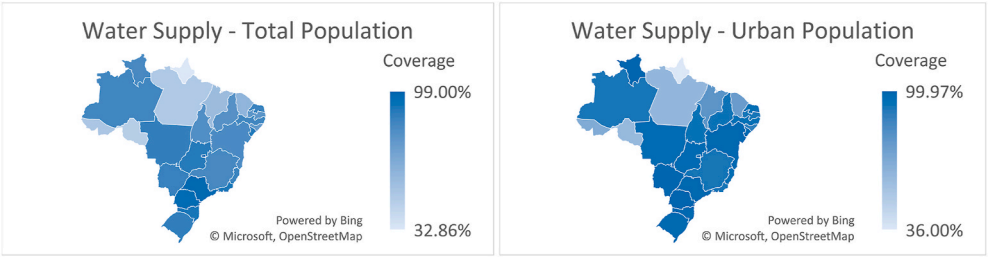

Fig. 1. Water supply coverage. Source: SNIS (2022).

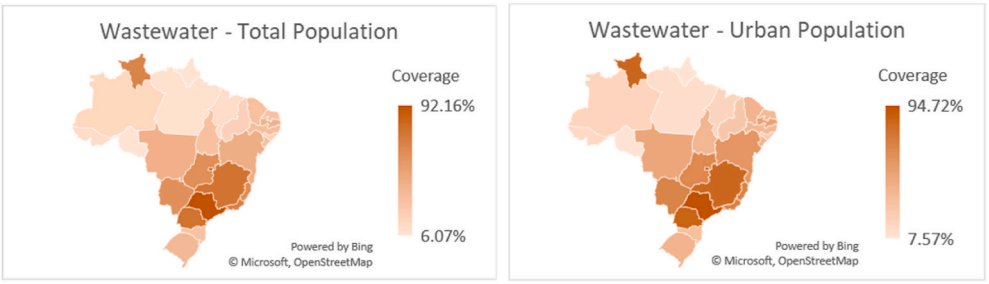

Fig. 2. Wastewater collection. Source: SNIS (2022).

highest auction price offered by bidders to the states (as compensation for the right to explore WSS services with profit for 35 years). Those contracts have mandatory WSS coverage goals following the new national guidelines from Law No. 14,026, as well as penalties for not accomplishing them, such as fines and temporary prohibition of new public contracts for two years. The contracts already bring their tariff structures (including the discounts applied to social tariffs), the periodic contract review methodology, and risk sharing between public and private partners, leaving to the state water regulators (ARSAL in Alagoas and AGENERSA in Rio de Janeiro), the role of conducting contract reviews if needed, conducting annual price adjustment to offset inflation, monitoring contract performance, and conflict resolution among users, utilities and contractors. As mentioned elsewhere, BNDES had a crucial role in those auctions. The National Bank conducted all the preparatory studies and designed the draft contract using the pre-existing tariff of the WSS state-owned companies (previous utilities).

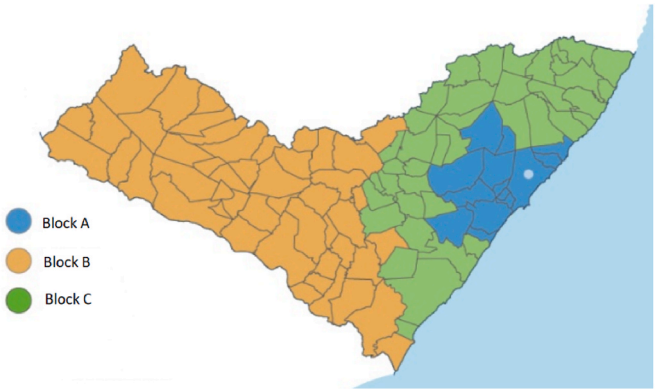

Fig. 3. Regional blocks of cities in Alagoas. Source: BNDES.

3.1. Alagoas

Alagoas state is located in northeast Brazil, where the state-owned WSS company CASAL was the provider of 77 of 102 cities.[4] The remaining 25 municipalities had their local public providers. Following the new national WSS law principles of economies of scale and regional cohesion, the state government has divided Alagoas into three regional units (Fig. 3). Blocks A, B, and C encompass 13, 49, and 40 cities, respectively, and BNDES and the state of Alagoas were responsible for the public tender processes, including pre-contractual studies.

The bidding of Block A was held in September 2020, and it was the first Brazilian WSS auction after the sector reform. It involves the urban area of 13 municipalities in the Metropolitan Region of Maceio (the state capital), with 1.5 million inhabitants (44% of the state population) and an estimated investment of BRL 2.6 billion (US$503.4 million) throughout a 35-year term. Investments for the first six years are BRL 2 billion (US$ 387.2 million[3]) since 88.4% of the local population have water services and only 29.2% have wastewater services. The universalization goals include 99% water supply coverage in the first six years and 90% sewage collection within a 16-year contract.

Blocks B and C are low-income regions, but concession contracts were signed months later. By the time of the Block A auction, a considerable debate was held on the wealthiest area being privatized alone, leaving low-income localities with low WSS coverage rates to the state-owned company. The idea of regional blocks of cities was to increase economies of scale, enabling cross-subsidization among them. Despite being encouraged by the new law, regional units may not be fully functional since mayors have the legal power to keep local providers or CASAL as their utility. That was the case of Blocks B and C. Designed for 40 cities, Block B auction encompassed 34 municipalities of Alagoas countryside, and Block C involved 27 out of the 49 cities planned by the state government. Since CASAL's employees are public workers, a human resource issue was created with the privatization, and to overcome the situation, CASAL became the bulk water provider in the cities with private WSS provision and the WSS utility where mayors had decided not to join the blocks. The estimated investments for blocks B and C will reach BRL 2.9 billion (US$ 561.5 million) throughout the 35-year term since access to water services is 92.4% in Block B and 81.3% in Block C, and only 9.31% for wastewater in Block B and 23.3% in Block C.

Besides previous mandatory technical prerequisites, such as

[4] Available at https://hubdeprojetos.bndes.gov.br/pt/projetos/Alagoas-Saneamento-Bloco-A/6cc46317-741b-11ea-8ee4-0242ac11002b (accessed on 27/02/2023).

experience in the water sector and financial qualifications, the bidding unique criterion was the highest auction price, which led to a winning bidding grant of BRL 2.009 billion (US$ 390.1 million) for Block A, representing a 13,180% premium over the minimum grant established by BNDES in preliminary studies (BRL 15.125 million, US$ 2.928 million). Blocks B and C also had bigger offers than pre-contractual studies, even though both tenders had just three participants, while Block A encompassed seven. The BRL 1.2 billion (US$ 231.9 million) and BRL 430 million (US$ 83.2 million) auction prices for Blocks B and C represented 37,551% and 1,227% premiums over the minimum grant established by BNDES. Such premiums should have caught experts' attention regarding the underestimation by the Brazilian Bank or the overestimation by private companies regarding project cost recovery. Block A also has several singularities. As mentioned, state-owned company CASAL became the bulk water supplier for new private operators in all three blocks to meet the human resources challenge. CASAL has two other contracts in Maceio city with private partners valid until 2048 - a Build-Own-Operate-Transfer (BOOT) in some neighborhoods and a concession for wastewater and commercial services in other areas of the capital. The high complexity of the arrangement led to the establishment of a specific contract, splitting each provider's duties.

Although the government claims 2.6 million people are under those concession contracts, the number is 1.9 million since the service area is restricted to urban zones and communities with more than 1000 inhabitants. The Alagoas rural area, which reaches 26% of the total population, is not included. The new WSS universalization national goals from Law No 14,026 (99% for water supply and 90% for sanitation by 2033) were made for the total population, either rural, peri-urban, or urban, which means that in Alagoas, where rural areas and small communities are not included in the concession service zones, the municipalities will be responsible for WSS provision, directly or through amendments to existing contracts, which indeed raise concerns.

3.2. Rio de janeiro

Rio de Janeiro state, located in southeast Brazil, has CEDAE as its state-owned WSS company, although local providers are responsible for 44 cities. Similarly to Alagoas, the state was divided into four blocks encompassing 48 cities, including its capital, Rio de Janeiro. Toward more attractive individual blocks, the capital was split into included areas, i.e., the blocks have cities and neighborhoods from the capital. Block 1 includes 18 municipalities, Block 2 includes two, Block 3 has 20, and Block 4 has eight cities, totalizing 13.7 million people (approximately 84% of the Rio de Janeiro state population). This infrastructure water project is considered the biggest in terms of capital mobilization in progress in Brazil, with investments of around BRL 30 billion (US$ 5.8 billion) and BRL 10.6 billion (US$ 2.1 billion) of auction prices for the four blocks.

Blocks 1, 2, and 4 encompassed the urban area of 29 municipalities and capital neighborhoods and a BRL 29.7 billion (US$ 5.8 billion) estimated investment throughout the 35-year term since 76% of the local population has water services, and only 40% has wastewater.[5] The contract sets universalization goals for WSS, most of which will be met within 12 years of the contract signing. Similarly to the Alagoas case, the bidding winner selection criterion was the auction price, which led to a BRL 22.690 billion (US$ 4.4 billion) winning grant, representing a 134% premium over the minimum grant established by BNDES. Rio de Janeiro's auctions also have variable auction prices: besides the initial payment of the auction price, 3% of the tariff revenue must go to the municipalities, and 0,5% goes to the Metropolitan Region Fund during the whole concession term. This "variable auction price" is also considered compensation for the municipalities and the Metropolitan Unit for delegating their WSS services to private operators, and it has been applied by BNDES probably for raising political support and collaboration from the municipalities with the regional block structures and bidding processes. Therefore, besides the massive investments and the auction price, part of the revenue is used for another purpose since the Metropolitan Fund has a variety of projects to finance, including public transportation, climate change adaptation, urban drainage, and WSS. Like the Alagoas case, CEDAE will also be the bulk water provider to private companies in 14 cities and is still the provider for 16 cities that did not join the blocks.

Table 2
Population of case studies.

States	Blocks total population[a]	Blocks contract zones population[a]	Total Population of the State[b]
Alagoas	2,634,600	1,876,800	3,365,351
Rio de Janeiro	13,627,600	7,644,100	17,463,349

[a] Source: BNDES, 2022: https://hubdeprojetos.bndes.gov.br/pt/projetos/nossos-projetos (accessed on March 03, 2023).
[b] Source: IBGE, 2021: https://www.ibge.gov.br/cidades-e-estados/al.html, https://www.ibge.gov.br/cidades-e-estados/rj.html (accessed on March 28, 2023).

4. Affordability analysis and discussion

Brazil faces significant challenges regarding WSS universalization, especially in the Northern and Northeastern macro-regions. Although its WSS regulatory framework reform aims to increase private sector participation based on the idea that privatization would offer advantages over public management, no methodology confronting those situations was observed in the bidding documents (Carvalho et al., 2015). Brazilian stakeholders have considered those case studies highly successful due to the amount of money raised with the auction prices. However, the assumption poses several problems.

Although the areas (Alagoas blocks A, B, and C and Rio de Janeiro blocks 1 to 4) have 16 million inhabitants, the contracts' service areas have 9.5 million people since they include urban zones, only part of informal settlements, and in the case of Alagoas, communities with more than 1000 people. The national WSS regulatory reform universalization goals are intended for the total population and not only for urban ones. Therefore, the municipalities must provide services in areas outside the contracts' service zones but with no revenue from wealthier urban neighborhoods. According to Table 2, the populations within the contracts' zones comprise 55.8% of Alagoas state and 43.7% of Rio de Janeiro state. 6.7 million people live in the areas but are included neither in the concession contracts nor in their goals.

As pointed out by national experts, the public tenders and their billionaire auction prices have erroneously emerged as a solution for fiscal constraints faced by municipalities and states. The deadlock around auction price distribution in Alagoas is an example of a misleading objective. Alagoas state did not split the auction budget satisfactorily among the state and municipalities (the responsible for WSS services, according to the Brazilian Constitution), leading to a lawsuit judged by the National Supreme Court. The Court demanded a new distributive and governance system for Block A, decreasing the dominance of Alagoas state over municipalities.[6] The situation becomes more dramatic, considering that all the revenue to pay the auction price and the investments come from the tariffs since, in general in Brazil, concession contracts rely exclusively on users' tariffs. Since no obligation, such as universalizing service to low-income areas, is imposed on the auction prices, the WSS services have become a financing tool for other sectors before full coverage of their needs.

[5] https://hubdeprojetos.bndes.gov.br/pt/projetos/nossos-projetos.

[6] Verdict available at https://portal.stf.jus.br/processos/detalhe.asp?incidente=6213264.

Moreover, both contracts limit the number of households with access to social tariffs – 8.5% of total households in the contract zone for Alagoas and 5% for Rio de Janeiro. If they need to increase these figures, a contract rebalancing will take place to accommodate it. As further discussed, no previous socioeconomic studies have established those limits. Since public budgetary resources have become scarce, public services have relied more on tariffs, increasing the burden on families' income. Although the WSS sector is known as heavily subsidized (Andres et al., 2019), i.e., artificial lower prices are commonly applied to users, it is still a sector with high sunk costs, especially for 100% coverage in low-density areas. For instance, Rio de Janeiro WSS state-owned company CEDAE reported 117,7% cost recovery in 2021 to the national WSS information system (SNIS), against 87.6% for Alagoas state-owned company CASAL and 66.7% for the new private operator in the Metropolitan Region of Maceió (Alagoas Block A, first year). We emphasize that these figures consider the current WSS coverage rates, such as 40% of sanitation coverage in Rio de Janeiro and 29% in Block A, Alagoas. That said, even when data are incomplete, affordability analyses should be mandatory in the business model and tariff structure process, especially in concession contracts that rely exclusively on tariffs. However, such analysis has not been found in the bidding documents.

A two-step affordability analysis was conducted in this research. First, the affordability ratio (AR) was calculated as the percentage of income spent on WSS bills according to two different consumptions. In the bidding studies, BNDES identified 155 L per capita per day (lpcd) for Alagoas and 150 lpcd for Rio de Janeiro; and the World Health Organization (WHO) specifies 100 lpcd as the minimum volume of water to meet essential needs (Howard et al., 2020). Second, the main socioeconomic characteristics of the case studies were evaluated according to national public data to understand if the limits and discounts imposed on social tariffs were enough.

Three income groups were used for the AR calculation: average income of each state, half of the minimum Brazilian wage per capita, and *Bolsa Família* beneficiary average income per capita. Half of the minimum Brazilian wage per capita was included in the analysis since it is used for several social programs, such as social tariffs in the energy sector. *Bolsa Família* beneficiaries were also included because it is Brazil's central social assistance program for families in extreme poverty. The number of inhabitants per household[7] and national employment rate (proportion of the population with paid occupation, which is 45.56%[8]) were considered for AR calculation for the state average income. Finally, the information from the Brazilian Institute of Geography and Statistics (IBGE) of the residents per low-income household was used for the AR calculation for *Bolsa Família* beneficiaries and low-income groups (1/2 minimum wage) since the value is higher than the residents per household considering state average wage.

The burden of tariffs on families' budgets was evaluated using two average WSS tariffs from the referential cash flow model, available in the pre-contractual studies conducted by BNDES, one with the predefined auction price and another with the winner auction price. BNDES considered the auction price part of investments in its referential cash flow, as did we. The goal was to provide an idea of the potential impact of the billionaire grants on tariffs and households' income. The basic premises adopted are shown in Table 3.

The following assumptions were made for the development of this exercise: the auction price was considered an event of economic-financial rebalancing concerning the BNDES referential cash flow, and the economic-financial equilibrium was assumed to be restored with a tariff adjustment, keeping the same internal rate of return (9.37% in Alagoas and 7.79% in Rio de Janeiro). Since the bidding winner business model was unavailable, the tender referential cash flow and its internal rate of return were adopted. Therefore, we assumed the regulator would adjust the tariff immediately toward the auction price payment. The auction price payment period was established in the bidding documents, as shown in Table 3, and included in the cash flow.

Table 3
Premises for affordability analysis.

Assumptions	Alagoas	Rio de Janeiro, Block 1	Rio de Janeiro, Block 2	Rio de Janeiro, Block 4
Auction price by BNDES (000) [a] (BRL)	14,500	4,036,856	3,172,208	2,503,249
Winners Auction Price (000)[a] (BRL)	2,009,000	8,200,000	7,286,000	7,203,000
Original Average tariff[2] (BRL/m[c])	9.3	10.9	13.1	11
Auction price payment period[b] (%)	Year 1 (100)	Year 1 (80), Year 3 (20)	Year 1 (80), Year 3 (20)	Year 1 (80), Year 3 (20)
Auction price impact on average tariff (%)	46.3	24.6	41.9	13.2
Average state monthly income[c] (BRL)	1873,00	3515,00	3515,00	3515,00
Average monthly income per capita of *Bolsa Família* beneficiaries[d] (BRL)	316,00	427,00	427,00	427,00
Residents per low-income household[e] (no.)	4	3.8	3.8	3.8

[a] Source: BNDES, 2021: https://www.bndes.gov.br/wps/portal/site/home/imprensa/noticias/conteudo/por-r-22-7-bilhoes-saneamento-de-municipios-do-rio-e-concedido-e-fluminenses-terao-universalizacao-de-agua-e-esgoto-ate-2033 (accessed on March 03, 2023).
[b] Source: https://parcerias.al.gov.br/projeto-saneamento-basico/(accessed on January 05, 2023), http://www.concessaosaneamento.rj.gov.br/documentos.php (accessed on January 05, 2023).
[c] Source: PNADc, 2022: https://sidra.ibge.gov.br/tabela/descricao/5436 (accessed on March 03, 2023).
[d] Source: PNADc, 2021: https://www.ibge.gov.br/estatisticas/sociais/trabalho/17270-pnad-continua.html?edicao=34039&t=resultados (accessed on February 27, 2023).
[e] Source: PNADc, 2021: https://www.ibge.gov.br/estatisticas/sociais/trabalho/17270-pnad-continua.html?edicao=34039&t=resultados (accessed on February 27, 2023).

Table 4 displays the results for the ARs, considering the three income groups, with and without the 50% discount from social tariffs, and with the predefined grant by BNDES and the auction price, according to the consumption per capita estimated by BNDES - 155 lpcd for Alagoas and 150 lpcd for Rio de Janeiro. The Brazilian Bank estimated a higher volume for informal areas, i.e., the AR results will be worse if its consumption estimative materializes in those neighborhoods.

A comparison of the two first columns of Table 4 with the two last ones shows that the auction price may negatively impact affordability ratios, especially for low-income families. Despite social tariffs, the burden on families in extreme poverty (*Bolsa Família* beneficiaries) reaches 10% in Alagoas and 9.8% in Block 2 of Rio de Janeiro.

There is no consensus on the affordability threshold worldwide, and researchers have suggested considering local socioeconomic context (Andres et al., 2020; Fagundes et al., 2023; Hoque and Hope, 2020; Kessides et al., 2009). Considering The World Bank's 5% WSS threshold, families in extreme poverty would face affordability issues in all case studies, and low-income families in Rio de Janeiro block 2 would face it even with social tariffs. In the absence of social tariffs (third column), low-income user groups in all blocks would struggle to pay their WSS bills, leading to the conclusion that social tariffs must reach all vulnerable households since, otherwise, it might harm access to WSS and

[7] Available at <https://www.ibge.gov.br/estatisticas/sociais/trabalho/22827-censo-demografico-2022.html?edicao=37225&t=resultados>.
[8] Available at < https://sidra.ibge.gov.br/home/pnadcm>.

Table 4
AR results with BNDES Average Water Consumption.

Case study	User group average income[a]	AR, with auction price by BNDES (%)	AR, with auction price by BNDES + Social Tariff[b] (%)	AR, with winner auction price (%)	AR, with winner auction price + Social Tariff[b] (%)
Alagoas, Block A	State Average Income	4.3	Na	6.3	na
	Bolsa Família beneficiary	13.7	6.8	20.0	10.0
	½ Minimum wage	6.6	3.3	9.7	4.9
Rio de Janeiro, Block 1	State Average Income	2.8	Na	3.5	na
	Bolsa Família beneficiary	11.5	5.7	14.3	7.2
	½ Minimum wage	7.5	3.8	9.4	4.7
Rio de Janeiro, Block 2	State Average Income	3.4	Na	4.8	na
	Bolsa Família beneficiary	13.8	6.9	19.6	9.8
	½ Minimum wage	9.1	4.5	12.9	6.4
Rio de Janeiro, Block 4	State Average Income	2.9	Na	3.2	na
	Bolsa Família beneficiary	11.6	5.8	13.1	6.6
	½ Minimum wage	7.6	3.8	8.6	4.3

[a] *Bolsa Família* beneficiary and ½ Minimum wage represent average income per capita.
[b] Social Tariff is assumed to be 50% of the regular tariff.

Table 5
AR results with WHO Water Consumption.

Case study	User group average income[a]	AR, with auction price by BNDES (%)	AR, with auction price by BNDES + Social Tariff[b] (%)	AR, with winner auction price (%)	AR, with winner auction price + Social Tariff[b] (%)
Alagoas, Block A	State Average Income	2.8	Na	4.1	na
	Bolsa Família beneficiary	8.8	4.4	12.9	6.5
	½ Minimum wage	4.3	2.1	6.3	3.1
Rio de Janeiro, Block 1	State Average Income	1.9	Na	2.4	na
	Bolsa Família beneficiary	7.7	3.8	9.5	4.8
	½ Minimum wage	5.0	2.5	6.3	3.1
Rio de Janeiro, Block 2	State Average Income	2.3	Na	3.2	na
	Bolsa Família beneficiary	9.2	4.6	13.1	6.5
	½ Minimum wage	6.0	3.0	8.6	4.3
Rio de Janeiro, Block 4	State Average Income	1.9	Na	2.2	na
	Bolsa Família beneficiary	7.7	3.9	8.7	4.4
	½ Minimum wage	5.1	2.5	5.7	2.9

[a] *Bolsa Família* beneficiary and ½ Minimum wage represent average income per capita.
[b] Social Tariff is assumed to be 50% of the regular tariff.

contribute to default rates (included in the contractual goals for private providers). Moreover, the 50% discount is not enough for families in extreme poverty, as shown by the AR results for *Bolsa Família* beneficiaries.

Some practitioners and researchers have highlighted the importance of AR calculation for full cost recovery tariffs considering a minimum volume for a regular life (Martins et al., 2019; Reynaud, 2016) since over or underconsumption should not be encouraged by tariff structure (Pinto and Marques, 2016). Researchers have proposed AR analyses with different volumes per capita, which can vary among local environmental, cultural, and socioeconomic conditions, but they usually follow WHO recommendations. Based on that, the same analysis but with 100 lpcd (Table 5) was conducted to investigate the tariff's affordability.

Although better than the previous situation, the last column of Table 5 indicates that the social tariff discount is insufficient for families in extreme poverty, even with lower consumption, especially in Alagoas and Rio de Janeiro Block 2. The situation with no social tariff remains negative for all low-income households, as shown in the third column. Furthermore, if the auction price were equal to the BNDES predefined one, affordability issues would not be a concern in any of the blocks as long as social tariffs were applied.

As addressed elsewhere, both states have limits on the number of households with access to social tariffs in their concession contracts. Although increases of 8.5% for Alagoas and 5% for Rio de Janeiro are not forbidden, they demand a contract rebalancing, leading to average tariff adjustments, an extension of the concession term, or another type of compensation.

A second phase of affordability analysis, gathering socioeconomic information from national public data, was then run to identify the strength and importance of the impact on the states. Table 6 shows the main socioeconomic characteristics of the case studies regarding their poverty situation. The available data refer to the whole state (except for "Households in low-income settlements in the capital" and "Urban low-income families with updated registration"); therefore, the number for the blocks is smaller.

The Brazilian energy sector has a consolidated and robust social assistance program through social tariffs (Law no. 10,438 of April 2022),[9] and the income line for the benefit is half of the minimum wage per capita. Table 6 also shows that the number of urban low-income families in both states surpasses 1 million, i.e., concerning the municipalities incorporated in the blocks, new private operators will have to

[9] Rules available at https://www.gov.br/aneel/pt-br/assuntos/tarifas/tarifa-social.

Table 6
Socioeconomic characteristics of the case studies.

Socioeconomic Characteristics	Alagoas	Rio de Janeiro
Households with *Bolsa Família*[a] (%)	21.3	4.2
Urban low-income families with updated registration (<1/2 minimum wage per capita)[b] (no.)	204,250[d]	1,539,096[d]
Households in low-income settlements[c] (%)	6.68	12.63
Households in low-income settlements in the capital[c] (no.)	55,152	453,571

[a] Source: PNADc, 2021: https://www.ibge.gov.br/estatisticas/sociais/trabalho/17270-pnad-continua.html?edicao=34039&t=resultados (accessed on February 27, 2023).
[b] Source: CADÚnico, 2022: https://cecad.cidadania.gov.br/tab_cad.php (January 2024 data, accessed on March 18, 2024).
[c] Source: IBGE, 2019: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/tipologias-do-territorio/15788-aglomerados-subnormais.html (accessed on January 16, 2023).
[d] Only the cities within the blocks, according to biddings' documents, were analyzed here.

deal with a substantial number of low-income families who may struggle to afford regular WSS bills. Households in low-income settlements are also a permanent issue in Brazilian Metropolitan areas, such as Maceio and Rio de Janeiro, as noticed by their number in both cities, which exceeded 500,000 in 2019 as estimated by the IBGE before the COVID-19 pandemic.

The bidding documents produced by BNDES remarked on the irregularity of service areas, the need for investments, and the implementation of social tariffs in both states, especially in Rio de Janeiro. Nevertheless, no detailed affordability analysis supporting the established percentage limits of households under social tariffs has been identified. In the Rio de Janeiro auction, the proposal of improvement to 5% of total households was celebrated since it was compared with the existing 0,54%, previously criticized by the National Brazilian Association of Regulatory Agencies - ABAR (Galvão Júnior et al., 2018). Considering data from SNIS 2021, urban low-income families expressed in Table 6 represent 54% and 36% of the total connections for Alagoas Block A and Blocks 1, 2, and 4 in Rio de Janeiro, respectively. In addition, Census 2022 provides enough information to conclude that urban low-income families represent 37% and 29% of total households in Alagoas Block A and Blocks 1, 2, and 4 in Rio de Janeiro, respectively. This simple calculation demonstrates that neither BNDES nor private companies conducted social and economic studies before setting the limits for households with social tariffs.

This research has some limitations. Since the BNDES referential cash flow model was adopted, the business model might be slightly different case by case, especially regarding the assumptions of expenditures and consumption. For example, private WSS providers might have adopted optimistic efficiency improvements (leading to greater savings on operational expenditures) or population growth (leading to an overestimated demand) over contract terms in their cash flows, enabling them to raise the auction prices. Nevertheless, the authors believe those efficiency levels are not that different from the BNDES referential cash flow since the Bank already estimated an average reduction of 50% in energy costs and 70% in human resources (comparing the proportion of these costs in OPEX in SNIS, 2021 and the proportion considered by BNDES in the OPEX of referential cash flow), and goals for non-revenue water as low as 25%. In some cities in Rio de Janeiro state, the referential cash flow model from BNDES considered only water revenue, and the same referential cash flow available for bidders was adopted in this study. The number of households in extreme poverty (*Bolsa Família* beneficiaries) for each state in Table 6 includes both rural and urban zones, which affects the number of households the private operators are responsible for, since the concession contracts do not include rural areas.

As addressed elsewhere, mayors and governors have the role of deciding the application of auction prices. Nevertheless, in the function of the socioeconomic condition in Alagoas and Rio de Janeiro, the ambitious goals of the recent WSS concession contracts, and the cities left on state-owned companies or local providers, the budget should be sued, at least, for universalization, relying on affordability analysis or focused on low-income localities. The fact that, in practice, neither the state nor the municipalities must allocate the grant to the WSS sector may transform an essential but unsolved sector into a financer one, which, in our opinion, makes no sense.

Private operators are known for their flexibility, innovation, know-how, and adequate provision of services. This paper is not a criticism of privatization but of the privatization process in Brazil. The objective of the private entities cannot simply be to sign the contract but to be sustainable over time. Public entities should elaborate on auction terms to avoid unnecessary early renegotiation. Despite renegotiation of contracts being possibly desirable due to the inevitable incompleteness of concession contracts, empirical evidence has shown that renegotiations often end up increasing concessionaire satisfaction and decreasing the welfare of the public party, primarily due to information asymmetry (Cruz et al., 2015; Guasch, 2004). Although responsible for contract renegotiation in Brazil, the first WSS auctions conducted by BNDES did not include water regulators' perspectives, leading to concession models in which auction prices are allowed as part of tariff-generated revenues. The four contracts analyzed in this paper possess specific rules for tariff revision, and the winner grant is not one of them. However, during contract renegotiation for any other reason, including auction prices on cash flow, is not explicitly forbidden. Regulators should be allowed to disallow them as regulatory costs, although the situation would be tricky since the government is promoting such auctions, allowing companies to offer grants irresponsibly.

Affordability analyses should be mandatory and robust, especially in low-income states such as Alagoas. The approaches for low-income areas and users in both states' auctions seem very superficial despite the high number of informal settlements in Rio de Janeiro, rural areas, and low-income families in Alagoas. As addressed elsewhere, universalization goals include the rural population, and the fact that concession contract areas have excluded rural zones and limited solutions for low-income users (as a predefined amount of investments for settlements in Rio de Janeiro and a percentage of social tariffs) transfer the responsibility for WSS universalization in the most challenging areas to the weaker stakeholder, i.e., municipalities. Law no. 14,026 of 2020 provides two solutions: extending concession contracts' scope with tariff review toward new investments or a different local provider. Neither appears to have economic, financial, and technical sustainability or a low impact on families' income, considering the billionaire auction prices, investments, and the number of medium and low-income users.

Besides the simplification and assumptions made in this study, the main message is that billionaire auctions such as the last ones in Brazil substantially impact families' expenditures and should not be celebrated. In addition, the BNDES should re-evaluate its bidding methodology and include post-auction analyses of the winner's business model, its long-term sustainability, and its impact on affordability, avoiding abnormal offers. These assessments (pre and post-auction) must include water regulators, who possess the expertise and are the entities responsible for contract renegotiations. Moreover, in our view, BNDES should never finance auction prices since they would lead to considerable interest payments to which society has not consented.

5. Conclusions

Governments, regulators, and utilities (publicly or privately owned) should not forget that water supply and sanitation are essential public services, implying obligations, such as universal and affordable access to every user. The best approaches to achieve that vary according to the local reality; however, they will always require strong coordination among service efficiency, affordability, and financial and social policies.

As warned before, billionaire auctions have aroused politicians' interest in WSS privatization aiming at fiscal balance. However, that cannot be the primary purpose of increasing private sector participation, especially in a country with high economic disparities, such as Brazil. Water and sanitation are considered human rights by the United Nations, and their universalization at an affordable price should be one of the main objectives of governments, regardless of provider ownership. The success of a public service concession should be evaluated after its termination, considering the quality of service provided, investments made, and average tariff and its impact on the household's budget, translated to physical and economic access.

As observed in the affordability analysis, the auction prices of the case studies negatively impact family budgets, especially those in extreme poverty, even with a 50% social tariff discount. WSS providers should review the discount for the most vulnerable families, based on affordability estimation, and ensure all low-income households have access to that benefit. The recent WSS law goals include total population, but the concession contracts involve neither rural areas nor 100% of the irregular ones, thus leaving the most challenging zones for public administration, which leads the authors to conclude that universalization, the main objective of the sector reform, will not be achieved on time.

Despite two recent auctions relying on lower tariffs (for wastewater services in Cariacica, Espírito Santo) and lower public payment (for wastewater services in Ceará State), BNDES has still promoted studies considering the highest auction price as the bidding criterion. The criteria for auctions of essential services that rely on tariffs should be only technical and based on customers' affordability. Moreover, private companies must conduct deep affordability analyses of the viability of their projects over the years, considering the population's average income does not increase as fast as tariff raises to fund all the investment required for universalizing the WSS in medium and low-income countries with a gap of infrastructure access, such as Brazil.

Infrastructure auctions should also include a post-auction analysis relying on the auction price's impact on tariffs and the economic and financial viability of the project, thus decreasing the probability of early contract renegotiation, a harmful but common action where the regulation is not consolidated and robust enough (Guasch et al., 2008; Marques, 2016; Marques and Berg, 2011). BNDES should consult water regulators from the beginning of the auction process and propose a framework for post-auction analyses and potential contract renegotiation, taking impacts on tariffs and service affordability into account.

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CRediT authorship contribution statement

Thalita Salgado Fagundes: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Rui Cunha Marques:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Tadeu Fabrício Malheiros:** Writing – review & editing, Supervision.

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.

Data availability

No data was used for the research described in the article.

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