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Research Paper

Subsidies and affordability: a social approach to water supply tariffs

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ABSTRACT

This study provides evidence of targeting the performance of subsidies and affordability of water supply services (WSS) in a low-income society marked by disparate socioeconomic indicators. We used sample microdata from the local census regarding income, as well as information about price, tariff structure, water consumption, distribution of consumer units by billed volume ranges, and the average cost of WSS by the service areas (SA) in the Federal District, Brazil, in 2019 and 2020/2021, periods in which there was a transition from the tariff methodology. The results showed average water consumption of 108 L.inhabitant^{-1}. day^{-1} and 399 L.inhabitant^{-1}. day^{-1} in the lower and higher-income areas, respectively. Customers with a monthly consumption of less than 27 m^3 were subsidized in both tariff cycles. The distribution of subsidies was regressive according to the connection and consumption index in the SA of lower income. Approximately a quarter of the families in the lowest income regions commit more than 3% of their income to consume water in the lifeline block of the WSS tariff structure. Findings also indicate that poorer households headed by women with children are more likely to have water poverty problems.

Key words: basic sanitation, consumer accessibility, water poverty, water tariff

HIGHLIGHTS

- Water tariff methodology as an exercise in balancing multiple objectives is exceptionally challenging in societies marked by disparate socioeconomic indicators.
- Subsidies in the water service tariff structure in the Federal District of Brazil are regressive.
- Almost 25% of the lowest income households face water poverty even in the lifeline block of water consumption.

INTRODUCTION

Drinking water and sanitation were formally recognized as human rights by Resolution 64/292 of the United Nations (UN 2010). This right is based on principles such as sufficiency, safety, acceptability, physical accessibility, and affordability, and it is up to the state to respect, protect, and ensure the provision of the service, with no obligation to provide it free of charge. Providing water supply services (WSS) or water and sewage services implies an economic cost for the continuity of the activity but also requires the safeguarding of equity principles and affordability (Vanhille *et al.* 2018).

The increasing blocks tariff (IBT) structure is said to promote rationality and equity when charging for water and sanitation services (Boland & Whittington 1998; Lu *et al.* 2019) and has been largely adopted worldwide, particularly in low- and middle-income countries (Whittington *et al.* 2015; Fuente *et al.* 2016). Additionally, subsidy policies are recommended as financial support tools to improve accessibility for disadvantaged population groups (Dalhuisen & Nijkamp 2002). However, the efficiency of these tools is highly dependent on the technical parameters of the tariff structure (volume and prices of each consumption block) and on the socioeconomic profile of communities.

Based on the positive correlation between income and water consumption, groups with higher income will indirectly subsidize the consumption by the poor in the IBT structure, since the water volume they use is in higher blocks (and prices) of the tariff structure. It is defined that there is progressiveness in the subsidy distribution if the poor have the largest share of the total benefits granted. If not, the distribution of subsidies is said to be regressive (Komives *et al.* 2005). The results obtained by Komives *et al.* (2005), Angel-Urdinola & Wodon (2007), Whittington *et al.* (2015), and Fuente *et al.* (2016) show regressivity

or low progressiveness in the application of the IBT structure, even when subsidies are applied. This might have happened due to the lack of access to private connections of WSS among poor users and due to the reduced number of large users capable of providing subsidies.

Targets 6.1 and 6.2 of the Sustainable Development Goals aim to achieve universal and equitable drinking water for all by 2030. In addition to physical accessibility, affordability is key in monitoring the achievement of Targets 6.1 and 6.2. It is not possible to assess the fulfillment of the human rights to water and sanitation without this element (UNICEF & WHO 2021).

Analysis of economic affordability of WSS includes the definition of an indicator to measure the limits of a family income commitment that is acceptable (Smets 2009; García-Valiñas *et al.* 2010). However, the literature does not show unanimity or even reasonable convergence in the definition of what could be an unaffordable water price (OECD 2003; UNDP 2006; Smets 2009; García-Valiñas *et al.* 2010; Reynaud 2010; Martins *et al.* 2016; Vanhille *et al.* 2018).

Clearly, the problem of economic affordability is more significant when analysis focuses on extreme values of costs or income, given these variables are highly influenced by the demand of high-volume consumers (Teodoro 2018). Economic affordability has its greatest impact in communities that have difficulties in accessing WSS even at the level of essential needs.

It is also important to investigate who are the people most likely to be impacted by issues of affordability. Analyzing the profile of communities impacted by affordability issues is relevant to building target public policies that could compensate for inequity issues (Reynaud 2010; Martins *et al.* 2016).

In 2020, Brazil approved a broad update in its Federal Policy on Basic Sanitation (Law 11,445/2007) through the publication of the New Legal Framework for Basic Sanitation established by Law 14,026/2020. The new legal framework did not embrace water and sanitation as a human right but rather prioritized the economic and financial sustainability of water utilities to increase the participation of the private sector. Being a country marked by unequal income distribution, economic affordability of public services is crucial for the society's well-being. This work analyzes the role of subsidies in WSS tariff structures and respective economic affordability in societies marked by socioeconomic disparities. The proposed methodology is applied to communities in the Federal District of Brazil (FDB), a typical metropolitan area in the country.

Even though physical accessibility to WSS is close to universalization in the FDB, subsidies' impacts and the issue of affordability still need to be investigated. Analysis of subsidies and conditions of affordability may clarify the social effects of tariffs to promote equity by means of charging mechanisms for these services. The study aims to investigate if the current subsidies' strategy used in the FDB is in fact promoting the necessary conditions of affordability in regions where physical access to water is already in place.

DATA AND METHODS

This section presents the main activities in the methodology to analyze the performance of WSS subsidies and to predict whether a household is below the poverty line.

The data used are the water utility tariff structure, residential water consumption, number of household units in each water volume range of the IBT framework considering the WSS tariff structure in force in 2019 and 2021, and the average costs of public WSS. This data set was combined with socioeconomic and demographic information from a local household survey.

The subsidies' analysis was based on Komives *et al.* (2005) and Angel-Urdiola & Wodon (2007). The parameter Ω was the product of the ratios of connection fee, subsidy beneficiaries, benefit incidence, and average amount of subsidized water consumed per unit to assess the tariff structure between the service areas (SAs) of high-income and low-income (Equation (3) in Supplementary Material (SM)) groups. The income groups were defined according to the average total family income per SA, in minimum wages (MW; 1 MW = US$ 224.5).

We applied a binary logistic model to identify the variables associated with the probability of water poverty occurrence (defined as income commitment greater than 3%) for consumption in the lifeline block of a tariff structure.

In SM, we present more detailed information about all the information needed. In Table S1 we present the main variables used, the definition, and the source of information.

RESULTS AND DISCUSSION

In 2019, the average monthly household income in the FDB was US$ 1,411.08 and increased to US$1,441.18 in 2020. However, income distribution varied significantly among SAs. Plano Piloto, Sudoeste/Octogonal, Jardim Botânico, Lago Norte, and Park Way SAs are home to 13% of the population and around 68% of their families had average incomes greater

than 20 MW (Figure 1(a)). Conversely, 50% of the families in the SAs Fercal, Recanto das Emas, Riacho Fundo II, Varjão, and SCIA have a monthly income of less than 2 MW.

Approximately 60% of the households in FDB consumed up to 10 m^3 per month in 2019. The percentages of household units in the lifeline block were the lowest in Plano Piloto, Sudoeste/Octogonal, Jardim Botânico, Lago Norte, and Park Way SAs (Figure 1(b)). Almost 13% of the WSS household units in Lago Sul SA consume more than 50 m^3 of water. The Lago Sul SA has the greatest average household income with extensive garden areas and a predominance of lawns. This same SA is the only one in which more than half of the household units consume more than 30 m^3 of water.

In 2020, after an update on the tariff structure, at least 59% of the units served by the Company of the Federal District (CAESB) had a reduction in the WSS price, as they consumed up to 7 m^3 per month. These units were within the previous lifeline block and with the tariff restructuring the price paid for the services had reduced. In the Fercal SA, around 48% of consumer units received such discounts.

In the tariff structure in force in 2019, users with consumption between 0 and 5 m^3, as well as those with consumption over 28 m^3, subsidized the WSS. This was due to the tariff rates applied to them being higher than the average cost of the services. In 2020, considering the connection fee and the price of the consumption blocks, users with consumption of more than 2 m^3 and up to 29 m^3 are subsidized. In both 2019 and 2020, 90% of WSS consumers were charged for up to 20 m^3 of water per month, and 2% of them, for more than 30 m^3. Given the significant number of units, the largest allocation of subsidies for the lifeline block is directed to Ceilândia SA.

The new tariff structure had no impact on the average water consumption patterns. Among the justifications was the perception of water as an essential good, by which there are basic needs to be met and for which there are no substitutes. Even if the price changes, the demand for water behaves inelastically. In the SA of Paranoá, Ceilândia, Samambaia, Santa Maria, and Riacho Fundo II, where the average family income is up to 3 MW per month, more than 80% of the consumer units were charged in the range of up to 20 m^3 in the two scenarios analyzed. Among SAs with a family income of more than 9 MW, at least 20% (in Jardim Botânico) and up to 62% of consumer units (in Lago Sul) were charged in water volume ranges above 20 m^3. These particularities of the higher- and lower-income groups indicate that behaviors originating in these SAs have a good chance of influencing the financial sustainability of the sanitation company given the great number of consumer units. Conversely, changes in tariff policy can affect social welfare or consumption levels in very different ways in these two groups of SA, given their socioeconomic inequalities.

The average per capita water consumption in the FDB was 140 and 136 $L{\cdot}inhab^{-1}{\cdot}day^{-1}$ in 2019 and 2020, respectively. In the SA Plano Piloto, Jardim Botânico, Lago Norte, and Park Way, the average per capita water consumption was 225 $L{\cdot}inhab^{-1}{\cdot}day^{-1}$, while in Lago Sul it reached 399 L $inhab^{-1}{\cdot}day^{-1}$. In Fercal, Ceilândia, Riacho Fundo II, Paranoá, and Itapoã, the per capita water consumption was 108 $L{\cdot}inhab^{-1}{\cdot}day^{-1}$ (Adasa 2022). Residential consumption by SA for the 2019 and 2020 periods is shown in Figure 3S.

In SA Plano Piloto and Sudoeste Octogonal, the predominant type of residence is high-standard apartments in 81 and 93% of observations, respectively, differing from Lago Norte, Lago Sul, and Park Way, whose areas have a very high construction standard, large residential lots, gardens, and at least one private pool. These SA are the only ones in the FDB where arboreal vegetation is present (Codeplan-Companhia de Planejamento do Distrito Federal 2018). Figure 2Sb shows the marked disparity of occupancy pattern in the FDB highlighting differences among SA Lago Sul, Plano Piloto, SCIA, and Fercal as a proxy for family income disparities.

The components of the Ω indicator (Equation (3) Supplementary Material) are shown in Table S1 for all SA in FDB. In the composition of the Ω indicator, apart from the connection rate, results in Table 1 show that this was influenced by the amount of subsidized water consumed and, consequently, the benefit incidence, over the observation period. Only Lago Sul and Park Way generated subsidies throughout the observation period, due to their high water consumption (refer to Figure 3S). Lago Norte, Jardim Botânico, Plano Piloto, and Sudoeste/Octogonal received subsidies for at least part of the period in which the new tariff structure was in force. Given the volatility of the incidence of the benefit, in this analysis, the Ω indicator was evaluated in the month of lowest water consumption. The connection rates in some of the low-income areas are lower than those in high-income areas (Table 1).

The regressivity of the Ω indicator was motivated mostly due to the connection rate for lower-income SA, such as SCIA and Fercal. Additionally, the amount of subsidized water consumption was higher in the higher-income regions, such as Lago Sul and Plano Piloto. Thus, even though there are a larger number of subsidized beneficiaries and more tariff discounts for them in Fercal and SCIA, the Ω indicator showed regressive results ($\Omega < 1$).

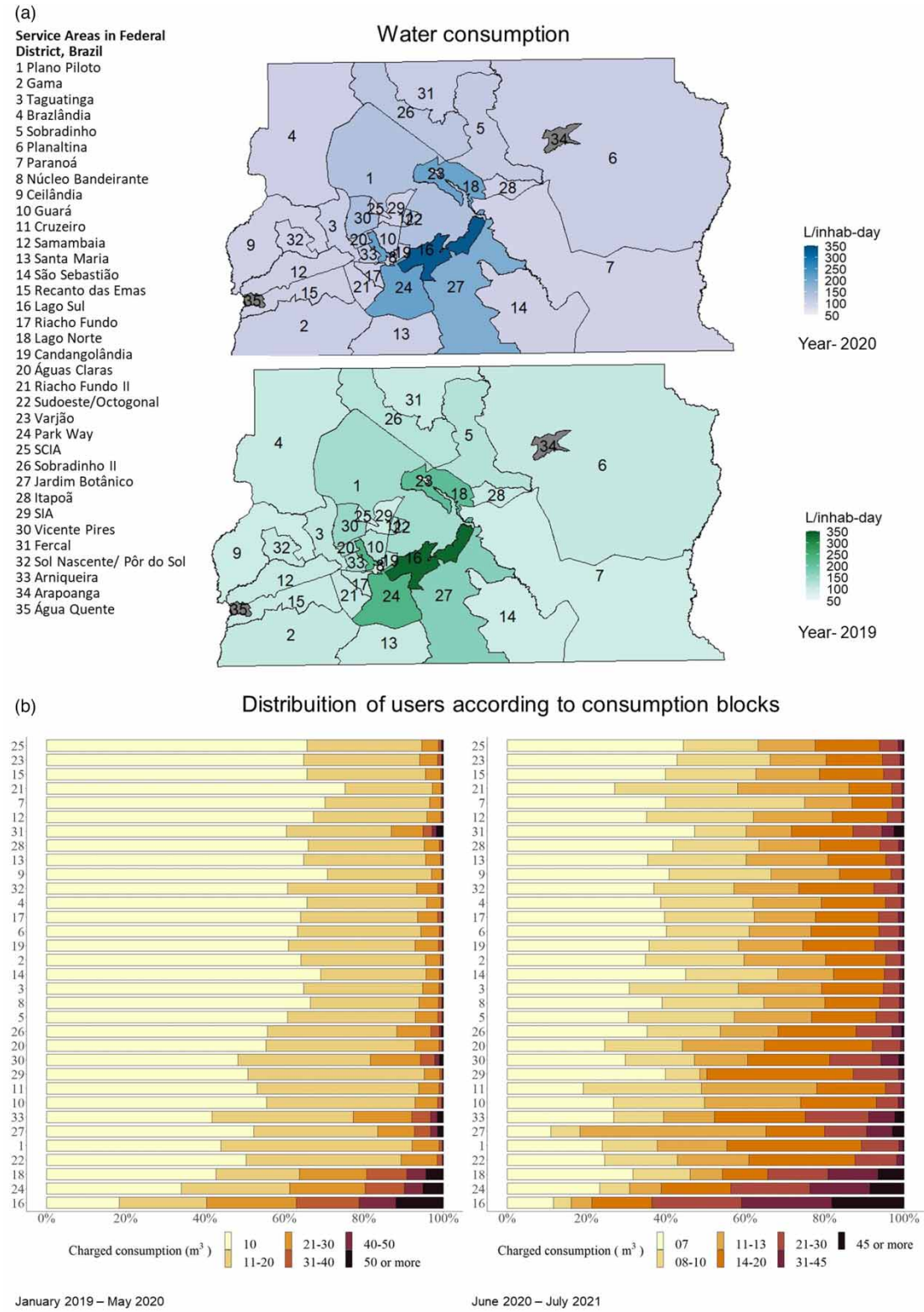

Figure 1 | (a) Estimated sample income per SA in the Federal District in 2020 and (b) percentage distribution of consumer units in the FDB by SA and by billed water volume ranges in 2019–2020 and 2020–2021. *Source*: (a) Based on ADASA (2022). (b) Based on data provided by CAESB's Corporate School in March 2022.

Table 1 | Ratio share for the segmentation of the components' connection, amount of subsidized water consumed, subsidy beneficiaries, and benefit incidence of the Ω indicator between SAs in the FDB

	Ratio share of				
	Omega Ω	**Connection (C_{LI}/C_{HI})**	**Amount of subsidized water consumed (Q_{LI}/Q_{HI})**	**Subsidy beneficiaries (B_{LI}/B_{HI})**	**Benefit oncidence (R_{LI}/R_{HI})**
SA – SCIA					
Ratio SA Plano Piloto	0.80	0.79	0.93	1.00	1.07
Ratio SA Lago Sul	1.35	0.80	0.74	2.00	1.13
SA – Paranoá					
Ratio SA Plano Piloto	0.66	0.92	0.60	1.05	1.14
Ratio SA Lago Sul	1.11	0.93	0.48	2.10	1.20
SA – Ceilândia					
Ratio SA Plano Piloto	0.92	1.00	0.79	1.04	1.12
Ratio SA Lago Sul	1.56	1.01	0.63	2.09	1.18
SA – Samambaia					
Ratio SA Plano Piloto	0.93	1.00	0.80	1.04	1.11
Ratio SA Lago Sul	1.57	1.01	0.64	2.08	1.17
SA – Recanto das Emas					
Ratio SA Plano Piloto	1.07	1.00	0.96	1.03	1.09
Ratio SA Lago Sul	1.82	1.01	0.76	2.06	1.15
SA – Riacho Fundo II					
Ratio SA Plano Piloto	0.87	0.99	0.74	1.04	1.15
Ratio SA Lago Sul	1.48	1.00	0.59	2.09	1.21
SA – Varjão					
Ratio SA Plano Piloto	0.94	1.00	0.83	1.03	1.10
Ratio SA Lago Sul	1.60	1.01	0.66	2.06	1.16
SA – Itapoã					
Ratio SA Plano Piloto	0.96	0.99	0.87	1.02	1.09
Ratio SA Lago Sul	1.63	1.00	0.69	2.04	1.15
SA – Fercal					
Ratio SA Plano Piloto	0.60	0.61	0.94	0.95	1.08
Ratio SA Lago Sul	1.01	0.62	0.75	1.91	1.13
SA - Sol Nascente/Pôr do Sol					
Ratio SA Plano Piloto	0.99	0.95	0.96	1.01	1.07
Ratio SA Lago Sul	1.68	0.96	0.76	2.02	1.13

Households in Lago Sul, Lago Norte, Jardim Botânico and Park Way received 3% of the subsidies granted for up to 20 m_3 and generated 45% of those for consumption greater than 30 m_3, but this consumer group represented only 5% of the total household units served by CAESB (2019). Between 2020 and 2021, these SA received 2.8% of the subsidies granted up to 20 m^3 and produced 29% of them given consumption of more than 30 m^3. Despite receiving a smaller share of subsidies, these users enjoy a greater amount of subsidized water than residents of other regions.

Analysis of the economic affordability of WSS services showed that the change in the tariff structure that took place in 2020/2021 was minimally effective in reducing the average income commitment for access to water. In 2019, the price of the lifeline block tariff represented 0.45% of the average monthly household income, while in 2020, this share decreased to 0.41%. The decreased share of household income was a result of the reduction in both the price and volume of the lifeline block under the 2020 tariff. Despite the price reduction, it is important to assess the tariff effects by analyzing income micro-data from the social groups served. Average family income does not reflect the incidence of water poverty problems.

Table 2 | Income groups in the FDB and family income commitment to water consumption under CAESB's standard tariff

Income groups	SAs	Total units	Units with social tariff (%)	Percentage of households with an income commitment of more than 3% for consumption of			
				7 m^3	10 m^3	20 m^3	30 m^3
1	SCIA	8,060	10.7	24.8	40.0	86.1	98.9
2	Varjão, Recanto das Emas, Riacho Fundo II, Paranoá, Samambaia, Fercal, Itapoã, Santa Maria, Ceilândia	393,556	3.4	14.8	30.1	72.6	92.7
3	Brazlândia, Riacho Fundo, Planaltina, Candangolândia, Gama	149,491	2.9	11.2	24.4	63.5	86.6
4	São Sebastião, Taguatinga, Núcleo Bandeirante, Sobradinho	162,497	1.7	5.5	13.8	46.0	71.6
5	Sobradinho II, Águas Claras, Vicente Pires, SIA, Cruzeiro, Guará	238,621	0.5	5.0	9.8	31.5	55.6
6	Jardim Botânico, Lago Norte, Sudoeste/Octogonal, Plano Piloto, Park Way, Lago Sul	189,759	0.1	2.8	4.5	12.7	25.3

Source: based on data provided by Codeplan (2018).

Therefore, the income commitment for monthly water consumption at levels of 7 m^3, 10 m^3, 20 m^3 and 30 m^3 was calculated (Table 2).

In the income group up to 2SM, almost a quarter of families were susceptible to water poverty, even for the lifeline block. The economic vulnerability of the population consuming 10 and 20 m^3 was even more evident. Although this level of water consumption exceeds the lifeline block, both levels of consumption might result from larger families, operational failures in the system (leakages) or age, and the use of domestic appliances (dishwasher, laundry, and other), so that extending observation of water poverty beyond the lifeline block illustrates a more reliable reality regarding the fragility of economic accessibility to water.

The conditions of socioeconomic disparity and income commitment among SA are clear. Around 30% of households in Ceilândia face income commitment above 3% for a monthly consumption of 10 m^3 of water, while in Plano Piloto this situation would reach only 4.5% of households. These discrepancies get worse as average consumption rises to levels of greater water volume (20 $m^3 \cdot month^{-1}$), even before reaching a scale of highest consumption volumes (above 30 $m^3 \cdot month^{-1}$).

The variables analyzed to verify the occurrence (or absence) of affordability problems in relation to WSS are presented in Table 3. Some characteristics related to the heads of households and to the household were significant predictors of the occurrence of water poverty problems. The results showed that education is positively correlated with income, so those with more years of schooling have a lower chance of facing affordability problems.

The other variables related to the heads of households associated with water poverty were brown or indigenous race/color and female gender. Women-headed households were 2.8 times more likely to face affordability problems than those in which the reference person was male. As for marital status, single people are more susceptible to water poverty than those living with a partner.

Increasing the number of people living in the same household by one reduces the chance of water poverty by 32% and having at least one elderly person in the family reduces the chance of facing affordability problems by 30%. The odds ratio (OR) for the elderly variable can be explained by possible access to retirement income or pensions.

The presence of children was an important factor in terms of affordability. Households with at least one additional child had a 49% increase in the chance of facing affordability problems. In the case of large families with few or no children, higher water consumption is to be expected, but there is an opportunity for these people to be economically active and contribute to the family income.

The subsidy distribution analysis suggests that the mechanisms present in a lifeline block tariff structure associated with IBT structure, even if applied to a population that has ample physical access to WSS, are susceptible to price and volume effects, with possible undesirable effects in terms of regressivity in the indirect distribution of subsidies among users, non-recovery of costs, and a lack of incentive to rationalize water consumption. Tariff methodologies that use a lifeline block or connection fee can generate some predictability of resources, but in the FDB, there are indications that the prices charged

Table 3 | Binary logistic regression results for the income commitment to access lifeline block of water greater than 3%

Variables	OR	CI 95%	*p*-value
Characteristics of heads of households			
Gender – Reference: Male			
Female	2.78	2.52–3.07	<0.001
Race/color – Reference: White			
Brown	2.84	1.45–5.42	0.002
Indigenous	1.14	1.02–1.26	0.017
Black	1.10	0.94–1.27	0.2
Yellow	1.14	0.8–1.60	0.5
Marital status – Reference: Married			
Single	1.27	1.14–1.41	<0.001
Separated	0.97	0.83–1.13	0.7
Widowed	0.81	0.68–0.97	0.026
Schooling – Reference: Literate			
Elementary School	0.70	0.43–1.15	0.2
High School	0.37	0.23–0.62	<0.001
Higher Education	0.12	0.07–0.20	<0.001
Household socioeconomic characteristics			
Number of people	0.68	0.65–0.71	<0.001
Elderly	0.70	0.64–0.77	<0.001
Children	1.49	1.38–1.60	<0.001

Note. Nagelkerke $R^2 = 0.190$.

by the company and the regulator in both 2019 and 2020/2021 caused dependance on external resources and failed to meet strategic objectives, especially regarding financial sustainability.

If the tariff model and prices are not sufficiently structured to the local socioeconomic reality, the lower-income population parcel will not receive the necessary support to guarantee minimum consumption, while the higher-income population will not have incentives to rationalize use in favor of both the financial and technical sustainability of the WSS.

The definition of the water tariff structure and the prices charged is an exercise in balancing multiple objectives (Pinto & Marques 2016; Vanhille *et al.* 2018) because, on the one hand, the tariff must seek economic efficiency, financial sustainability, and revenue generation so that the expansion and universalization of service is possible, and on the other hand, it must be economically accessible to its users. However, this research has shown that these objectives are exceptionally challenging in societies marked by such disparate socioeconomic indicators.

When the tariff requires that possible conflicts of interest be balanced to achieve the multiple objectives of a public supply system, regulators play a key role in assessing the scope of the tariff for the regulated company. For example, this scope can be geared toward economic efficiency or emphasize aspects of affordability. The tariff itself is not necessarily a multiple instrument, but rather a dynamic one, which must be permanently reviewed and restructured to achieve the objective(s) it proposes.

This work also raised attention to the fact that socioeconomic inequalities have a significant impact on affordability issues and that tariff structures are a powerful instrument to be used for the welfare of societies. So, defining what is accessible to a community marked by inequalities cannot be based on average data. The payment of WSS tariffs may represent a major effort for the lower-income population, even for volumes considered to be essential for survival and, to the extent that the population cannot afford the price of the services, the water utility itself will suffer the economic effects of nonpayment. Therefore, the provision of this service could include the supply of a minimally sufficient volume, but not equal for all families, to maintain personal and household hygiene conditions. Guaranteeing access to water is legitimate given its relationship with various health and human rights indicators.

As we have seen in this paper, household characteristics and income between groups are diverse and local problems are not necessarily related to service provision, but to coping with income problems. For now, the inability of average income information to characterize water poverty has been corroborated.

The explanation and analysis of the achievement of tariff objectives should be a constant exercise on the agenda of water utilities, regulators, and other state stakeholders, so that issues related to tariff policies and the consideration of viable affordability criteria for the Brazilian territory can mature.

This work did not investigate the impacts of COVID on water consumption or affordability. However, one could expect an increase in household water consumption due to the extended time that families stayed at home. On the other hand, the impact of COVID on average household income was expected, in this case, a negative impact, reducing the income of the families, especially those included in informal economic activities. Both issues could lead to a significant impact on issues related to water affordability or access, making it an important subject for future research.

CONCLUSIONS

This work presented a methodology to evaluate the efficiency of the IBT framework in societies marked by socioeconomic disparities. Income data and water consumption at the local level (households) were analyzed to evaluate the distribution of subsidies among water consumers. The logistic regression supported the analysis of variables influencing the affordability of water access. The methodology was applied to the FDB considering the WSS tariff structure in 2019 and 2021.

Due to the tariff structure characterized by using a price below what is necessary to recover costs, it was found that users with monthly consumption up to 28 m^3 are subsidized, i.e. they pay a price below the average cost of the service. For 2019, only 2% of consumers maintained consumption levels capable of subsidizing all other consumers, showing that the tariff structure in 2019 did not have mechanisms to support social initiatives (called 'pro-poor') usually defended when using the IBT structure.

Problems of affordability for the lifeline consumption block were not evidenced for average population incomes, since the impact of the lifeline block tariff on the part of the population with low income is masked by the high level of income of small groups of households.

The results of the methodology application, which can be extended to other locations that use the IBT tariff structure, suggest the need to develop, and reformulate the tariff model to avoid negative effects of socioeconomic disparities. As supply subsidies depend on factors related to price, costs, and limits of the water volume ranges, the necessary measure if the same tariff structure model is to be continued is to reformulate the limits for the first water volume range, for which the price must be at least equal to the cost of the service.

The definition of water demand subsidies applicable to consumers who are known to be economically vulnerable requires an agreement about acceptable consumption accessibility criteria and identification of vulnerability factors and consumption patterns in low-income societies. This set of information is still not widely available in the literature for sanitation regulators or companies. This is not a simple exercise, but it needs to be on the agenda of sanitation institutions (water utilities and regulators).

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Adasa – Agência Reguladora de Águas e Saneamento do Distrito Federal (2022) *Boletim de consumo de água*. Brasília, Distrito Federal. Available at: https://www.adasa.df.gov.br/ (Accessed: 8th August 2022).

Angel-Urdinola, D. & Wodon, Q. (2007) Do utility subsidies reach the poor? framework and evidence for Cape Verde, Sao Tome, and Rwanda, *Economics Bulletin*, **9**, 1–7.

Boland, J. J. & Whittington, D. (1998) The political economy of increasing block tariffs in developing countries. In: *World Bank Sponsored Workshop on Political Economy of Water Pricing Implementation*, Washington, DC, World Bank.

CAESB-Companhia de Saneamento Ambiental do Distrito Federal (2019) *Tarifas e preços*. Brasília, Distrito Federal. Available at: https://www.caesb.df.gov.br/tarifas-e-precos.html (Accessed: 10th January 2022).

Codeplan-Companhia de Planejamento do Distrito Federal (2018) *Pesquisa Distrital por Amostra de Domicílios*. istrito Federal: Secretaria de Estado de Fazenda, Planejamento, Orçamento e Gestão do Distrito Federal. Available at: https://www.codeplan.df.gov.br/ (Accessed: 10th January 2022).

Dalhuisen, J. & Nijkamp, P. (2002) Critical factors for achieving multiple goals with water tariff systems: combining limited data sources and expert testimony, *Water Resources Research*, **38** (7), 7.1–7.11. https://doi.org/10.1029/2001wr000841.

Fuente, D., Gatua, J. G., Ikiara, M., Kabubo-Mariara, J., Mwaura, M. & Whittington, D. (2016) Water resources research, *Journal of the American Water Resources Association*, **52**, 4845–4862. https://doi.org/10.1002/2015WR018375.

García-Valiñas, M. A., Martínez-Espiñeira, R. & González-Gómez, F. (2010) Affordability of residential water tariffs: alternative measurement and explanatory factors in southern Spain, *Journal of Environmental Management*, **91** (12), 2696–2706. https://doi.org/10.1016/j.jenvman.2010.07.029.

Komives, K., Vivien, F., Halpern, J. & Wodon, Q. (2005) *Water, Electricity and the Poor: Who Benefits From Utility Subsidies?* Washington, DC: The World Bank.

Lu, L., Deller, D. & Hviid, M. (2019) Price and behavioural signals to encourage household water conservation: implications for the UK, *Water Resources Management*, **33**, 475–491. https://doi.org/10.1007/s11269-018-2133-z.

Martins, R., Quintal, C., Cruz, L. & Barata, E. (2016) Water affordability issues in developed countries – The relevance of micro approaches, *Utilities Policy*, **43**, 117–123. https://doi.org/10.1016/j.jup.2016.04.012.

OECD – Organisation for Economic Co-operation and Development. (2003) *Social Issues in the Provision and Pricing of Water Services*. Paris: OECD Publishing.

Pinto, F. S. & Marques, R. C. (2016) Tariff suitability framework for water supply services: establishing a regulatory tool linking multiple stakeholders' objectives, *Water Resources Management*, **30**, 2037–2053.

Reynaud, A. (2010) Private sector participation, regulation and social policies in water supply in France, *Oxford Development Studies*, **38** (2), 219–239. https://doi.org/10.1080/13600811003753362.

Smets, H. (2009) Access to drinking water at an affordable price in developing countries. In: El Moujabber M., Mandi L., Trisorio-Liuzzi G., Martín I.,Rabi A. & Rodríguez R. (Eds.) *Technological Perspectives for Rational Use of Water Resources in The Mediterranean Region*, Bari: CIHEAM Options Méditerranéennes. Série A. Séminaires Méditerranéens. n. 88.

Teodoro, M. P. (2018) Measuring household affordability for water and sewer utilities, *American Water Works Association*, **110**, 13–24. https://doi.org/10.5942/jawwa.2018.110.0002.

UN – United Nations (2010) *Human Right to Water and Sanitation*. Genebra: UN. Document A/RES/64/292.

UNDP – United Nations Development Programme (2006) *Beyond Scarcity: Power, Poverty and the Global Water Crisis*. New York: PNUD.

UNICEF – United Nations Children's Fund - & WHO- World Health Organization (2021) *The Measurement and Monitoring of Water Supply, Sanitation and Hygiene (WASH) Affordability: A Missing Element of Monitoring of Sustainable Development Goal (SDG) Targets 6.1 and 6.2*. New York: UNICEF & WHO.

Vanhille, J., Goedemé, T., Penne, T., Van Thielen, L. & Storms, B. (2018) Measuring water affordability in developed economies. The added value of a needs-based approach, *Journal of Environmental Management*, **217**, 611–620. https://doi.org/10.1016/j.jenvman.2018.03.106.

Whittington, D., Nauges, C., Fuente, D. & Wu, X. (2015) A diagnostic tool for estimating the incidence of subsidies delivered by water utilities in low- and medium-income countries, with illustrative simulations, *Utilities Policy*, **34**, 70–81. https://doi.org/10.1016/j.jup.2014.12.007.

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