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Challenges and Strategies in Water Tariff Implementation: A Multi-Dimensional Analysis of Ecuador's Urban and Rural Sectors

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Abstract In Ecuador, potable water tariffs are set by Service Providers under the guidelines of the Water Regulation and Control Agency (ARCA), a critical component for ensuring sustainable water management. These tariffs consist of two components: 1) fixed tariffs are based on a basic monthly consumption which should at least cover the operational and maintenance costs (O&M) of the service; 2) variable tariff component is intended to recover the investment and fund repairs and expansions to increase geographic and demographic coverage and to improve water quality. This study analyzes whether basic consumption limits and the basic tariffs align with the population sizes and hydraulic flow rates of water supply systems, using mathematical equations governing their design. Linear regression analysis and the determination coefficient R^2 are employed to assess the relationship between population sizes, hydraulic flow rates and tariff settings. A positive linear relationship is hypothesized, reflecting an expected correlation between population sizes, flow rates, and O&M costs. However, the study finds weak correlations, with the highest R^2 being only 10.7%, suggesting that current tariff structures are inadequate for covering operational and maintenance costs. This insufficiency poses challenges to the sustainability of water services. Additionally, the analysis reveals that both small and large communities struggle with cost recovery due to billing practices that do not effectively address basic consumption limits, compounded by issues such as incomplete and delayed payments. These findings underscore the need for revised tariff structures and improved billing and collection strategies to ensure financial sustainability and equitable water service provision.

Keywords Potable Water, Tariffs Analysis, Sustainable Management

1. Introduction

The implementation of water tariffs in Ecuador faces significant challenges, in both urban and rural sectors. Despite the established legal frameworks and regulatory bodies, the practical application of these tariffs often fails to cover the operational, maintenance, and investment costs necessary for sustainable and efficient water services. This study aims to address key issues hindering effective water tariff implementation in Ecuador.

1.1. Water and Sanitation Situation in South America

A comparative analysis of water and sanitation legislation in South America reveals that, unlike countries like Chile, Colombia, and Peru, which set tariffs to cover comprehensive costs, Ecuador struggles with tariffs that do not even meet the basic operation and maintenance expenses. For instance, while Chile uses direct subsidies based on household income, Ecuador employs cross-subsidies influenced by geographical factors, leading to inefficiencies in coverage and service quality [1].

The Economic Commission for Latin America and the Caribbean (CEPAL) [2] has analyzed regulatory and tariff policies in the potable water and sanitation sector in Latin America and the Caribbean. In Ecuador, Potable Water Boards (JAAP) and Parish Boards provide potable water services when Cantonal Municipalities are unable to do so. Municipal Departments and/or Municipal Companies generally provide both potable water and sewerage services, while the former two usually only provide potable water, especially in communities and rural parishes lacking sewerage or wastewater treatment [3], [4].

1.2. Ecuadorian General Information

Ecuador's political division is structured with provinces as the largest unit, composed of Cantons (cities). Each Canton is divided into Urban and Rural Parishes. A Rural Parish includes Communities, while an Urban Parish contains Neighborhoods (Figure 1).

The Ecuadorian Water Regulation and Control Agency (ARCA) [5] mandates that water tariffs should be supportive, equitable, sustainable, and periodic. However, the current tariff structures often fail to reflect these principles, leading to a significant portion of unbilled water and inadequate revenue for proper maintenance and operation. The average unbilled water in Ecuador stands at 40%, highlighting a critical inefficiency in the system [1].

1.3. Tariffs for Drinking Water Service

Water tariffs in Ecuador do not adequately account for socioeconomic disparities. For example, households in lower socioeconomic strata, which typically have more members [6], face higher per capita costs, exacerbating economic inequalities. This study hypothesizes that current basic rate structures do not adequately cover operational and maintenance costs, primarily due to a lack of alignment with demographic and socioeconomic variables.

Tariff is an economic policy tool that encourages environmentally, socially, and economically sustainable and efficient water consumption [7]. These authors propose tariffs that reflect the value of water scarcity. Ahmed et al. [8] suggest water management strategies incorporating water metering and pricing to enhance water conservation and establish climate resilience measures in Islamabad. In Chile, higher rates in arid zones ensure resource sustainability. Fernández et al. [2] indicate that tariffs representing the unit values users must pay per household or per unit of water consumed and/or for wastewater discharged. Low tariffs may not cover service operating costs, leading providers to rely on alternative funding sources or reduce maintenance, impacting service quality and coverage. Dikgang et al. [9] argue that tariffs should integrate fairness, equity, cost recovery, efficiency, sustainability, and political feasibility, ensuring high-quality services are distributed equitably.

The tariff structure (Figure 2) is a combination of types of charges, user categories, and consumption blocks. The latter two aim to ensure that all users have access to the service regardless of their economic capacity and to encourage the preservation of water resources without compromising the financial stability of the service provider. Moreover, user types are generally divided into categories and subcategories for the application of what are termed differentiated rates [2]. In Ecuador, categories typically include residential, commercial, and industrial, often divided into subcategories based on consumption levels [10], [11]. Consumption blocks and user categories should be adjusted to better represent household monthly drinking water consumption (HMDWC), as observed in Chile [1]. In Scotland and some regions of England and Wales, water charges are determined by property size and value [9] which are associated with household size and economic capacity.

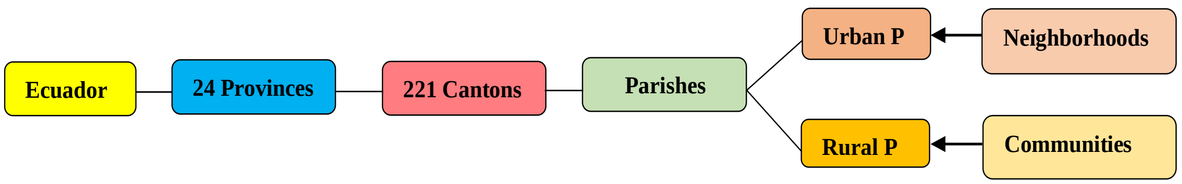

Figure 1. Ecuadorian Political-Administrative Division

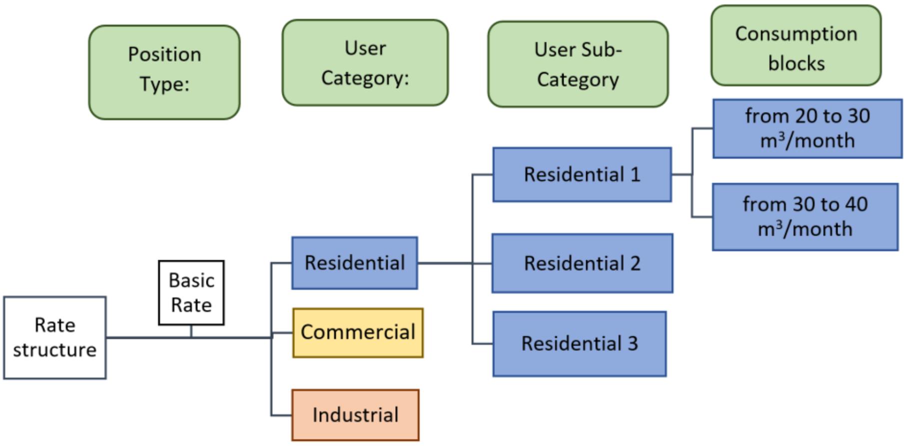

Figure 2. Rate Structure

Recent literature explores mathematical models linking tariff variables with HMDWC to ensure that increased consumption correlates with higher unit prices [12]. However, these models often neglect socioeconomic differences and demographic variations, leading to a mismatch between tariffs and actual consumption needs.

In South Africa, guidelines for setting retail water and sanitation tariffs include recommendations for Increasing Block Tariffs linked to marginal costs, aiming to meet social goals such as ecological sustainability and equitable water access. However, these guidelines have shortcomings, such as not specifying appropriate marginal cost references or defining minimum basic water demand levels [9].

In Ecuador, the tariff structure includes a "Fixed Charge" known as the "Basic Rate" (BR), established by the PWS Managers.

$$Tar = CF_{apysa} + \Sigma(VC_j * CV_{ij})_{ap\ y\ sa} \qquad (1)$$

Where:

Tar: Rate to be Paid (US Dollars)

VC_j: Volume Consumed within a Consumption Block, Expressed in Cubic Meters (m^3)

CF_{apysa}: Fixed Charge for Public Potable Water and Environmental Sanitation Services

CV: Variable Charge

i: Consumer Category

j: Consumption Block

ap: Potable Water Service

sa: Environmental Sanitation Service

The fixed charge (CF_{apysa}) must be paid with BR (expressed in US dollars/month) which assigns a price to a constant volume of water consumed in a month, named Basic Consumption (BC) (expressed in m^3/month). BR should cover operation and maintenance costs [1], [2], [13].

1.4. Ecuadorian Standards for Potable Water Systems (PWS)

Costs depend on PWS components such as water intake, conveyance, treatment, storage, and distribution [14]. Component sizing is calculated using formulas detailed in Table 1.

Table 1. Design Flows - Components of a PWS

Hydraulic Structures	Designs flows	Equation
surface water intake	$Q1 = 1.2\ Qmax.day$	(2)
groundwater intake	$Q2 = 1.05\ Qmax.day$	(3)
surface water conveyance	$Q3 = 1.1\ Qmax.day$	(4)
groundwater conveyance	$Q4 = 1.05\ Qmaxday$	(5)
distribution network	$Q5 = Qmax.día + Q$ fire	(6)
treatment plant	$Q6 = 1.1\ Qmax.day$	(7)

Source: Ecuadorian standards for study and design of potable water systems and wastewater disposal for populations exceeding 1000 inhabitants [15]

Where:

Q1: is the design flow rate for surface water intake, expressed in m^3/second.

Q2: is the design flow rate for groundwater intake, expressed in m^3/second.

Q3: is the design flow rate for surface water conveyance, expressed in m^3/second.

Q4: is the design flow rate for groundwater conveyance, expressed in m^3/second.

Q5: is the design flow rate for the distribution network, expressed in m^3/second.

Q6: is the design flow rate for the treatment plant, expressed in m^3/second.

Qmax.day: is the maximum daily flow rate, expressed in m^3/second.

Q fire: is the flow rate allocated for firefighting, expressed in m^3/second.

The dimensions of civil and hydraulic works for each component are proportional to the Maximum Daily Flow, which should be calculated as follows:

$$Qmax.day = Kd\ x\ Qmed \qquad (8)$$

Where:

Qmed: is the average daily consumption, expressed in m^3/second.

Kd: is the coefficient of variation for maximum daily consumption, ranging between 1.3 and 1.5 according to Ecuadorian regulations [15].

$$Qmed = q\ \ N/(1000x86400) \quad (9)$$

Where:

q: is the allocation provided by the Ecuadorian standard in ranges of values, expressed in liters per capita per day

N: is the town size (number of inhabitants)

Equations (8) and (9) are substituted into equation (2), then we have:

$$Q2 = \frac{1.2\ Kd\ q\ N}{1000\ x\ 86400} \quad (10)$$

The same can be applied to equations (3), (4), (5), (6), and (7) for sizing the hydraulic structures.

Kd and q are provided by the Ecuadorian standard, which fall within established ranges and can be considered constants. Therefore, design flow rates directly depend on the number of inhabitants (equation 10). Consequently, as the served population increases, component sizes and associated operation and maintenance (O&M) costs will also rise due to greater resource needs. Therefore, basic rates (BR) covering O&M costs will directly correlate with population size. In Islamabad, variations in household size have been observed. Additionally, tariffs are linked to O&M costs as well [8]. In the European Union, O&M costs of the irrigation sector are recovered through tariffs [16].

1.5. Socioeconomic and Demographic Information Considered

This study compiles BR information from 45 Ecuadorian towns of varying sizes as shown in Table 2.

Previous research has established well-defined socioeconomic strata (SES) in Ecuadorian towns and cities with populations up to 150,000 inhabitants. Consumption patterns vary by SES, influencing household water use. Strata 'A' is the 'highest' (with greater economic capacity); 'B' is termed 'upper middle', 'C' is 'lower middle', and 'D' is 'low' (with less economic capacity than the other three) [18]. Per capita drinking water consumption is not the same in each SES. Additionally, the lower strata have more people per family as shown in Table 3 [6].

In some very small towns, the 'A' SES does not exist. The household’s sanitary equipment (toilets, sinks, showers, basins, and washing machines) differs between each SES and town size [20], suggesting that basic consumption may be significantly different across the five demographic ranges. Consequently, it is expected that basic consumption per family will differ due to their distinct socioeconomic and demographic characteristics. Arellano et al. [20] analyze both the overall and individual correlations between potable water consumption and various factors. They reported a perfect correlation between per capita water consumption and sanitary equipment in large towns, a considerable correlation in medium-sized towns, and no correlation in small towns. They concluded that household per capita water consumption is higher with an increasing number of toilets. For example, a high SES family of three with four toilets will have higher per capita consumption than a low SES family of six with only two toilets. This peculiarity should be considered for targeted rate adjustments focused on the family unit so that those with lower economic capacity are charged less, ensuring they do not limit water use in compliance with ARCA policy. This variable should influence the definition of rates so that low-income families do not restrict water use because they cannot afford a high price due to their large family size, contradicting the Human Right to Water Sanitation (HRWS) [21] and the Goals for Sustainable Development: sixth (Clean Water and Sanitation), tenth (Reduced Inequalities), eleventh (Sustainable Cities and Communities), and twelfth (Responsible Consumption and Production) [22]. Sereno [21] also indicates that sometimes it is necessary to increase the service price, but subsidies should be considered for those groups who cannot afford it.

Table 2. Demographic Ranges

Range	1	2	3	4	5
Population	Very small	small	medium	large	Very large
inhabitants	< 500	500-8000	8000-30000	30000-150000	>150000

Source: Zuñiga et al. [17]

Table 3. Inhabitants per Household in Different SES

Socioeconomic Strata (SES)	Household Inhabitants average
D	5.660
C	4.795
B	4.336
A	3.940

Source: Izurieta et al. [19]

1.6. Objectives

This study aims to analyze the relationship between basic water rates and town demographics in Ecuador and to propose a method for assessing whether these rates cover the operational and maintenance (O&M) costs of public water systems (PWS). By examining data from 45 towns of various sizes, the research seeks to demonstrate that water rates should scale with town size and population to accurately reflect water service costs. This study identifies inefficiencies in Ecuador's water tariff system and offers recommendations for tariff structure adjustments to promote sustainable and equitable water service provision.

1.7. Scope

The results of this study will be useful for providers of potable water services, especially those in Communities and Parishes lacking resources from Cantons and technical assistance as reported by [23], [24] in low and middle-income developing countries according to the World Bank classification.

2. Materials and Methods

2.1. Sample Location

Figure 3 displays the provinces containing the sampled towns. Provincial boundaries are marked by lines, and the numbers within each province indicate the number of towns investigated. In Chimborazo Province, 18 samples were analyzed, while 8 towns were sampled in Pichincha.

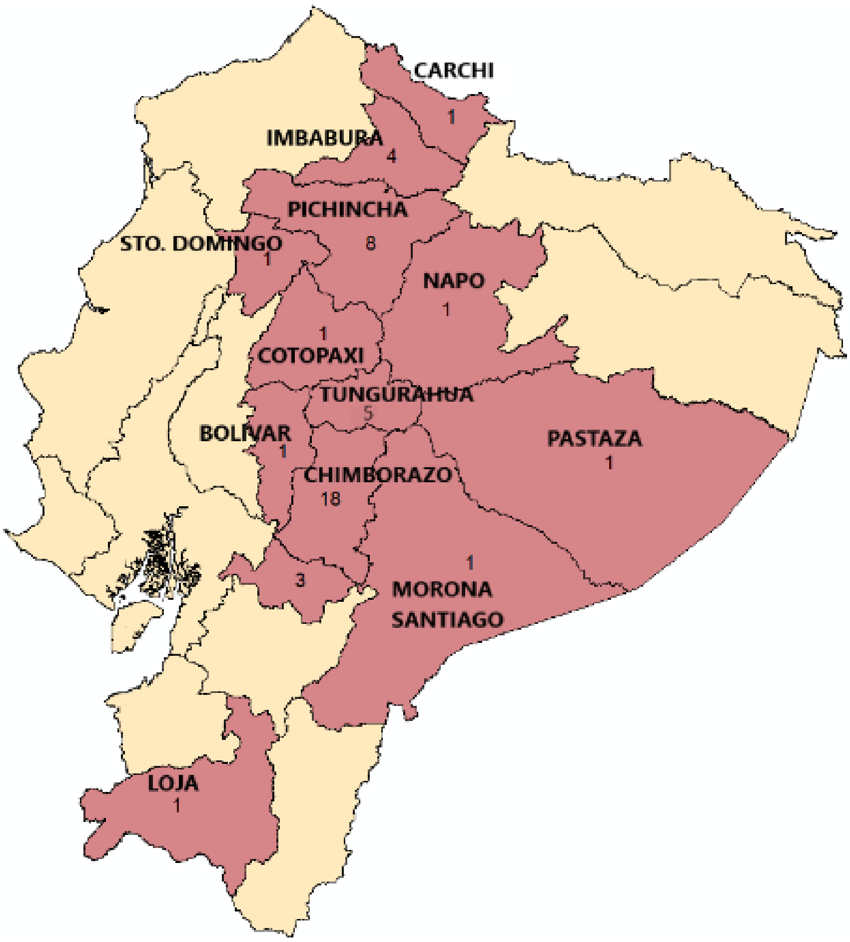

Figure 3. Towns and cities sampled in each province.

2.2. Data Processing

The household consumption database is sourced from 45 PWS providers which was also used by Zuñiga et al. [17] for analyzing consumption changes during the quarantine months of 2022 associated with the COVID-19 pandemic. This extensive dataset includes over 26 million monthly records for nearly a quarter of a million users across several years. Demographic data was obtained from the Ecuadorian Institute of Statistics and Census (INEC, 2010). The towns were randomly selected from three of the country's four regions: Coastal, Inter-Andean, and Amazonian.

2.2.1. Average Water Monthly Consumption (HMDWC) vs. Basic Consumption (BC)

Statistical analysis revealed patterns relating to these two variables, facilitating a comparison with the predetermined basic monthly limits consumption.

2.2.2. Analysis of Demographic Size vs. Basic Consumption (BC)

This study employs a linear regression model to explore the potential correlation between population size and the BC across the dataset [25]. The model's fit was evaluated using the coefficient of determination (R^2) which measures its predictive accuracy relative to the sample points. We hypothesize a positive linear relationship, anticipating that larger towns will require greater design flows for their PWS, encompassing collection, conveyance, treatment, and distribution. A significant finding is the high sample dispersion and clustering observed in populations under 100,000. This pattern warrants further analysis to understand its implications on water system design.

2.2.3. Analysis of Basic Rates (BR) and Town Sizes Divided into Five Demographic Ranges

This analysis replicates the initial approach by examining the correlation between the BR value and population size but refines the methodology by disaggregating the data from 45 towns into five demographic ranges as specified in Table 2. Each range is analyzed using a linear regression model, with model accuracy assessed via the coefficient of determination R^2.

3. Results and Discussion

3.1. HMDWC vs. BC across Different Town Sizes

Figure 4 compares HMDWC values with BC, revealing that consumption in small villages (Range 2), medium villages (Range 3), and large towns (Range 4) is 11, 14, and 20 m^3/month, respectively. Notably, in small towns, BC effectively meets HMDWC standards. For example, families consuming 11 m^3 are charged the basic rate, even if their usage does not reach the set limit of 12 m^3. This finding suggests that as long as historical HMDWC remains below the basic limit, the invoiced amounts are sufficient to cover O&M costs, provided that collections are effective and timely.

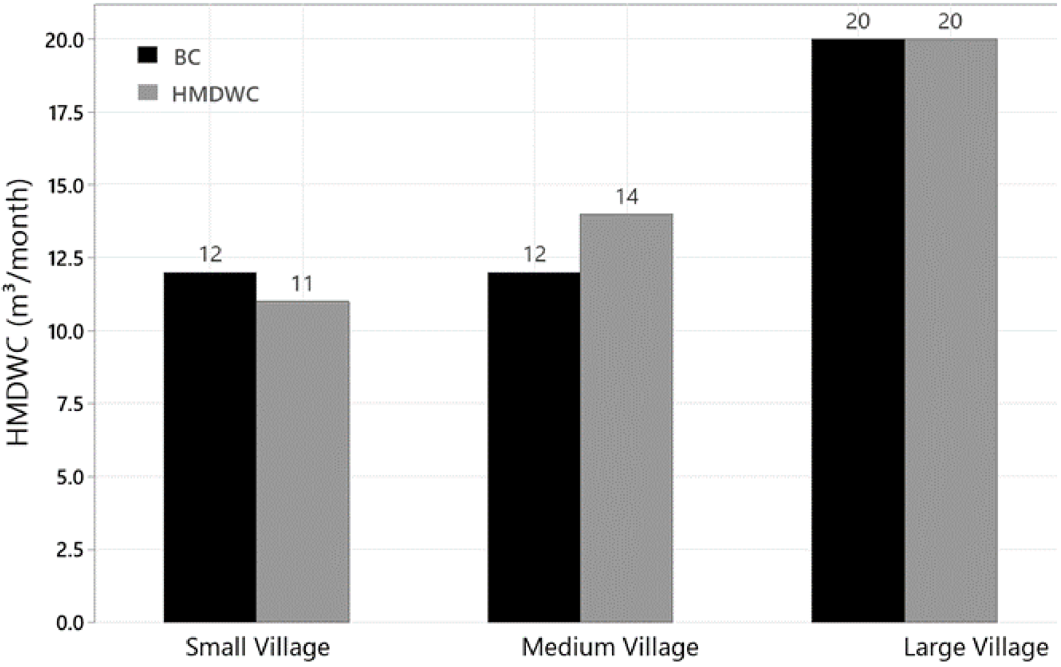

Figure 4. Comparison between HMDWC and Basic Consumptions (BC). Adapted from Zuñiga et al. [17]

In medium-sized towns, HMDWC typically exceeds BC, resulting in households paying both the fixed Basic Rate (BR) and an additional variable rate for consumption above BC (2 m³/month). In contrast, HMDWC in large towns closely aligns with BC, indicating a balance between usage and billing. However, the rate of uncollected bills is high in very small to medium-sized towns, often due to delays in service cutoffs. Larger towns, on the other hand, enforce service cutoffs more promptly, leading to better bill collection. Comparative analysis suggests that in both small and large towns, users may limit their HMDWC to avoid exceeding the basic consumption threshold set by their respective tariffs.

Extensive evidence indicates that pricing tariffs discourage water consumption, thereby reducing waste and facilitating a more equitable distribution among users [12], [26], [27]. However, when aiming to cover O&M costs through the collection of the basic tariff based on BC, a rigorous and up-to-date analysis of these costs and the tariff is necessary. Since HMDWC values are variable, both BC and BR should be reviewed and updated periodically.

3.2. Analysis of Population Size and Basic Consumption (BC)

Figure 5 presents a scatter plot of the population sizes of 45 towns on the X-axis. On the Y-axis are the Basic Consumption (BC) values stablished by each water provider in their tariffs. The majority of the data points are clustered between 10 to 20 m³/month, with only two towns exceeding 30 m³/month. The analysis reveals a weak correlation between population size and BC (determination coefficient R^2=0.055; F=3.18; p value= 0.082), suggesting a minimal direct relationship. Although there is a positive trend, it only provides limited support to the hypothesis that higher population sizes necessitate higher BC limits. This variability indicates that not all PWS providers proportionally increase the BC limits as population size increases. In larger towns, the demand for more extensive hydraulic infrastructure to meet increased water demands escalates operation and maintenance costs. According to Marques & Miranda [28], tariffs are political and contingent issues that do not allow for cost recovery. This may explain the lack of a logical trend between BC and the size of the villages.

The data in Figure 5 are highly dispersed and have been presented in this manner to highlight the need to categorize them into demographic groups in order to minimize generalizations in the analysis. For this reason, the data are presented grouped as follows.

3.3. Detailed Analysis of Basic Rate Variations across Demographic Ranges

Figure 5 illustrates that data points closely align with the linear model for populations under 100,000, prompting further data disaggregation by demographic ranges as outlined in Table 2. Subsequent analysis, depicted in Figure 6, plots Basic Rates (BR) in US dollars per month, against population sizes for each demographic range. Notably, BR tend to escalate with increasing population sizes in Ranges 1, 2, 3, and 5, although the strength of the correlation varies significantly.

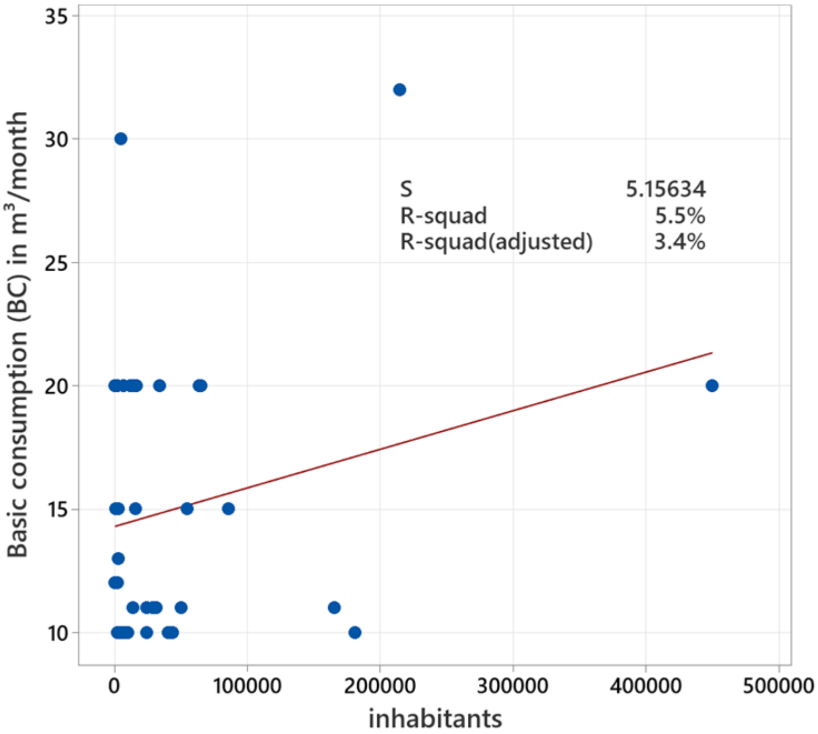

Figure 5. The ratio between the upper limit of basic consumption (m³/month) and demographic ranges (inhabitants)

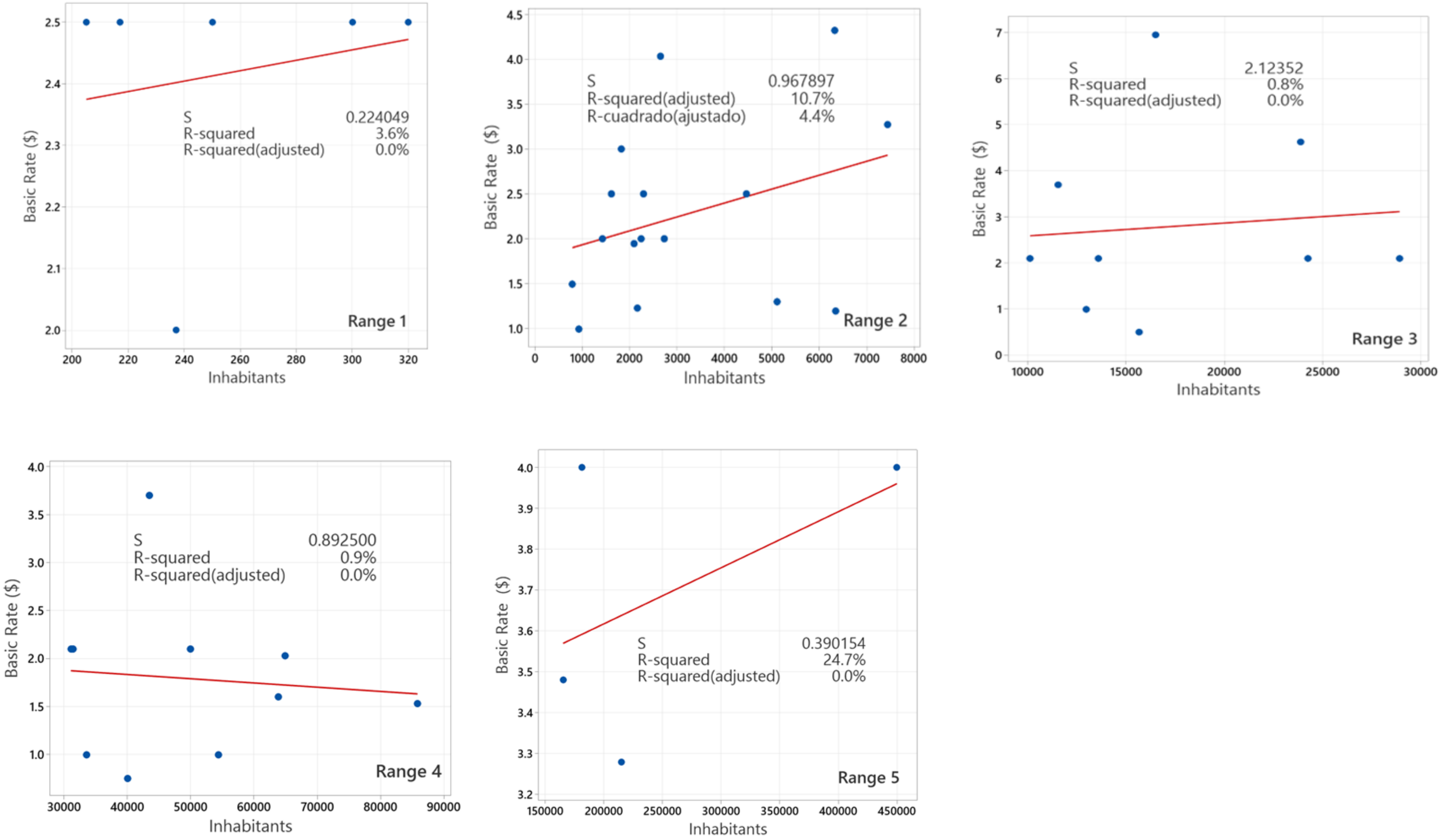

Figure 6. Base rates (BR) vs demographic ranges

In Range 1, characterized by populations ranging from about 200 to 320 inhabitants, there is a minimal correlation (R^2=0.036) primarily because five of the six samples maintain a consistent basic rate of $2.50 per month, irrespective of population size. The deviation by one sample, priced at $2.00, disrupts the potential for a constant rate trend. Despite small population increments, the expected increase in hydraulic infrastructure size—such as intake tanks, conduit pipes, and distribution networks—suggests that revenue generation should proportionally cover rising operation and maintenance costs.

Range 2 presents 16 samples with Basic Rates ranging from $1.00 per month to nearly $4.50 per month, covering populations from about 1,000 to 8,000 inhabitants. Most samples (12 out of 16) share a rate of $2.50 or less, similar to Range 1, but with a weak correlation (R^2=0.107). Conversely, in Range 3, where rates span from $0.50 per month to $7.00 per month across populations, no significant correlation is observed (R^2=0.008). The rate distribution in this range is highly variable, with one sample notably higher at $7 per month and others remaining below $2.50 per month, reflecting a lack of consistent relationship between demographic size and pricing.

In Range 4, among 9 samples, 5 have basic rates below $2.50. Uniquely, this range exhibits a negative correlation (R^2=0.009) between basic rate prices and increasing population sizes, suggesting a decrease in rates with larger populations, though the correlation is too weak to be deemed significant. Conversely, Range 5, which includes 4 very large city samples with professionalized service provision by Municipal Departments or Companies, shows a moderate correlation (R^2=0.247). Here, rates start slightly above $3 and ascend to $4 as the population increases, with no rates below $2.50 or reaching the $7.00 seen in Range 3.

Table 4 summarizes the key results (F and p-value) of the analyzed regressions.

Table 4. Summary of F and p-value Results in Regression Analyses

Range	F test	P Value
1	0.15	0,718
2	1.68	0.215
3	0.06	0.814
4	0.07	0.799
5	0.66	0.503

In the five regressions analyzed, there is no statistical significance between BR and demographic size, as the p-values from the F-tests are all greater than 0.05. Thus, the independent variables do not significantly affect the dependent variable in any model evaluated.

Ranges 1 and 2, typically small towns reliant on larger cantons for technical oversight, contrast with the more autonomous medium and large towns in Ranges 3 and 4.

The analysis across demographic ranges shows no consistent trend of a statistically significant relationship between BR and population size, suggesting that rate pricing may not systematically account for O&M costs, aligning with Marques et al. [28] assertion that prices are driven by political interests.

4. Conclusions

4.1. The Basic Consumption (BC) Observations

The basic consumption (BC) uniformly applies to all residential users, disregarding socioeconomic and demographic variations [10]. This approach not only promotes inequity but also potentially restricts water access for economically disadvantaged families while inadvertently subsidizing smaller households that typically consume less than BC [21], [26].

In some cities, households in the lowest socioeconomic stratum SSE “D” can outnumber those in the highest “A” by two-fold (Table 3). Therefore, BC should proportionally reflect design flows as written in Equation (10), to ensure they accurately mirror service demand and supply. The lack of a coherent correlation between BC and BR calls into question the effectiveness of ARCA's regulatory oversight, particularly in parishes and communities lacking technical expertise (from towns with less than 8000 inhabitants).

4.2. The Basic Consumption (BC) and Household Monthly Drinking Water Consumption (HMDWC)

In towns of various sizes, BC generally meets HMDWC. However, financial sustainability depends on timely user payments, which are crucial for covering O&M costs. In developing countries, the recovery of these costs is often suboptimal, raising concerns about the adequacy of funds collected, especially in medium (8000-30000 inhabitants) and large towns (30000-150000 inhabitants) [29].

4.3. Relationship between Basic Rates (BR) and Demographic Size

Basic rates lack correlation with both design flows and population size, leading to a misalignment with the operational needs of the infrastructure required [13], [26]. This discrepancy suggests an ineffectiveness in rate setting mechanisms that fail to consider actual service demands.

4.4. Family Structure and Subsidies

Current rate structures do not account for the socioeconomic disparities within family units. Consequently, less affluent families might unintentionally subsidize the water consumption of wealthier ones, perpetuating economic disparities in water access [30].

4.5. Legislation and Regulations

Regulations aiming to indiscriminately increase geographic coverage fail to address the socio-demographic divides that characterize service delivery. As a result, the least economically capable people, often residing in urban peripheries and rural areas, receive inadequate service coverage.

4.6. Unsustainability

The current billing structure begins with a fixed basic rate, intended to fund the minimum operational and maintenance needs. However, if this base rate is insufficient, funds are diverted from variable charges meant for system upgrades and repairs, compromising the financial sustainability needed to enhance service coverage and water quality [9]. The economic downturn caused by the COVID-19 pandemic underscores the need for a more resilient and equitable billing structure that prioritizes sanitary improvements, especially in developing countries.

Enhanced water service coverage should consider not just geographic but also socio-demographic factors, focusing on economically disadvantaged users to develop fair rates that do not strain their limited financial resources. Differentiated rates could be based on the number of sanitary fixtures, a proxy for water usage and socioeconomic status, allowing for a more equitable redistribution of costs.

This study's findings are pivotal for towns within the examined demographic ranges and those with similar characteristics, providing a framework for informed decision-making in water service management.

REFERENCES

[1] G. Donoso and M. E. Sanin, "*Critical Analysis of Policies Applied in the Water and Sanitation Sector in Latin America,"* Inter-American Development Bank, 2020. doi: 10.18235/0002263.

[2] D. Fernández, S. S. Matus, and M. Gil, "Regulatory and Tariff Policies in the Potable Water and Sanitation Sector in Latin America and the Caribbean 205 Natural Resources and Development," Santiago, 2021. [Online]. Available: www.cepal.org/apps

[3] M. G. Almendariz Miranda, "Impact of Wastewater on Residents and Producers, Izamba Parish, Ambato, Tungurahua," *Ciencia Latina Revista Científica Multidisciplinar*, vol. 7, no. 5, pp. 10663–10686, Dec. 2023, doi: 10.37811/cl_rcm.v7i5.8686.

[4] M. Pozo, J. J. Viteri, and L. M. Aprobado, "National Survey of Employment, Unemployment, and Underemployment (ENEMDU) - Water, Sanitation, and Hygiene (ASH) Module Methodological Document," Quito, 2019. Accessed: May 26, 2024. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ecuadorencifras.gob.ec/documentos/web-inec/EMPLEO/2019/Indicadores%20ODS%20Agua,%20Saneamiento%20e%20Higiene-2019/6.%20Documento%20metodologico%20de%20la%20operacion%20estadistica.pdf

[5] ARCA, Regulation-ARCA-RG-006. Ecuador: Water Regulation and Control Agency 12, 2017. Accessed: Feb. 04, 2023. [Online]. Available: http://www.regulacionagua.gob.ec/wp-content/uploads/downloads/2018/08/REGULACION-Nro.-DIR-ARCA-RG-006-2017.pdf#page=21

[6] C. Izurieta, A. Arellano, and G. Muñoz, "Demography and Drinking Water Consumption into the Urban Socio-Economic Strata," *FIPCAEC*, vol. 7, no. 31, pp. 809–829, Jun. 2022, doi: 10.23857/fipcaec.v7i1.552.

[7] G. Donoso and M. Molinos-Senante, "*Proposals for Chile: Public Policy Competition 2016*," vol. Capítulo V. Pontificia Universidad Católica de Chile, Centro UC Políticas Públicas, 2017. Accessed: Feb. 04, 2023. [Online]. Available: https://politicaspublicas.uc.cl/content/uploads/2017/04/Libro-Propuestas-para-Chile-2016_con-portada-8.pdf#page=158

[8] T. Ahmed, H. Sipra, M. Zahir, A. Ahmad, and M. Ahmed, "Consumer Perception and Behavior Toward Water Supply, Demand, Water Tariff, Water Quality, and Willingness-To-Pay: A Cross Sectional Study," *Water Resources Management*, vol. 36, no. 4, pp. 1339–1354, Mar. 2022, doi: 10.1007/s11269-022-03085-5.

[9] J. Dikgang *et al.*, "Insight into setting Sustainable Water Tariffs in South Africa," Johannesburg, Aug. 2019. [Online]. Available: www.wrc.org.za

[10] L. V. Giler Escandón, M. P. Sánchez Sarmiento, A. Mora Bernal, and M. Guerra Coronel, "Challenges in Providing Potable Water Public Services in the New Normal in Cuenca, Ecuador," *Con-texto*, no. 55, pp. 71–85, Jul. 2021, doi: 10.18601/01236458.n55.07.

[11] G. Ruiz, "Potable Water Service in China," in *XXIII Congreso Nacional de Hidráulica*, Puerto Vallarta, Jalisco, México, 2014. [Online]. Available: https://www.researchgate.net/publication/371305060

[12] M. Macchiaroli, L. Dolores, and G. De Mare, "Design the Water Tariff Structure: Application and Assessment of a Model to Balance Sustainability, Cost Recovery and Wise Use," *Water (Switzerland)*, vol. 15, no. 7, Apr. 2023, doi: 10.3390/w15071309.

[13] J. P. Truslove, A. B. Coulson, M. Nhlema, E. Mbalame, and R. M. Kalin, "Reflecting SDG 6.1 in rural water supply tariffs: Considering 'affordability' versus 'operations and maintenance costs' in Malawi," *Sustainability (Switzerland)*, vol. 12, no. 2, Jan. 2020, doi: 10.3390/su12020744.

[14] National Assembly of the Republic of Ecuador, Organic Law on Water Resources, Uses, and Exploitation. Ecuador: Official Register, 2014. Accessed: May 18, 2024. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.regulacionagua.gob.ec/wp-content/uploads/downloads/2016/03/Ley-Org%C3%A1nica-de-Recursos-H%C3%ADdricos-Usos-y-Aprovechamiento-del-Agua.pdf

[15] INEN 005-9-1, "Standards for the Study and Design of Potable Water Systems and Wastewater Disposal for

Populations Exceeding 1,000 Inhabitants," 1992, *Instituto Ecuatoriano de Normalización INEN, Quito*. Accessed: Jul. 13, 2022. [Online]. Available: https://archive.org/details/ec.cpe.5.9.1.1992/page/n43

[16] J. Berbel, M. M. Borrego-Marin, A. Exposito, G. Giannoccaro, N. M. Montilla-Lopez, and C. Roseta-Palma, "Analysis of irrigation water tariffs and taxes in Europe," *Water Policy*, vol. 21, no. 4, pp. 806–825, Aug. 2019, doi: 10.2166/wp.2019.197.

[17] Zuñiga M, Izurieta C, and Arellano A, "Comparative Analysis of Historical Potable Water Consumption and Consumption During the COVID-19 Pandemic in Ecuador.," *NOVASINERGIA REVISTA DIGITAL DE CIENCIA, INGENIERÍA Y TECNOLOGÍA*, vol. 6, no. 2, pp. 46–61, Jul. 2023, doi: 10.37135/ns.01.12.03.

[18] M. Zúñiga, E. Calderón, M. I. Tello, A. Andrade, and A. Arellano, "Methodology for the Generation of Hourly Residential Drinking Water Consumption Curves and Their Relationship with the Consumption of Socioeconomic Strata," *Civil Engineering and Architecture*, vol. 12, no. 4, pp. 2532–2546, Jul. 2024, doi: 10.13189/cea.2024.120403.

[19] C. Izurieta, A. Arellano, and G. Muñoz, "Demographics and Potable Water Consumption in Urban Socioeconomic Strata," *FIPCAEC*, Jan. 2022, doi: 10.23857/fipcaec.v7i1.552.

[20] A. Arellano, C. Izurieta, C. Bravo, A. Merino, and D. Yépez, "Drinking water wastage through sanitary equipment," *Novasinergia*, vol. 2, no. 2, pp. 68–74, 2019, Accessed: May 26, 2023. [Online]. Available: https://www.researchgate.net/publication/337893973_Drinking_water_wastage_through_sanitary_equipment_Desperdicio_de_agua_a_traves_del_equipo_sanitario

[21] A. Sereno, "Human Right to Water and Sanitation: Water for All vs. Full Cost Recovery," *Frontiers in Water*, vol. 4, Jul. 2022, doi: 10.3389/frwa.2022.885193.

[22] A. Molina-Vera, M. Pozo, and J. Serrano, "Water, Sanitation, and Hygiene: Measuring Sustainable Development Goals in Ecuador," 2018. [Online]. Available: www.ecuadorencifras.gob.ec

[23] P. Hutchings *et al.*, "A systematic review of success factors in the community management of rural water supplies over the past 30 years," 2015, *IWA Publishing*. doi: 10.2166/wp.2015.128.

[24] M. Gomez, J. Perdiguero, and Àlex Sanz, "Socioeconomic factors affecting water access in rural areas of low and middle income countries," *Water (Switzerland)*, vol. 11, no. 2, Jan. 2019, doi: 10.3390/w11020202.

[25] R. Hernández Sampieri, C. Fernández Collado, and P. Baptista Lucio, "*Research Methodology*," Cuarta. México: McGraw-Hill, 2006.

[26] F. Arbués and M. García-Valiñas, "Water Tariffs in Spain," *Oxford Research Encyclopedias*, 2020, doi: 10.1093/acrefore/9780190632366.013.246 ï

[27] A. Reynaud, M. Pons, and C. Pesado, "Household water demand in Andorra: Impact of individual metering and seasonality," *Water (Switzerland)*, vol. 10, no. 3, Mar. 2018, doi: 10.3390/w10030321.

[28] R. C. Marques and J. Miranda, "Sustainable tariffs for water and wastewater services," Jun. 01, 2020, *Elsevier Ltd*. doi: 10.1016/j.jup.2020.101054.

[29] H. G. Ordóñez-Almeida, V. P. Moreno-Narváez, and J. F. Díaz-Córdova, "Internal Management and Control in the Potable Water Administrators of the La Troncal Canton," *Revista Arbitrada Interdisciplinaria Koinonía*, vol. 5, no. 4, p. 562, Sep. 2020, doi: 10.35381/r.k.v5i4.971.

[30] D. Fernández, S. S. Matus, and M. Gil, "Regulatory and Tariff Policies in the Potable Water and Sanitation Sector in Latin America and the Caribbean 205: Natural Resources and Development," *RECURSOS NATURALES YDESARROLLO*, 2021, [Online]. Available: www.cepal.org/apps