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The efficiency (tariffs) and the equity (subsidies) in the provision of the public service domiciliary of potable water in the city of Bucaramanga, (2004-2018)

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Abstract: The aqueduct service tariff system in Colombia is made up of the fixed charge (CMA fixed fee/subscribers) and the consumption charge (CMLP), which in turn are used to determine the rates for strata 4 and to establish the subsidies (strata 1, 2 and 3) and the surcharges or cross-subsidies to strata 5 and 6 as well as to the industry and commerce sectors; the above, added to the consumption blocks, constitutes the basis of the aqueduct bill per user according to strata and sector. In Acueducto Metropolitano de Bucaramanga S.A.E.S.P., AMB the value of basic consumption tariffs (at current prices), were close to quadrupling between the years 2004 and 2018 for some strata and sectors; in addition, they tripled for the case of complementary consumption during that same period of time. The high value of tariffs has led users in strata 4 and 5 to restrict water consumption to levels below 14m^3 per month, going from 19.41 m^3 of monthly consumption in 2015 to 14.2 in 2017. Total residential subscribers increased by 90,959 between 2000 and 2017, and by 10,035 for non-residential subscribers. The total increase in subscribers between the years 2000 and 20017 was 102,182; this evidences the expansion of the city of Bucaramanga.

Key words: efficiency; tariff; equity; subsidies; potable water

1 Introduction

Public policies for the provision of residential public utilities (SPD) changed radically in Colombia after 1991. *The 1991 Constitution* and *Laws 142* and *143* of 1994 generated a new model for the provision of SPD. The "provider" State gave way to the "regulator" State in which the public sector (decentralized) and the private sector operate as service providers, while the State regulates, controls and supervises the provision by the aforementioned agents with the assumption that they must protect the common good and the public interest (Silva and Figueredo, 2008).

The privatization model of public utilities was accompanied by an emphasis on demand subsidies. In this new framework, the tariff regime for residential public utilities must be guided by the criteria of economic efficiency (P = CMg, in Colombia P = CMLP, the base of the variable charge), financial sufficiency (the tariff charged must reflect the economic costs of providing the service, the base of the fixed charge, and the equivalent of the CMA/number of subscribers), solidarity (cross-subsidies: users with greater capacity to pay are obliged to finance those with lesser capacity to pay by providing prices higher than the CMLP), redistribution (allocation of government subsidies - national and local - to the lower strata that pay prices below the CMLP and as a complement to cross-subsidies), simplicity (that the user can

understand the information on the bill), transparency (information on cost, price and quantity consumed) and neutrality (equal tariff treatment of users).

Law 142 of 1994 defines the following services as SPD: water, sewerage and sanitation, electric power, basic public switched telephone service, rural mobile telephone service and fuel gas distribution. SPD can be provided by public utilities (official or private), municipalities when they directly assume the provision of these services, organized communities and authorized entities.

Law 142 initiated a series of reforms in public utilities and in a few years a new institutional structure was created. This began to function with the creation of the Superintendency of Public Utilities (SSPD), the organization of the regulatory commissions for the energy and gas sectors (CREG), drinking water and basic sanitation (CRA) and communications (CRC). In this context, the State sold part of the ownership of the electric power generation and distribution companies to the private sector, which gave rise to the operation of the wholesale energy market.

Some sanitation companies were ceded to the private sector through concessions, while in the country's largest cities (Bogota, Medellin, Cali and Bucaramanga) drinking water operators continued to be officially owned (Silva, 2012).

The regulation model of *Law 142* of 1994 is the "rate of return" model, and the tariff methodology is determined based on the recognition of long term average costs (LRMC) where the price P = LRMC. As a result of the application of this model, the service providers obtained higher reference costs than the tariffs applied up to that time. In the case of the tariff regime in Colombia, a non-linear pricing system was also chosen: a two-part tariff with three increasing blocks (basic, complementary and luxury consumption).

The monopoly characteristic of the SPD, and in particular of the drinking water service[2], generates problems in obtaining financial equilibrium, since the presence of economies of scale implies that their production costs are decreasing. One of the alternative solutions lies in the setting of non-linear prices, including the two-part tariff - a tariff that was adopted and adapted by the Colombian regulatory system (*Law 142* of 1994). This type of tariff structure is composed of two parts: a fixed fee "A" (fixed charge) and an additional constant price "P" per unit consumed (variable charge or consumption charge). The two-part tariff is intended to simultaneously achieve the objectives or criteria of efficiency, financial sufficiency and equity. In addition to the two-part tariff, the adoption of three increasing blocks (basic, complementary and luxury consumption) is intended to induce users to reach certain consumption levels.

Indeed, the systematic increase in tariffs, both the consumption or variable charge and the fixed charge, as well as the increasing block mechanism, have been effective in the case of the city of Bucaramanga, where users have reduced their average monthly consumption from 19.1 m^3 in 2005 to 14.2 m^3 in 2017 (Table 9). This is combined with awareness campaigns on water saving and conservation, changes in consumption habits, and the introduction of water-saving and low-pressure technologies in the construction of new homes or in the remodeling of used homes.

For the analysis of tariffs in terms of efficiency, financial sufficiency and redistribution (equity) objectives, this article considers their value between 2004 and 2018, as well as the demand (consumption) of the different user strata.

2 Theoretical framework and methodology

The economic literature related to the design and evaluation of the tariff structure of public utilities, including potable water services, generally considers the criteria of the normative approach of welfare economics: economic efficiency, cost coverage (financial sufficiency), simplicity (administrative simplicity) and equity. The regulatory system in Colombia adopted the above criteria and, in a complementary manner, established that the criteria of redistribution (state subsidies), solidarity (cross-subsidies), neutrality and transparency (*Article 87, Law 142* of 1994) must be considered in the operation and evaluation of residential public utility tariffs (SPD). Therefore, the theoretical framework starts from the normative

approach.

From this theoretical perspective, the methodology consists of evaluating the criteria of economic efficiency, financial efficiency and equity (subsidies for strata 1, 2 and 3 and surcharges for strata 5 and 6 and the industrial and commercial sectors) based on the principles of benefit (each subscriber pays according to the benefits received -consumption-) and capacity to pay (vertical equity, the higher the income level, the higher the contribution).

3 Marginalist price formation (linear and nonlinear): the two-part tariff model and the criteria of efficiency and equity[3]

In the economic literature and in practice, in the case of SPD, there is a wide variety of pricing methods. From a theoretical point of view, efficient prices can be merged into two groups: first-best (marginal cost) and second-best (average cost) pricing. In first degree discrimination the transfer of surplus is usually achieved by linear pricing; but it can also occur through the two-part tariff - the variable part of the tariff can have one or more blocks. An alternative to average cost pricing is the Ramsey-Boiteux discriminatory pricing, although two-part and block pricing can also be used as a variant (Silva, 2012).

The two-part tariff, consisting of a variable part equal to the cost per unit consumed, and a fixed part intended to cover the deficit in fixed costs, has been proposed to achieve optimal cost coverage (Lewis, 1941; Henderson, 1947; Coase, 1946; Feldstein, 1972 and Willig, 1976; among other authors). The method of allocating fixed costs can be arbitrary; therefore, Brown and Sibley (1986) suggested determining the share of personalized fixed costs in such a way that the user does not choose to abandon the system. Some more recent studies have shown the regressivity[4] of the two-part tariff in cases where the fixed components of the tariff are important, and even in apparently more progressive systems. A fundamental objective in trying to achieve equity is to ensure that no consumer is left out of the water service because of income or location, or because of efficiency or cost-covering targets alone, thus aiming at excessively high fixed tariffs.

4 The most commonly used pricing schemes in the public water utility (the two-part tariff) are as follows

According to the literature, alternative pricing schemes are divided into two broad categories from an efficiency perspective: linear pricing schemes (the uniform tariff) and non-linear pricing schemes (the two-part tariff and the block tariff, the two-block tariff and the n-block tariff). In the linear pricing scheme, the price (tariff) is set based on marginal cost (in Colombia the uniform tariff has been applied quite frequently in the private and public sectors). In this pricing scheme, the tariff is set by equating the price equal to the marginal cost (first best), or by equating the price to the average cost (second best) with the conceived loss of social efficiency (Silva, 2012).

Pricing or tariff structures that differentiate according to quantities consumed are called non-linear or non-uniform pricing schemes; they are generally adopted when companies face decreasing average costs (Figure 2). This circumstance (decreasing costs), gives rise to a dilemma in the establishment of a pricing scheme: 1) setting the price equal to the marginal cost, with an average cost curve above the marginal cost, leads the company to a situation of not being able to cover its total costs and, consequently, to incur in losses; or 2) setting the price above the marginal cost implies an inefficient allocation but allows the company to obtain a minimum profit (CRA, 2004).

This type of tariff structure is composed of two elements (Figure 1): a fixed fee A (residential fixed charge, which is equivalent in Colombia to fixed costs -average administration costs, AMC-) divided by the number of subscribers, that is, administration costs plus the costs of billing, collection, meter reading and other service administration costs (equivalent to AMC/number of subscribers), and an additional constant price (P) per unit consumed whose value varies according to the

units consumed and the block to which they belong. This non-linear pricing structure (two-part tariff) is the least complex, the most used in practice and the one with the most analysis and literature (Silva, 2012).

One way of defining the tariff in two parts, with the aim of achieving a balance between the loss of economic efficiency due to the implementation of a flat fee and the achievement of less inequality, is represented by the formula:

$$R(q) = \begin{bmatrix} A, & si & q = 0 \\ A + Pq, & si & q > 0 \end{bmatrix}$$

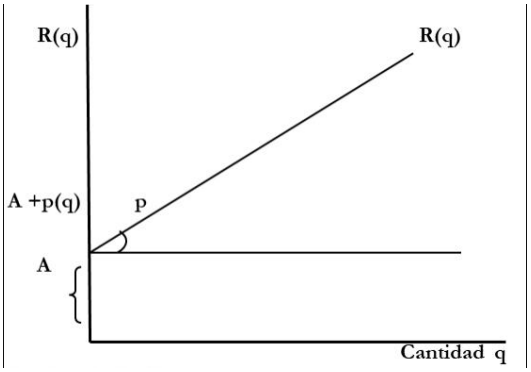

Figure 1. Tariff in two parts Source: own elaboration

Where, R(q): cost incurred to demand q units

A: fixed cost (fixed fee or fixed charge)

P: price per unit demanded (variable charge)

This definition considers the case when q = 0, the expenditure would not be zero but A, i.e., when the user is connected to the public service and temporarily consumes nothing (due to a period of absence from home for vacations, for example). According to a CRA study (2004, p.51), "in this way, the two-part tariff achieves a higher level of social welfare than the tariff that is defined by an average price equal to the average cost, provided that the variable component or marginal price that we define is equal to or greater than the marginal cost. If it were lower, consuming an additional unit would cause the utility to make a loss."

Figure 2 shows the nonlinear tariff scheme, in which the water service operator is considered as a monopoly that equals its revenues to its average costs at the point (P1, Q1). At a price (P1-δ), the firm would increase the level of output to Qδ, but would incur losses (H) if it sold all its output at that price, since it would not be able to cover its total costs. The losses (H) can be shared among all users (n) thus modifying the linear price P1 which would now be a tariff with two parts: a fixed component equal to H/n and a variable component with a price equal to (P1-δ) (CRA, 2004). If the regulator or the government wishes to expand production up to Q2, it should subsidize the company to cover the price difference (P1-δ)-P2 (Silva, 2012).

One of the advantages of considering a non-linear pricing scheme lies in the existence of heterogeneous users, with different levels of price elasticity of demand; thus, and as an additional advantage, this pricing structure creates markets that allow these different population groups to be incorporated into the drinking water service, while uniform prices could exclude them. As a disadvantage, it is recognized that the fixed component of the tariff is considered to be potentially regressive: prices for low-income consumers or those with low consumption, which would have a high price at least in relation to the fixed component. In addition, social welfare may be reduced, both because supply is reduced by price discrimination or prevented, and because demand is reduced and ends up affecting the company's revenues, which in turn translates into higher prices for users (Silva, 2012).

Feldstein's (1972) two-part tariff model considers both efficiency and equity criteria, with a clear predominance of the former and a partial inclusion of the latter in order to ensure access to the service for the poorest and/or lowest income households or users (Silva, 2012).

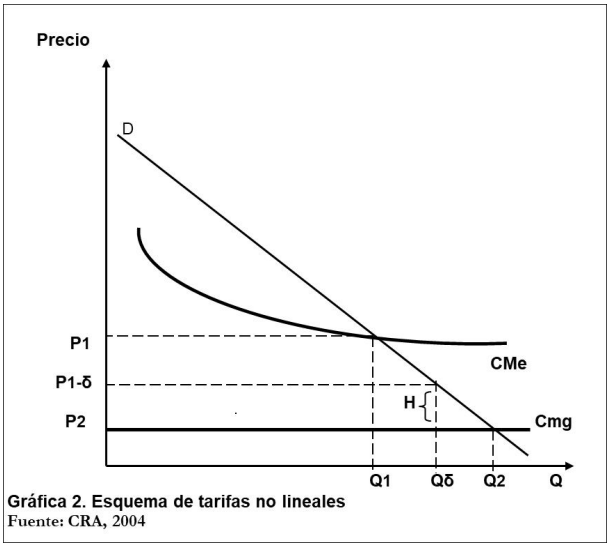

Figure 2. Schematic of non-linear tariffs Source: CRA, 2004

5 The economic concept of residential public utilities and their characteristics

"The market failure associated with the characteristics of public utilities (drinking water) is a cost structure linked to the existence of networks, economies of scale and scope that leads to a monopoly situation" (Bohem in Silva, 2012).

5.1 Monopoly in residential public utilities, SPD

The monopoly characteristic is generally attributed to the SPD industries (energy, water, sewerage and natural gas). In these industries, the free entry of companies could result in duplication of networks and costs (water, sewage and electricity networks). The existence of monopoly refers to a property of productive technology, often associated with market demand, where a single operator is able to satisfy it at lower cost than two or more (Silva, 2012).

In residential public utilities, in general, there is no competition; therefore, they are normally subject to government regulation for the protection of the public interest. Some services seem to function more effectively as monopolies (water and sewerage). The presence of monopoly is often associated with government regulation of tariffs (price), management (quality and continuity), investments, externalities and entry barriers. However, the identification of increasing returns to scale describes the productive technology a little more (Heyman, 1995; Phillips Jr., 1993).

A monopoly operator to maximize its profits will decide to produce at a level at which marginal revenue equals marginal cost, and since the monopoly faces a downward sloping demand curve (negative slope) for its product, marginal revenue will be lower than the market price (this is known as the optimality principle). To sell one additional unit, the monopolist must reduce the price of all the units it will sell, in order to generate the additional demand to absorb this additional unit. The average cost curve and the demand curve of a monopolist can be represented as shown in Figure 3 (Silva, 2012; Silva and Figueredo, 2008).

In a monopoly service a level of production is assumed at which the operator obtains a profit. The maximum level of production, to achieve profit without subsidies, is Q*. In this, the demand curve intersects the average cost curve, such an intersection is designated as the point of zero profit, and the policy that makes it possible is called "suboptimal" or "second best". Efficiency is expressed in the equality between price (PR) and marginal cost (point E, with a quantity of production Q0), but setting a price equal to marginal cost would lead to a loss, since the average cost is above marginal cost (Silva,

2012).

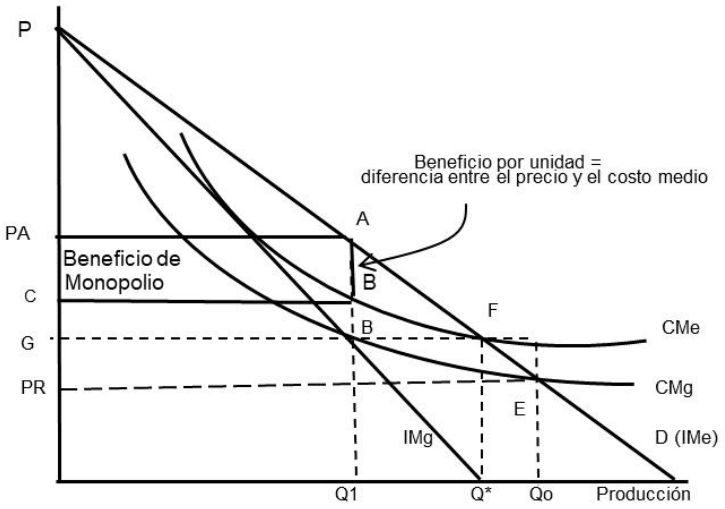

Figure 3. Declining costs (utility monopoly)

Source: Nichols]on (2001, 2004), Train (1994), Musgrave (1959)

As operators produce at long-run average cost, they could underprice their costs to push up tariffs, given low or zero marginal costs. In the absence of competition problems, the monopoly operator can charge a price (PA) that maximizes its profits (A) with an output Q1; that is, with monopoly profits given by the C-PA-A-B space in Figure 3 (Silva, 2012).

5.2 Sunk costs

Sunk costs are represented by capital investments, which are considered irreversible (once the networks are installed underground, it is difficult to recover the investment made), and adjustment costs, which impede the ability of economic agents to adapt to changes in market conditions. The market responds to sunk costs and compensates for risks with long-term contracts.

The economic characteristic of domiciliary public utilities such as sanitation, energy, water, sewerage and natural gas distribution, require large investments in infrastructure (networks), which become sunk costs. Distribution networks typify the monopoly element, since it would be too costly and harmless to install two or more networks in the streets of the city (Silva, 2012).

Long-term contracts provide an incentive for participation risk and encourage increased capital investment. The benefits of this increase in productive investment generate incentives for the formation of long-term contractual relationships: the market determines the terms of the contract, the number of contractual agreements, and the price of each contract. However, there are elements of the contract that are not fully described, such as performance and negotiation terms.

5.3 Economies of scale and scope

The presence of economies of scale and the quality of "public service" justify government intervention in the SPD. Economies of scale are found when the average cost of production decreases, while the quantity of production increases. The average cost curve slopes downward indicating that the average cost falls, while the quantity produced increases. Declining average cost means that marginal cost falls below average cost. When the price is set at marginal cost as required by optimality, the firm loses money on each unit sold. Figure 3 illustrates such a situation. In theory, the firm could be subsidized by the amount of its loss in each period. In the absence of subsidies, the market allocation will not be optimal (Spulber, 1989).

Thus, economies of scale present two dilemmas. First, marginal cost pricing would not yield enough revenue to cover costs, while average cost pricing or other pricing rules may cause deviations in the levels of the optimal social product (Silva, 2012; Silva and Figueredo, 2008).

An economy of scope occurs when the quantity of two or more services can be produced by one company at a lower total cost than if they were produced separately by several companies (as in the case of AMB, which manages water, sewer and other services, thus reducing administration costs).

6 The two-part tariff model adopted in Colombia for the SPD: the potable water service regul ated by the CRA

In Colombia, *Article 87 of Law 142* of 1994 establishes the regulatory regime of the tariff system for the supply of drinking water and other SPD (sewerage and natural gas). This multi-objective context, or context of various objectives to be achieved, confers great complexity to the drinking water service.

6.1 The objectives of the SPD regulatory system

In accordance with *Law 142* of 1994 (Article 87), the regulatory system in Colombia establishes that the design, operation and evaluation of tariffs for residential public utilities, particularly for potable water services, must take into account economic efficiency, financial efficiency (cost coverage), redistribution (equity), solidarity (cross-subsidies), simplicity (simplicity), neutrality and transparency as guiding criteria (Figure 4).

The economic and financial efficiency criteria are the direct responsibility of the service operator (AMB in this case) and the regulator (CRA); the other criteria, including the redistribution (equity) criterion, are the responsibility of other areas of government (Ministries, DNP). To achieve these two objectives, the regulator uses both the tariff level (the amount of revenue) and the tariff structure. The main problem for a monopoly with decreasing costs is that both objectives are difficult to achieve at the same time. The price level that maximizes consumer surplus[5] (economic efficiency) does not cover the costs of the service (self-financing), since the existence of economies of scale in the relevant sections of production causes the marginal cost to be below the average cost - which makes the equalization of price and marginal cost unsustainable. In general, then, an attempt should be made to reach a second-optimal solution consisting the reduction of consumer surplus to a self-financing situation (Silva, 2012).

However, the objectives of efficiency and financial sufficiency are not the only ones that prevail in a public service such as drinking water, nor in countries with heterogeneous and unequal consumers. Drinking water service is considered an "essential" public health service, a basic necessity to be satisfied. To correct these problems, economic theory proposes subsidizing the consumption of this type of good (Pigou, 1920). For this reason, the prices of the service have traditionally been subsidized, so that we can speak of "political prices".

Water conservation and saving criteria should be added to the above criteria. According to Bös (1985), the adoption of these multiple objectives lends great complexity to the setting of prices or tariffs in the drinking water sector, and this dimension implies very long term horizons ("master plans" of 20, 30, or more years).

From the perspective of analysis of the normative approach, the redistribution (equity) criterion or objective considers the principles of benefit and ability to pay - with a clear option for the former, combined (in cases such as this one of heterogeneous consumers and unequal income) with a partial application of the latter to ensure access to the service for low-income households (an aspect of relevance in countries such as Colombia with strong disparities in income distribution).

The principle of benefit implies that the costs of the service should be distributed among users in proportion to the benefit received by each consumer, so that equal benefit equals payment and the greater the benefit the greater the payment,

and this benefit is approximated by the amount consumed; however, although water is a divisible and measurable good, in practice the amount consumed (m^3) per subscriber (household or residential unit) is measured, but not on an individual basis (per person) (Silva, 2012).

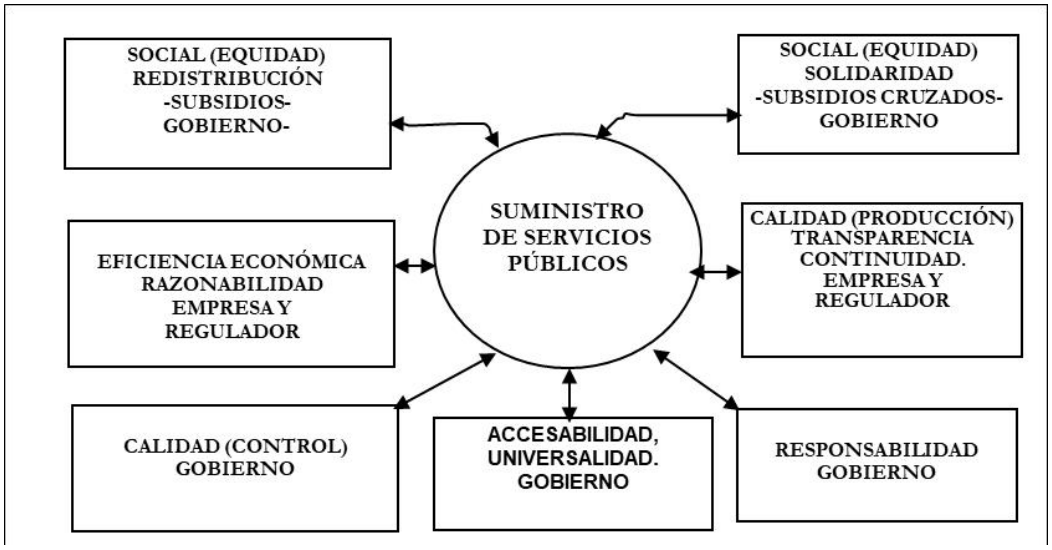

Figure 4. Criteria of the tariff regime (multiple principles)

Source: Prepared by the authors, based on *Article 87, Law 142* of 1994

The principle of capacity to pay establishes that users should contribute to the cost of the service precisely in accordance with their capacity to pay (income or revenue); this implies that users with the same capacity pay the same (horizontal equity), and users with greater capacity pay more (vertical equity); that is, equity measured in terms of users' income or revenue in relation to their expenditure and volume of consumption. This is the concept of equity used in this text.

In the drinking water service, it is necessary to guarantee access to all users and coverage of their "unsatisfied basic needs" at affordable prices. In Colombia, the solidarity criterion relies on cross-subsidies and in part on subsidies with general taxes, which have been gradually dismantled - the goal of total dismantling was initially set for 2006, then postponed to 2010, and still remains. In reality, cross-subsidies are equivalent to price discrimination by user group - classified into six strata- (Silva, 2012).

The criterion of financial sufficiency - sometimes interpreted as covering or recovering costs associated with the service - refers to the fact that the revenue obtained through the application of the water tariff should tend to cover the fixed costs of the supply service, so as to ensure the continuity of service provision in the long term.

6.2 Increasing blocks (ranges of consumption) of drinking water service

Since May 1, 2016, CRA *Resolution number 750* of February 8 (Ministry of Housing, City and Territory), which modifies the ranges of basic consumption of drinking water in Colombia, has been in force. The Commission assumes this measure, based on Article 80 of the *Political Constitution* of 1991 and *Law 373* of 1997, stating in Article 7 that "it is the duty of the Drinking Water and Basic Sanitation Regulatory Commission, the Regional Autonomous Corporations and other environmental authorities, in accordance with their competencies, to establish basic consumption based on water uses, discourage the maximum consumption of each user and establish procedures, rates and measures for those consumers who exceed the maximum consumption set" (Table 1).

Resolution CRA 750 of 2016 modifies the ranges of basic, complementary and sumptuary consumption in order to update the basic or subsistence consumption in the terms of *Law 142 of 1994* and *Law 373 of 1997*, to improve the

regulatory signal and encourage rational water consumption (Table 1).

Table 1. Basic potable water consumption levels in m3 per subscriber/month and type of climate in Colombia (Resolution CRA 750 of 2016)

Deadline	COOL (m3/subscriber/month)	TEMPLADO (m3/subscriber/month)	WARM*. (m3/subscriber/month)
May 1, 2016	17	18	19
January 1, 2017	15	16	18
July 1, 2017	13	14	17
January 1, 2018	11	13	16

Source: Design and author's elaboration based on CRA Resolution No. 750 of 2016

*Bucaramanga: 959m above sea level (warm climate)

The consumption adjustments, listed in Table 2, were made according to a study that UAE CRA conducted among residential subscribers in eighteen (18) capital cities of Colombia. In this study, variables such as climate and stratum were considered over a period of ten (10) years, where it was evidenced that the average consumption of residential subscribers has decreased.

In order to encourage rational consumption of drinking water, differentiated rates will also be established, with a higher cost for consumption ranges defined as complementary and a higher charge for luxury consumption.

However, in some countries the mechanism of consumption blocks was considered seasonal and clearly differentiable consumption volumes between indoor use (cooking, bathing, laundry and general housekeeping) and outdoor use (garden, lawn, car wash, swimming pool), with a lower price for "base" water (water used for necessities) and a higher price for excess water. This could be classified in terms of indoor water use as a necessity (relatively inelastic demand) and outdoor use as additional water use (relatively elastic demand). On the face of it, this is more equitable, as low-income consumers are not restricted to the water base and there is an increase for high-income users, who can pay the higher price for outdoor water, i.e. swimming pool and gardens. In particular, the current trend towards increasing blocks of tariffs is based, to some extent, on this reasoning.

Table 2. Drinking water consumption levels in m3 per subscriber/month and altitude in Colombia (Resolution CRA 750 of 2016)

Altitude cities and municipalities	Basic consumption	Supplementary consumption	Luxury consumption
Cities and municipalities with average altitude above 2,000 meters above sea level	11m3	>11 m3 < 22 m3	>22 m3
Cities and municipalities with average altitude between 1,000 and 2,000 meters above sea level	13m3	>13m3 <26m3	>26 m3
Cities and municipalities with average altitude below 1,000 meters above sea level (Bucaramanga: 959m above sea level)	16m3	>16m3 <32m3	>32m3

Source: Prepared by the author based on CRA Resolution No. 750 of 2016

6.3 The structure of costs and expenses established by the CRA for the drinking water service in the two-part tariff

In order to carry out the analysis of the objectives of equity, economic efficiency and financial sufficiency, the tariff

applied to the residential sector by the AMB in the city of Bucaramanga have been taken as a reference. An attempt is made to look as empirical evidence at some of the most reiterated conclusions of the theoretical analysis of the two-part tariff. 1) increasing tariffs levied on aggregate household consumption, the problem being that the larger the household size, the heavier the burden meeting the basic water needs of households (the assumption is that more people live together per subscriber, household or residential unit in the lower strata). 2) The regressivity of the fixed fee or fixed charge of the service bill; 3) inequity, given that the higher the consumption, the lower the weight of the fixed charge; and 4) the users' ability to pay in relation to the value of the bill by stratum -price elasticity of income (Silva, 2012).

The cost structure is defined by means of comparative efficiency models, in the search for the provider companies to recover the costs and expenses incurred to guarantee the service. Mathematically, it is expressed with formulas contained in various CRA resolutions, including *Resolution No. 287 of 2004*, which restructures the cost base and includes environmental costs, the adopted methodology and part of the second-best methodology. Thus, "the new tariff methodology has sought to include components of various regulatory mechanisms in order to provide elements to the water and sewerage sector that increase economic efficiency within a framework of financial sustainability, better coverage and improvements in the quality of service" (CRA 2004, p. 11).

Since 2006, the long-term average cost (LTOC) and the average administration cost (AMC) have been used as reference costs to establish the consumption charge (CC) and the fixed charge (FC), respectively, for the AMB's water supply service. These should be equal to the value of the tariffs for stratum 4 and the basis for establishing subsidies and surcharges for the other strata and sectors (Silva, 2012).

6.3.1 Consumption charge (CC) and long-term average cost (LTOC)

The CC is composed of the average cost of operation (CMO), the average cost of investment (CMI) and the average cost of environmental charges (CMT). The consumption charge (CC) is equal to the long-term average cost, thus: CC = CMO+CMI+CMT = CMLP.

• Average cost of operation (CMO). It is made up of the comparative average operating costs (CMOc) and the particular average operating cost (CMOp). The CMOp is called particular because it is constituted by the specific costs of each company, due to its geographical location, which may facilitate or hinder access to water sources and water quality, and incurs different costs for chemical inputs, energy and transport. The CMOc is constituted from the comparative costs (with other operators) and is composed of the costs of depreciation of the operating infrastructure, maintenance, insurance, salaries and remuneration of operating personnel, contracting (Silva, 2012). CMO = CMOc + CMOp.

• Average cost of investment (CMI)

CMI = (VA + VPI) /VPDp + CMIt

Where:

VA: asset valuation

VPI: present value of investments (investment plan).

VPDp: present value of projected demand

CMIt: average value of land investments

The value or price assigned to the cubic metre of water by CMI is a figure equal to the sum of the valuation of the undepreciated assets, the present value investment plan and the average value of the land investments - each at a discount rate (13.34%) - and the result is divided by the projected amount of demand.

The CRA, through *Resolution 312 of 2004*, establishes that the discount rate for SPD operators' investments can be set by the companies within a range between 13.34% and 13.92%.

• Average cost of environmental charges (CMT). Tariffs for water use charges (aqueduct), similarly to the retributive charges (sewerage), are set by applying regional differentiation criteria based on two basic factors: a minimum tariff, unique and homogeneous at the national level, and a multiplicative factor: the regional factor. This factor increases the minimum tariff according to regional and local factors (Rudas, 2011).

The value of the minimum tariff for water use fees was established by the Ministry of Environment, Housing and Territorial Development (MAVDT) based on a study of the economic value of water. However, the study uses only two variables: the "costs and investments incurred by the competent environmental authorities for the recovery of water sources" and the "available water supply in the jurisdiction of each of the competent environmental authorities". Responsibility for environmental damage - water use and pollution (sewage) - is under the guardianship of regional corporations and the government through the MAVDT (Silva, 2012).

6.3.2 Fixed charge

The fixed charge is calculated on the basis of the average cost of administration (AMC/number of subscribers). The average cost of administration includes administration costs and expenses that involve billing, collection, meter reading and other administration costs related to the service (salaries and overheads). The AMC also includes depreciations related to the infrastructure and equipment of the administration and part of the production assets of the service (Silva, 2012).

6.4 The allocation of subsidies in the city of Bucaramanga (drinking water)

Based on the four cost lines mentioned in the previous section and with the premises of the Average Management Cost (AMC) and the Long Term Average Cost (LTOC), the two basic concepts of the water service tariff for subscribers or users are obtained for the water service: the Fixed Charge (fixed part) and the Consumption Charge or variable part of the tariff (in both, basic, complementary and luxury consumption).

In order to determine the bill for fixed charge subscribers, the AMC is divided by the number of subscribers to establish the tariff for stratum 4, and subsidy and surcharge factors are also applied. The calculation of the consumption charge tariff is based on the long-term average cost (LTOC). From the multiplication of the subsidy and surcharge factors to the LMCF, the value of the bill for each type of user according to their stratum is obtained (Table 3).

Table 3 shows the percentages of subsidy factors for users in strata 1, 2 and 3, and the percentages of solidarity contributions for strata 5 and 6 and industrial and commercial sectors (Agreement 030 of December 30, 2016, Bucaramanga Council).

7 Evaluation of the two-part tariff practice: Bucaramanga case (AMB)

The evaluation of the practice of the two-part tariff model for the residential and non-residential public water service (drinking water), operated in the city of Bucaramanga by Empresa AMB, focuses on the basic objectives of the regulatory system: efficiency, financial sufficiency (fixed charge or cost coverage) and equity (in relation to subsidies and surcharges, and the volume of consumption in m3). In addition, in order to discourage over-consumption under a criterion of environmental sustainability, incremental tariffs are established for blocks of consumption.

Table 3. AMB Bucaramanga: percentages of subsidies and solidarity contributions for drinking water service 2017-2021

Subscriber	Acuerdo Consejo Municipal No. 030 Fiscal Year 2017 - 2021 December 30, 2016
Stratum 1	-50%
Stratum 2	-30%
Stratum 3	-10%
Stratum 4	0

Stratum 5	+50%
Stratum 6	+60%
Industrial	+30%
Commercial	+50%
Official	0
Special	0
Temporary	+50%
Public Batteries	-70%

Source: AMB, *Management Act 003*, February 12, 2018. Author Redesign

7.1 The rate structure of the aqueduct service -drinking water supply

The potable water tariff system in Colombia is composed of a fixed charge (CMA fixed quota/subscribers) and a consumption charge (CMLP), both of which constitute the stratum 4 tariff, which is the reference for establishing subsidies and surcharges, and for determining the service bill, according to consumption ranges.

Table 4 shows the rates by strata and sectors and their variation expressed in $/m3 at current pesos, for the period 2004- 2018 in the city of Bucaramanga. The value of the tariffs for basic consumption (at current prices) almost quadruples from 2004 to 2018, for some strata and sectors; and triples for the case of complementary consumption for the same period of time (see last column, Table 4). Another relevant aspect is that the tariff for complementary consumption is equal to that for luxury consumption, which implies in practice that the AMB only contemplates two consumption blocks: basic and complementary. Let us remember that the rate for strata 4 must be equal to the CMLP and is the reference rate for establishing subsidies (strata 1 to 3) and surcharges for strata 5 and 6 and the industrial and commercial sectors.

7.1.1 Basic consumption tariff at 2018 prices

In the city of Bucaramanga, the high tariffs (Tables 4 and 5) have conditioned users in strata 4 and 5 to restrict their consumption to less than $14m^3$ of water per month (Table 9).

The tariff for basic consumption in 2018 pesos (Table 5, Figure 5) decreases in 2005 for all strata and sectors and increases systematically and uniformly between 2006 and 2018, with values more than double those of 2005 in relation to 2018 for strata 1, 2, 5 and for the commercial and business sectors (penultimate fla, Table 5). The last column of Table 5 relates the value of the 2004 rates to the 2018 rates, and with the exception of strata 3 and 4 and the industrial sector, for the other strata and sectors, the rates reach a value greater than double.

The tariff of the official sector throughout the period is lower than that of strata 4 (with the exception of 2018); similarly, the tariff of the industrial sector has been lower than that of strata 5, and that of the commercial sector has generally been similar to that of strata 5; the tariff of strata 6 is the highest tariff in the whole set, above the tariff of the commercial sector.

The above shows that tariffs and, in general, decisions regarding public goods and services are ultimately political in nature (Board of Directors of the service operator and/or Municipal Council, and even the CRA itself, which endorses them). Figure 5 shows the behavior of basic consumption tariffs for the different strata and sectors between 2004 and 2018 at 2018 prices.

7.1.2 Supplementary consumption rates at 2018 prices (Table 5)

The rates for supplementary consumption for the first four strata are equal to the rate for stratum 4 of basic consumption, including the official and special sectors; the rate for strata 5 and 6 is equal to the rate for stratum 5 of basic

consumption; and for the industrial and commercial sectors the rates are not modified in relation to those of basic consumption. Thus, the rates for 2004 in relation to those for 2018 (last column of Table 5) increase by 46% for strata 1 to 4 and the commercial sector, and increase almost twice as much for the other sectors (85% for strata 6 and commercial sector and 95% for strata 6).

Figure 6 shows the similarity of the rates for strata 1 to 4 and the commercial sector. As of 2007, the rates for the industrial sector differ from those for the commercial sector, with a higher rate for the latter.

7.1.3 Fixed charge rate (at current prices)

The fjo charge rate in current pesos (Table 6) shows a permanent growth for all strata between 2004 and 2018. The rate for stratum 4 should be the result of the mathematical operation of CMA/number of subscribers.

7.1.4 Fee per fjo charge (at constant 2018 prices)

Table 7 shows a ratio of 3.9 between the rate paid by stratum 1 and the rate of stratum 6 in 2004, and ends with a ratio of 3.2 in 2018. The rate of stratum 1 is the lowest and that of stratum 6 the highest (including the industrial and commercial sectors). The last column shows that the 2018 rate is lower than that of 2004 for strata 3 and 4 and the industrial sector, and slightly higher for the other strata and sectors.

Table 4. AMB Bucaramanga: basic, complementary and luxuryconsumption tariffs $/m^3, September 2004-2018 (current prices)

Basic consumption of potable water															
Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Stratum1	285,49	343,11	397,57	458,08	529,51	616,79	636	656	677	677	701	723	802	896,85	1062,98
Stratum 2	393,96	478,09	556,6	641,31	741,31	863,51	890	919	947	947	981	1012	1123	1255,59	1448,17
Stratum 3	637,78	738,99	755,39	870,35	1006,07	1171,91	1208	1181	1218	1218	1262	1302	1444	1614,33	1913,36
Stratum 4	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Stratum 5	859,54	886,79	1033,69	1374,23	1588,53	1850,38	1907	1968	2029	2029	2103	2169	2407	2690,55	3188,93
Stratum 6	859,54	886,79	1033,69	1465,84	1694,43	1973,74	2034	2099	2165	2165	2243	2314	2568	2869,92	3401,52
Offcial	716,28	6403,16	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Industrial	859,54	7705,36	1033,69	1191	1376,73	1603,67	1652	1706	1759	1759	1822	1880	2086	2331,81	2763,74
Comercial	859,54	7705,36	1033,69	1374,23	1588,53	1850,38	1907	1968	2029	2029	2103	2169	2407	2690,55	3188,93
Complementary Consumption															
Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Stratum 1	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Stratum 2	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Stratum 3	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Stratum 4	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Stratum 5	859,54	886,79	1033,69	1374,23	1588,53	1850,38	1907	1968	2029	2029	2103	2169	2407	2690,55	3188,93
Stratum 6	859,54	886,79	1033,69	1465,84	1694,43	1973,74	2034	2099	2165	2165	2243	2314	2568	2869,92	3401,52
Official	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Industrial	859,54	886,79	1033,69	1191	1376,73	1603,67	1652	1706	1759	1759	1822	1880	2086	2331,81	2763,74
Comercial	859,54	886,79	1033,69	1374,23	1588,53	1850,38	1907	1968	2029	2029	2103	2169	2407	2690,55	3188,93

Sundry consumption

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
stratum1	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
stratum 2	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
stratum 3	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
stratum 4	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
stratum 5	859,54	886,79	1033,69	1374,23	1588,53	1850,38	1907	1968	2029	2029	2103	2169	2407	2690,55	3188,93
stratum 6	859,54	886,79	1033,69	1465,84	1694,43	1973,74	2034	2099	2165	2165	2243	2314	2568	2869,92	3401,52
Official	716,28	738,99	795,15	916,15	1059,02	1233,59	1271	1312	1353	1353	1402	1446	1605	1793,7	2125,95
Industrial	859,54	886,79	1033,69	1191	1376,73	1603,67	1652	1706	1759	1759	1822	1880	2086	2331,81	2763,74
Comercial	859,54	886,79	1033,69	1374,23	1588,53	1850,38	1907	1968	2029	2029	2103	2169	2407	2690,55	3188,93

Table 5. AMB Bucaramanga: basic and complementary potable water consumption rate $/m^3, September 2004-2018 (at 2018 prices). T2017/ T2005

Basic Consumption

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	T2017/ T2005
Stratum 1	521,43	594,00	656,44	723,92	791,76	856,56	865,92	865,71	861,30	840,78	854,02	849,72	882,80	933,53	1062,98	2, 04
Stratum 2	719,54	827,68	919,02	1013,49	1108,45	1199,19	1211,75	1212,79	1204,80	1176,10	1195,14	1189,38	1236,14	1306,94	1448,17	2, 01
Stratum 3	1164,86	1279,35	1247,25	1375,45	1504,34	1627,48	1644,71	1558,54	1549,57	1512,66	1537,48	1530,20	1589,49	1680,36	1913,36	1, 64
Stratum 4	1308,24	1279,35	1312,90	1447,83	1583,51	1713,14	1730,48	1731,42	1721,32	1680,32	1708,04	1699,44	1766,71	1867,06	2125,95	1, 63
Stratum 5	1569,90	1535,23	1706,77	2171,75	2375,27	2569,70	2596,41	2597,13	2581,35	2519,86	2562,06	2549,17	2649,51	2800,59	3188,93	2, 03
Stratum 6	1569,90	1535,23	1706,77	2316,53	2533,61	2741,02	2769,32	2770,01	2754,37	2688,76	2732,62	2719,58	2826,73	2987,30	3401,52	2, 17
Official	718,11	6404,89	796,80	917,73	1060,52	1234,98	1272,36	1313,32	1354,27	1354,24	1403,22	1447,18	1606,10	1794,74	2125,95	2, 96
Industrial	1569,90	13339,67	1706,77	1882,19	2058,57	2227,09	2249,22	2251,37	2237,84	2184,54	2219,72	2209,51	2296,17	2427,18	2763,74	1, 76
Comercial	1569,90	13339,67	1706,77	2171,75	2375,27	2569,70	2596,41	2597,13	2581,35	2519,86	2562,06	2549,17	2649,51	2800,59	3188,93	2, 03

Complementary Consumption																T2017/ T2005
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Stratum 1	1308, 24	1279, 35	1312, 90	1447, 83	1583, 51	1713, 14	1730, 48	1731, 42	1721, 32	1680, 32	1708, 04	1699, 44	1766, 71	1867, 06	2125, 95	1, 46
Stratum 2	1308, 24	1279, 35	1312, 90	1447, 83	1583, 51	1713, 14	1730, 48	1731, 42	1721, 32	1680, 32	1708, 04	1699, 44	1766, 71	1867, 06	2125, 95	1, 46
Stratum 3	1308, 24	1279, 35	1312, 90	1447, 83	1583, 51	1713, 14	1730, 48	1731, 42	1721, 32	1680, 32	1708, 04	1699, 44	1766, 71	1867, 06	2125, 95	1, 46
Stratum 4	1308, 24	1279, 35	1312, 90	1447, 83	1583, 51	1713, 14	1730, 48	1731, 42	1721, 32	1680, 32	1708, 04	1699, 44	1766, 71	1867, 06	2125, 95	1, 46
Stratum 5	1569, 90	1535, 23	1706, 77	2171, 75	2375, 27	2569, 70	2596, 41	2597, 13	2581, 35	2519, 86	2562, 06	2549, 17	2649, 51	2800, 59	3188, 93	1, 82
Stratum 6	1569, 90	1535, 23	1706, 77	2316, 53	2533, 61	2741, 02	2769, 32	2770, 01	2754, 37	2688, 76	2732, 62	2719, 58	2826, 73	2987, 30	3401, 52	1, 95
Official	1308, 24	1279, 35	1312, 90	1447, 83	1583, 51	1713, 14	1730, 48	1731, 42	1721, 32	1680, 32	1708, 04	1699, 44	1766, 71	1867, 06	2125, 95	1, 46
Industrial	1569, 90	1535, 23	1706, 77	1882, 19	2058, 57	2227, 09	2249, 22	2251, 37	2237, 84	2184, 54	2219, 72	2209, 51	2296, 17	2427, 18	2763, 74	1, 58
Commercial	1569, 90	1535, 23	1706, 77	2171, 75	2375, 27	2569, 70	2596, 41	2597, 13	2581, 35	2519, 86	2562, 06	2549, 17	2649, 51	2800, 59	3188, 93	1, 82
Inflation	5, 5	4, 85	4, 48	5, 69	7, 67	2	3, 17	3, 73	2, 44	1, 94	3, 66	6, 77	5, 75	4, 09	---	
Deflator	1, 8264	1, 7312	1, 6511	1, 5803	1, 4953	1, 3887	1, 3615	1, 3197	1, 2722	1, 2419	1, 2183	1, 1753	1, 1008	1, 0409	1	

Source: Table designed by the author based on information registered in SUI (September 2004 to 2016), for the years 2017 (October) and 2018 (March) the AMB website, General Management, *Management Act 003*, February 12, 2018 and *Management Act 002*, February 2, 2017 were consulted.

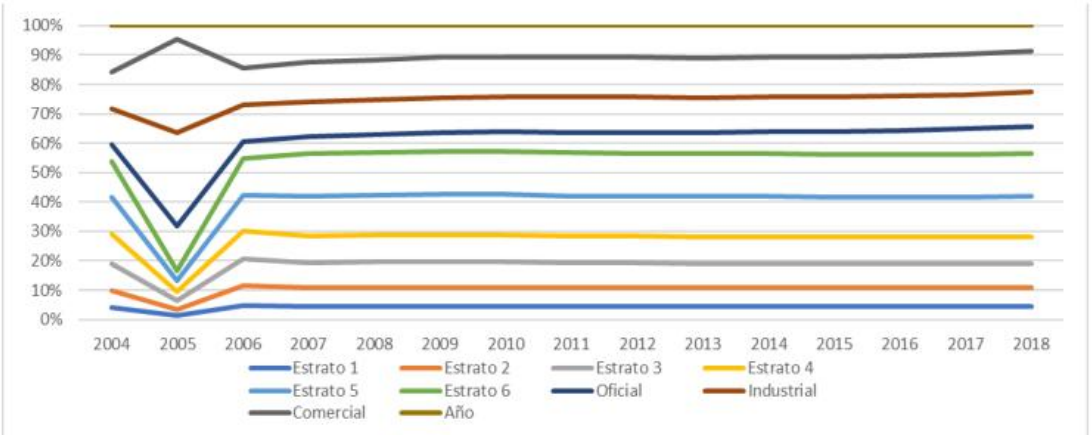

Figure 5. AMB Bucaramanga. Basic consumption tariffs 2004 - 2018. $/m^3 at prices of 2018

Source: Elaborated and designed by the author based on the statistics in Table 1

Figure 7 shows the behavior of potable water tariffs for the fixed charge between 2004 and 2018. For stratum 6, the tariff decreases from 2004 to 2006, increases slightly again in 2007; and all strata and sectors from 2007 onwards maintain a uniform behavior until 2017, when they increase significantly and then decrease again to prices similar to those of 2016.

7.2 Number of subscribers and coverage of aqueduct service -potable water

Table 8 shows the relationship of the number of subscribers by stratum and by sector between the years 2000 and 2017. The stratum with the highest number of subscribers is stratum 3 with 68,978 in 2017, followed closely by stratum 4 with 68,019 in the same year; and those with the lowest number of subscribers are stratum 5 with 13,907 and stratum 6 with 9,795 in 2017. The commercial sector had 24,129 subscribers in 2017 out of a total of 25,016; that is, 96.4% non-residential subscribers. Total residential subscribers increased by 90,959 between 2000 and 2017, and by 10,035 for non-

residential. The total increase in subscribers between the years 2000 and 2017 was 102,182.

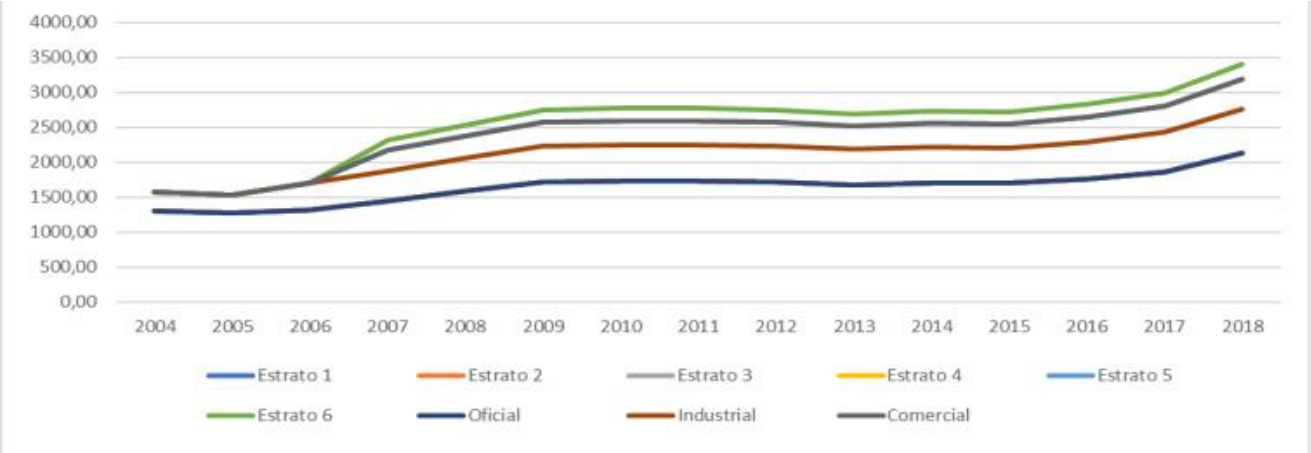

Figure 6. AMB Bucaramanga. Complementary consumption rates 2004 - 2018. $/m3 at 2018 prices

Source: Prepared and designed by the author based on the statistics in Table 5

Table 6. AMB Bucaramanga: Fixed charge rate for potable water, $/m3, September 2004-2018 (at current prices)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Stratum 1	2394,35	2934,41	3228,34	3007,52	3037,11	3233,34	3332	3439	3546	3546	3674	3790	4206	5404, 2	5275,81
Stratum 2	3460,37	4151,07	4519,68	4210,53	4251,95	4526,67	4664	4815	4965	4965	5144	5307	5889	7565,87	7386,13
Stratum 3	5591,20	6403,16	6133,85	5714, 3	5770,51	6143,34	6330	6191	6383	6383	6613	6823	7571	9727,55	9496,45
Stratum 4	6279,42	6403,16	6456,68	6015,05	6074,22	6466,67	6663	6879	7093	7093	7348	7581	8412	10808,39	10551,61
Stratum 5	7535,30	7705,36	8450,00	8870,61	9111,33	9700,01	9995	10318	10639	10639	11022	11371	12618	16212,59	15827,42
Stratum 6	9397,36	8857,96	8450,00	9441,72	9718,75	10346,67	10661	11006	11348	11348	11757	12129	13459	17293,42	16882,58
Official	6279,42	6403,16	6456,68	6015,05	6074,22	6466,67	6663	6879	7093	7093	7348	7581	8412	10808,39	10551,61
industrial	7535,30	7705,36	8450,00	7728,38	7896,49	8406,67	8662	8942	9220	9220	9552	9855	10936	14059,91	13717,09
Commercial	7535,30	7705,36	8450,00	8870,61	9111,33	9700,01	9995	10318	10639	10639	11022	11371	12618	16212,59	15827,42

Source: Table designed by the author based on information registered in SUI (September 2004 to 2016), for the years 2017 (October) and 2018 (March) the AMB website, General Management, Management Act 003, February 12, 2018 and Management Act 002, February 2, 2017 were consulted.

Table 7. AMB Bucaramanga: fixed charge rate for potable water, $/m^3, September 2004-2018 (at 2018 prices)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	T2017/ T2004
Stratum 1	4373, 13	5080, 11	5330, 44	4752, 91	4541, 27	4490, 28	4536, 56	4538, 38	4511, 31	4403, 86	4475, 99	4454, 28	4629, 76	5625, 23	5275, 81	1, 29
Stratum 2	6320, 15	7186, 41	7462, 62	6654, 07	6357, 77	6286, 38	6350, 10	6354, 26	6316, 60	6166, 14	6266, 87	6237, 17	6482, 33	7875, 31	7386, 13	1, 25
Stratum 3	10211, 97	11085, 28	10127, 84	9030, 54	8628, 41	8531, 52	8618, 38	8170, 13	8120, 61	7927, 19	8056, 54	8018, 89	8333, 79	10125, 41	9496, 45	0, 99
Stratum 4	11468, 96	11085, 28	10660, 88	9505, 83	9082, 54	8980, 55	9071, 76	9078, 07	9023, 89	8808, 96	8951, 98	8909, 74	9259, 52	11250, 45	10551, 61	0, 98
Stratum 5	13762, 75	13339, 67	13952, 13	14018, 58	13623, 81	13470, 82	13608, 32	13616, 45	13535, 21	13212, 81	13427, 97	13364, 03	13889, 29	16875, 68	15827, 42	1, 23
Stratum 6	17163, 69	15335, 08	13952, 13	14921, 13	14532, 06	14368, 87	14515, 09	14524, 39	14437, 21	14093, 34	14323, 41	14254, 88	14815, 02	18000, 72	16882, 58	1, 05
Official	11468, 96	11085, 28	10660, 88	9505, 83	9082, 54	8980, 55	9071, 76	9078, 07	9023, 89	8808, 96	8951, 98	8909, 74	8756, 05	11250, 45	10551, 61	0, 98
Industrial	13762, 75	13339, 67	13952, 13	12213, 47	11807, 31	11674, 71	11793, 43	11800, 57	11729, 92	11450, 52	11637, 08	11582, 31	12037, 82	14634, 96	13717, 09	1, 06
Commercial	13762, 75	13339, 67	13952, 13	14018, 58	13623, 81	13470, 82	13608, 32	13616, 45	13535, 21	13212, 81	13427, 97	13364, 03	13889, 29	16875, 68	15827, 42	1, 23
Inflation	5, 5	4, 85	4, 48	5, 69	7, 67	2	3, 17	3, 73	2, 44	1, 94	3, 66	6, 77	5, 75	4, 09	---	
Deflator	1, 8264	1, 7312	1, 6511	1, 5803	1, 4953	1, 3887	1, 3615	1, 3197	1, 2722	1, 2419	1, 2183	1, 1753	1, 1008	1, 0409	1	

Source: Table designed by the author based on information registered in SUI (September 2004 to 2016), for the years 2017 (October) and 2018 (March) the AMB website, General Management, Management Act 003, February 12, 2018 and Management Act 002, February 2, 2017 were consulted.

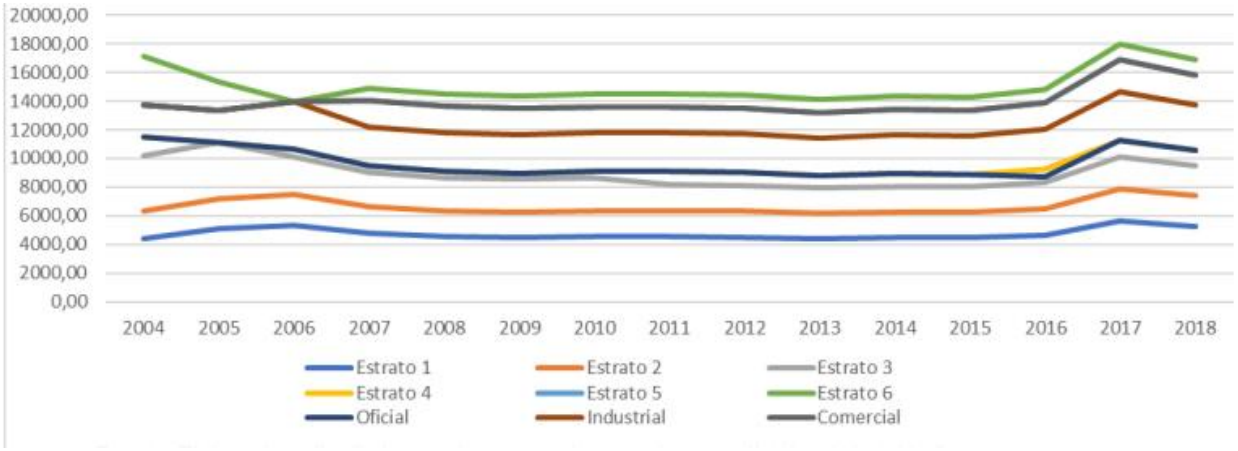

Figure 7. AMB Bucaramanga. fjo charge rates 2004 - 2018. $/month subscriber, at 2018 prices

Source: Prepared and designed by the author based on the statistics in Table 2

The coverage of the aqueduct service (potable water) in the city of Bucaramanga is 79.10% according to the 2017 report prepared by SUI; while for DANE it is 96.1%. According to the municipal population projections, 2005 - 2020 by DANE, the number of inhabitants of the city of Bucaramanga for the year 2017 would be 522,224. 52.4% of the dwellings are houses and 40.4% are apartments. Households with 3 and 4 persons predominate, for an average of 3.6 persons per household; 46.8% of the total population are men and 52.2% are women; 46.3% of the population is single and 26.7% are married.

7.3 Average consumption per subscriber per month

Table 9 shows the average consumption of potable water in m^3/month for the population strata of Bucaramanga. The average consumption (last fla) for all strata and sectors decreased by 5.21m^3/month by going from an average consumption of 19.41 m^3/month in 2005 to 14.2 m^3/month in 2017. Strata 4, 5 and 6 were the ones that most reduced the average consumption in m^3/month exceeding 6m^3, and strata 6, very close to 7 m^3; the lowest reduction is that of strata 1 with 3.33 m^3.

8 Conclusion

In the practice of the public drinking water service operated by the AMB in the city of Bucaramanga, equity is achieved through subsidies for the lower strata, financed with taxes (national and local government) and with surcharges for the upper strata (cross-subsidies). Regulation and equity, through state and cross-subsidies, is the responsibility of the government (i.e., a political issue), while efficiency is the responsibility of the regulator and the service operator (a technical issue). However, this separation is not straightforward, as taxation and benefits affect the incentive structure and have the potential to distort efficiency. Thus, the tariff of a residential public utility ultimately has a high political ingredient.

The reduction in consumption (Table 9) considerably postpones investments in expansion of water production capacity, and in this reduction of consumption, the change in consumption habits and customs of water use, the replacement of existing hydraulic devices or appliances (in new homes and in the renovation of old homes), educational and pedagogical campaigns of rationalization (especially with children and young people in schools), and relevantly, economic measures such as high tariffs and consumption blocks have played an important role. While the number of subscribers grew 161% (Table 8) from 168,745 subscribers in 2000 to 270,927 in 2017, the city's potable water consumption decreased on average to 5.21 m^3/month (Table 9).

Table 8. AMB Acueducto Bucaramanga. Number of subscribers by stratum and sector 2000 - 2017

Year	2000	2002	2004	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Stratum 1	12. 678	15. 147	16. 316	22. 757	22. 850	23. 443	24. 025	23. 287	23. 448	22. 548	23. 123	25. 104	27. 351
Stratum 2	40. 928	42. 804	43. 665	43. 678	46. 213	46. 739	47. 286	48. 224	49. 213	52. 069	53. 684	54. 551	57. 273
Stratum 3	52. 115	52. 224	52. 668	55. 430	57. 392	57. 988	59. 473	61. 200	62. 834	63. 354	64. 859	66. 595	68. 978
Stratum 4	36. 652	37. 489	39. 447	44. 124	45. 952	48. 369	50. 225	51. 471	54. 864	57. 970	61. 244	64. 963	68. 019
Stratum 5	4. 690	4. 823	5. 220	6. 838	7. 242	7. 655	8. 063	8. 657	9. 056	9. 942	11. 297	12. 642	13. 907
Stratum 6	6. 701	6. 607	6. 659	7. 602	7. 847	8. 148	8. 386	8. 742	8. 794	9. 012	9189	9. 567	9. 795
Subtotal	153. 764	159. 094	163. 995	180. 424	187. 496	192. 352	197. 460	201. 581	208. 211	214. 895	223. 486	233. 422	244. 723
Official	-----	-----	-------	------	-------	-------	-------	-------	------	760	762	766	764
Industrial	-----	-----	-------	------	-------	-------	-------	-------	------	138	125	121	123
Commercial	-----	-----	-------	------	-------	-------	-------	-------	------	22. 239	22. 806	23. 605	24. 129
No residencial	14. 981	15. 468	16. 944	20. 189	20. 848	21. 558	22. 739	23. 435	24. 441	223. 237	23. 693	24. 492	25. 016
TOTAL	168. 745	171. 857	180. 909	200. 618	208. 344	213. 900	220. 197	225. 016	232. 660	239. 866	249. 180	260. 008	270. 927

Source: Table designed by the author based on information obtained from AMB's management reports and/or sustainability reports in different years

The tariff for basic consumption in 2018 pesos decreases in 2005 for all strata and sectors and increases systematically and uniformly between 2006 and 2018. The last column of Table 5 relates the value of the 2004 tariffs in relation to the 2018 tariffs, and with the exception of strata 3 and 4 and the industrial sector, for the other strata and sectors, the tariffs reach a value greater than double.

The rate of the fixed charge for stratum 1 is the lowest and for stratum 6 the highest (including the industrial and commercial sectors). In the last column of Table 5, it is evident that the 2018 tariff is lower than that of 2004 for strata 3 and 4 and the industrial sector, and slightly higher for the other strata and sectors.

The water supply, conservation and savings policy has focused basically on prices (tariffs) and on rationalizing the service in times of scarcity through service suspensions and cuts; the use of technologies developed in other countries and incorporated in new housing construction has also been disseminated and promoted. The change to horizontal housing construction, with little or no green areas, has also contributed to lower water use, as have the socially sensitive educational

campaigns at the national level aimed at achieving voluntary savings through the altruism of users. The change in consumption habits is also evident, with greater use in the last 15 years of car washing services, washing clothes and household garments, and food service in restaurants or at home; this of course has reduced water consumption in households.

Table 9. AMB Acueducto Bucaramanga. Average consumption m^3/month subscriber

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2005/ 2017
Stratum 1	18,83	18,15	18,30	17,96	17,26	16,63	16,47	16,75	17,21	17,56	17,3	15,9	15,5	3,33
Stratum 2	20,24	20,28	20,39	19,72	18,69	17,44	17,19	17,21	17,31	17,42	16,6	15,5	14,8	5,44
Stratum 3	19,59	19,60	19,61	19,07	18,23	17,31	16,92	16,98	16,46	16,18	15,6	14,4	13,8	5,79
Stratum 4	19,42	19,08	18,82	18,10	17,30	16,10	15,68	15,47	15,13	14,57	15,0	13,8	13,2	6,22
Stratum 5	19,56	19,60	19,24	18,37	17,87	16,12	15,47	15,24	15,01	14,90	16,0	14,3	13,5	6,06
Stratum 6	23,26	22,62	22,25	21,05	20,18	18,07	17,46	17,37	17,14	16,65	18,6	17,4	16,4	6,86
Average	19,41	19,56	19,47	18,81	17,99	16,84	16,46	16,42	16,19	15,92	16,0	14,8	14,2	5,21

Source: Prepared by the author based on: Bonilla, Santana and Sotomayor, (2015). And according to SUI statistics, table 2005-2014, p. 49; CRA

AMB 2015, 2016 and 20017: Indicators for social control of service providers (average consumption m^3/month user).

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Acueducto Metropolitano de Bucaramanga, S.A. E.S.P., AMB (2018). Acto de Gerencia 003, febrero 12 de 2018 y Acto de Gerencia 002, febrero 2 de 2017. En: Gerencia General, Página web AMB, Bucaramanga.

[2] Acueducto Metropolitano de Bucaramanga, S.A: E.S.P., AMB (2018). Informes de Gestión de 2000 a 2017. Página web AMB, Bucaramanga.

[3] Acueducto Metropolitano de Bucaramanga, S.A: E.S.P., AMB (2018). Tarifas vigentes: Cargo fjo y cargo por consumo, 2004-2017. Página web AMB, Bucaramanga.

[4] Arbués, F. y Barberán, R. (2008). La equidad en el diseño de la tarifa del agua para uso doméstico. El caso de Zaragoza, España. Departamento de Economía Aplicada; Publicación Documento, Universidad de Zaragoza, España.

[5] Bonilla, J.; Santana, M. y Sotomayor, C. (2015). Rango de consumo básico. Documento de trabajo proyecto general, CRA, Bogotá, junio 06.

[6] Bös, D. (1985). *Economic Theory of Public Enterprise*. Springer, New York.

[7] Brown, S. & Sibley, D. (1986). *The Theory of Public Utility Pricing*. Cambridge University Press.

[8] Coase, R. (1946). The Marginal Cost Controversy. *Economica*,13(51), 169-182. doi:10.2307/2549764

[9] Comisión de Regulación de Agua, CRA. Resolución CRA 750 de 2016 "Por la cual se modifca el rango de consumo básico", Bogotá, Colombia.

[10] CRA (2004). Metodología y Fórmula Tarifaria para Regular los Servicios Públicos de Acueducto y Alcantarillado. Documento de Trabajo. Bogotá, mayo de 2004.

[11] Feldstein, M. (1972). La equidad distributiva y la estructura óptima de precios públicos. *American Economic Review*, (61).Feldstein, M. (1972b). Equity and Efficiency in Public Sector Pricing: The Optimal Two-Part Tarif. *The Quarterly Journal of Economics*, 86(2), 176-187. Recuperado de http://www.jstor.org/stable/1880558

[12] Herderson, A. (1947). La Fijación de Precios de las Empresas de Servicios Públicos. En: *La economía del bienestar, selección de Arrow Kenneth y Scitovsky Tibor*. México: Fondo de Cultura Económica.

[13] Lewis, W. (1941). The Two-Part Tarif: A Reply. *Economica*, 8(32), 399-408. doi:10.2307/2550106

[14] Musgrave, R. (1969). *Teoría de la Hacienda Pública*. [Traducido al español de The Theory of Public Finance]., México, Aguilar S.A.

[15] Ministerio de Ambiente, Vivienda y Desarrollo Territorial. (2003). Metodologías para la valoración económica de bienes, servicios ambientales y recursos naturales. Bogotá, Colombia.

[16] Pigou, A. (1920): The Economics of Welfare. Edit. Mcmillan, Londres. Edición castellana publicada por el Instituto de Estudios Fiscales. — (1928).

[17] Silva, J. y Figueredo, E. (2008). "Gestión de servicios públicos". Módulo del Programa de Administración Pública Territorial. ESAP, Bogotá (acceso libre en internet).

[18] Silva, J. (Noviembre, 2011). "El proceso de participación ciudadana y las políticas públicas de los servicios públicos domiciliarios, SPD, en Colombia: caso Bogotá". Ponencia presentada al XVI Congreso Internacional del CLAD, Asunción, Paraguay.

[19] Silva, J. (2012). *Bienes públicos e interés colectivo: la prestación del servicio público domiciliario de agua potable en Bogotá*. (Tesis doctoral, Universidad Nacional). Recuperado de http://bdigital.unal.edu.co/9129/1/ joseplacidosilvaruiz.2012.pdf.

[20] Silva, J. (Septiembre, 2014). "Tarifas, Subsidios y Equidad en la Prestación de los Servicios Públicos Domiciliarios en Colombia: el caso del agua potable en la ciudad de Bogotá". Ponencia presentada en las 47° Jornadas Internacionales de Finanzas Públicas, Universidad de Córdoba, Argentina.

[21] Superintendencia de Servicios Públicos Domiciliarios, SSPD. Régimen Básico. Contenido: Leyes 142 y 143 de 1994, Ley 689 de 2001, Ley 632 de 2000, Decretom990 de 2002. Bogotá, Colombia.

[22] Superintendencia de Servicios Públicos Domiciliarios, SSPD; Sistema Único de Información de Servicios Públicos Domiciliarios, SUI. Consulta Libre en la WEBB de la SSPD, Servicio de Acueducto de Bucaramanga.

[23] Vickrey, W. S. (1987). "Marginal - and Average - Cost Pricing", *The New Palgrave*, 3. MacMillan, New York, pp. 311-318.

[24] Willig, R. (1976). Consumer's Surplus Without Apology. *The American Economic Review*, 66(4), 589-597. Recuperado de http://www.jstor. org/stable/1806699