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Performance of water usage charge in the Nation's domain as a water resource management tool in the São Francisco River basin

Atuação da cobrança pelo uso da água de domínio da união como instrumento de gestão de recursos hídricos na bacia hidrográfica do Rio São Francisco

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ABSTRACT

The present work consists in a study on the performance of usage charge as a management tool in the São Francisco River Basin in the period between 2010 and 2013, according to the objectives defined by the law 9.433/97. The objectives of this study considers: assessment of user participation in the amounts billed and type of use; comparative analysis of charged and collected amounts in the basin to observe user compliance to payments; analysis of the application of financial resources obtained from the revenue particularly the actions set forth by the basin investment plan, review of the evolution of uses: withdrawal, consumption, organic load discharge to assess the influence of usage charge on the rational use of water resources and comparison of pricing mechanisms of the Paraíba do Sul river, Piracicaba-Capivari-Jundiá rivers, Doce river and São Francisco river basins for major uses. It is noted that the compliance by users to the usage charge is increasing gradually. Even though over 91% of the payments were on time by users in 2013, the financial resources obtained and the management to employ them do not meet the actual needs for investments in the basin conservation actions. With regards to the use of water withdrawal it is not observed the effect of the usage charge. For the uses of consumption and organic load discharge, the results were minor but positive. It is recommended a review of the reference flow and parameters of charging for water resources uses, and also it is suggested a study of the mechanisms of usage charge models implemented in the Paraíba do Sul river, Piracicaba-Capivari Jundiá river and Doce river basins, which uses the granted and measured flows for adjustments in the usage charge model, in the São Francisco river basin. All in all, the implementation of water usage charge in the São Francisco River basin despite it being recent, it is a process that will gradually be consolidating and contributing to environmental sustainability of the basin.

Keywords: Water usage charge; Management tool; Evolution of the uses of water; São Francisco River basin.

RESUMO

O presente artigo versa sobre a atuação da cobrança como instrumento de gestão na Bacia Hidrográfica do rio São Francisco no período entre 2010 e 2015, de acordo com os objetivos definidos na Lei 9.433/97. Os objetivos deste trabalho contemplaram: avaliação da participação dos usuários nos valores cobrados e por tipo de uso; comparação entre os valores cobrados e arrecadados para observar a aceitação do usuário em relação ao pagamento; aplicação dos recursos financeiros obtidos com arrecadação em relação às ações previstas no plano de investimento da bacia, avaliação da evolução dos usos: captação, consumo, lançamento de carga orgânica visando aferir a influência da cobrança no uso racional dos recursos hídricos e comparação entre os mecanismos de cobrança das bacias dos rios Paraíba do Sul, Piracicaba-Capivari-Jundiá, Doce e São Francisco para os principais usos. Observou-se que a aceitabilidade dos usuários em relação à cobrança vem aumentando gradativamente. Apesar da adimplência dos usuários superior a 91% em 2013, os recursos financeiros arrecadados e a gestão da aplicação destes estão aquém da real necessidade de investimentos em ações de conservação da bacia. Em relação ao uso de captação de água não se observa o efeito da cobrança. Para os usos de consumo de água e lançamento de carga orgânica foram observados resultados discretos mas positivos. Recomenda-se uma revisão quanto aos critérios das vazões de referência e parâmetros da cobrança pelos usos dos recursos hídricos, bem como sugere-se estudar os mecanismos do modelo de cobrança das bacias dos rios Piracicaba-Capivari-Jundiá e Paraíba do Sul, que utilizam a vazão de outorga e a vazão aferida para ajustes



no modelo de cobrança vigente na Bacia Hidrográfica do rio São Francisco. De uma forma geral, a implantação da cobrança pelo uso da água na bacia do rio São Francisco apesar de ser recente, é um processo que aos poucos vem se consolidando e contribuindo para a sustentabilidade ambiental da bacia.

Palavras-chave: Cobrança pelo uso da água; Instrumento de gestão; A evolução dos usos da água; Bacia hidrográfica do rio São Francisco.

INTRODUCTION

Water is an essential resource used as a raw material to supply human, industry, irrigation, power generation and as a means of support in the case of navigation and fishing, as well as being the final destination for waste.

Water resources have suffered from the increasing localized demand, due to population growth, accelerated industrialization processes and urbanization, uneven distribution in Brazil, in addition to the expansion of irrigated agriculture in the country, registered in Brazil from the second half of the XX Century (SETTI et al., 2001).

In this scenario, it stands out as positive the structuring of the water resources sector management in Brazil, aiming to comply with social-environmental and economic demands of a developing country (AZEVEDO et al., 2003).

The proper valuation of water resources is essential to encourage the rational and sustainable use of water (WORLD WATER FORUM, 2012) and shows the need to reconcile the economic development with social and environmental sustainability (HESPANHOL, 2008).

As a public good, only the public sector can promote this valuation in all its dimensions. It is up to it to promote the regulation, supervision and charging for the use of water, combined with incentive policies for rational use (RAMOS; FORMIGA-JOHNSSON, 2012).

Charging for the use of raw water is an economic tool of the National Water Resources Policy management, instituted by the Federal Law 9.433/97. Its inclusion in the Brazilian legislation, along with other management tools, can be understood as a reaction to the constant degradation of hydrographic basins, in order to incorporate the principles of economic valuation (ACSELRAD, 2013).

In addition to their goals to rationalize the use of water and discourage pollution, it is the management tool that allows the provision of resources to finance the investment program of the basin (PEREIRA; FORMIGA-JOHNSSON, 2005).

Charging for the use of raw water acts as a balancing factor between supply and demand. The acknowledgement that water is an economic good and prone to be valued only materializes by a billing instrument for its use (BARCELLOS; ACSELRAD; COSTA, 2011).

In the rivers of the Nation's domain, the usage charge was implemented in the basins of Paraíba do Sul River, Piracicaba, Capivari and Jundiá Rivers, São Francisco River and Doce River.

In the São Francisco River Hydrographic Basin – BHSF (for its acronym in Portuguese), water usage charge started in July 2010 for withdrawal, consumption and wastewater discharge.

Given the extreme importance of the São Francisco River in the provision of water to the semi-arid region and the need for environmental recovery of degraded areas to mitigate the impacts on water resources, this article aims to analyze the performance of charging for water usage as a water resources management tool within the São Francisco River Basin, as an encouragement of a more rational water usage and the provision of financial resources to enable actions of the water resources Master Plan of the basin. It was also carried out a comparison with the pricing mechanisms for water use already in place in the Paraíba do Sul River, Piracicaba-Capivari-Jundiá (PCJ) Rivers and Doce River basins.

Considering that only the State of Minas Gerais has introduced the usage charge in the state domain rivers in accordance with the guidelines established by the Federal Law 9.433/97 and because of the difficulty of obtaining consistent information regarding the water usage charge of the state domain, it was chosen for this work to develop the studies only considering the São Francisco River water usage.

STUDY AREA

The São Francisco River Basin covers a 638,576 km² of drainage area (7.5% of the country) and natural average flow at the mouth of 2,846 m³/s (ANA, 2013), but throughout the year it can vary between 1,077m³/s to 5,290m³/s (BRASIL, 2006). The São Francisco River is 2,700 km long, rising in the Serra da Canastra in Minas Gerais, flowing in the south-north direction over seven federative states: Bahia (48.2%), Minas Gerais (36.9%), Pernambuco (10.8%), Alagoas (2.2%), Sergipe (1.2%), Goiás (0.5%) and Federal District (0.2%) - and 521 counties (about 9% of the counties in the country). Given its extensive territorial dimension, the basin was divided into 04 (four) sub-regions, as indicated in Figure 1, for planning purposes and to favor a characterization of the populational and natural peculiarities (CBHSF, 2015).

In the hydrographic basin of the São Francisco River there are several types of water uses, which gives it an important feature for the development of studies, compatibility and optimization of these uses, especially power generation, navigation, irrigation, fishing, tourism and leisure, dilution of effluents, domestic supply, mining, among others (ANA, 2003).

METHODOLOGY

The study was based mainly on gathering information on websites and direct consultation with the National Water Agency – ANA (for its acronym in Portuguese) and the Executive Support Association for Peixe Vivo Hydrographic Basins Management – AGB Peixe Vivo (for its acronym in Portuguese). It was used

lists annually made available with data of registered users and of withdrawal, consumption and organic load discharge flows, amounts charged and paid in the hydrographic basin of the São Francisco River by multiple uses of raw water. To support the

results obtained, the works were developed from the analysis of the following topics:

- Description of pricing mechanisms and fees for the use of water resources;



Figure 1. Physiographic division São Francisco River Basin. Source: CBHSF Resolution n° 74 (CBHSF, 2012).

- Evaluation of user participation in the amounts charged and by type of use;
- Comparative analysis: amount charged x amount collected;
- Assessment of the evolution of uses: withdrawal, consumption, organic load discharge;
- Analysis of the charging methodologies applied to the main uses in hydrographic basin of the São Francisco River, Paraíba do Sul River, Piracicaba-Capivari-Jundiá Rivers and Doce River.

Description of pricing mechanisms and fees for the use of water resources

Charging for the use of water resources in the hydrographic basin of the São Francisco River was the third experience in rivers of the Nation's domain to be implemented in Brazil. The calculation methodology proposed by the São Francisco River Basin Committee to charge for withdrawal, consumption and discharge of effluents, follows the guidelines established in the National Water Resources Policy, which determines that the usage charge will focus on the uses subject to grant.

The pricing mechanisms and fees for calculating the usage charge were established by the CBHSF resolution n°. 40/08 and are highlighted below:

Withdrawal

$$Value_{CAP} = Q_{CAP} \times PPU_{CAP} \times (K_{CAP\ CLASSE} \times K_T) \quad (1)$$

In wich: $Value_{CAP}$: Annual payment for water withdrawal; Q_{CAP} : Withdrawed water flow; PPU_{CAP} : Basic Unit Price for water withdrawal; $K_{CAP\ CLASSE}$: Multiplier unit price coefficient for withdrawal depending on the river class at the pickup point; K_T : Coefficient that takes into account the good practices of conservation and use of water.

Consumption

$$Value_{CONS} = Q_{CONS} \times PPU_{CONS} \times K_T \quad (2)$$

In wich, $Value_{CONS}$: Annual payment for water consumption; Q_{CONS} : Water flow consumed; PPU_{CONS} : Basic Unit Price for water consumption.

Organic load discharge

$$Value_{BOD} = CO_{BOD} \times PPU_{LANÇ} \times K_{LANÇ} \quad (3)$$

In wich, $Value_{BOD}$: Annual payment for discharge of BOD load; CO_{BOD} : Annual $BOD_{5,20}$ load (Biochemical Oxygen Demand after 5 days at 20 °C) discharged in the receiving body; $PPU_{LANÇ}$: Basic Unit Price for the $BOD_{5,20}$ load discharged; $K_{LANÇ}$: Coefficient that considers the specific objectives to be achieved by charging for the organic load discharge

Consider $CO_{BOD} = C_{BOD} \times Q_{LANÇ}$ where C_{BOD} corresponds to the average annual concentration of $BOD_{5,20}$ discharged in kg/m^3 and $Q_{LANÇ}$ is the total annual discharged volume in m^3 .

Particularly for the irrigation sector, it is adopted that the amount charged for consumption, the following equation.

$$Value_{CONS} = Q_{CONS} \times K_{CONS\ IRRIG} \times PPU_{CONS} \times K_T \quad (4)$$

In wich, $K_{CONS\ IRRIG}$ is the coefficient which aims to quantify of volume of water consumed by irrigation.

Transposition of basins

The usage charge for water volumes transposed to other basins considers the volumes withdrawn and consumed, where the consumed volume is equivalent to 100% of the withdrawal.

The usage charge for the transposition of basins is calculated by the following equation.

$$Value_{CONS} = (Q_{CAP} \times PPU_{CAP} + Q_{CONS} \times PPU_{CONS}) \times \left(\frac{K_{CAP\ CLASS} \times}{K_{PRIORIDADE}} \right) \quad (5)$$

In wich, $K_{PRIORIDADE}$: coefficient that takes into account the priorities of use as established in the São Francisco River Basin Water Resources Plan.

In this case, it was considered that all discharging happened in the receiving basins, so there is no portion corresponding to the discharge in this mechanism.

This usage charge is conceived by the São Francisco River Integration Project – PISF (for its acronym in Portuguese), whose flow granted of 26.4 m^3/s corresponds to the projected demand for the year 2025 for human and animal consumption.

The multiplier coefficients were established in order to adapt the pricing mechanisms as specific objectives determined by the São Francisco Hydrographic Basin Committee and they are summarized in Table 1.

The Public Unit Prices – PPU (for its acronym in Portuguese) were established in order to promote the rational use and to obtain financial resources to finance recovery actions of the basins. The PPU can be adjusted when assessing the implementation of this management tool in the basin every 3 (three) years, starting from the beginning of charging. Aspects related to the impact of usage charges on the users were considered for the proposal of the unit price since it is a price limiting factor. Table 2 has the unit values for each type of use.

Table 1. Multiplier coefficients of pricing:

Variable	Class	Value
Kcap classe	1	1.1
	2	1
	3	0.9
	4	0.8
Kcons irrig		0.9
Kt (for irrigation, livestock and aquaculture)		0.025
Kt (other sectors)		1
Klanç		1
Kprioridade (for supply)		0.5

Source: CBHSF Resolution n°40/2008 (CBHSF, 2008).

Table 2. Public Unit Prices by type of use in the rivers of the Nation's domain in BHSF.

Type of use	Unit	Value (R\$)
Raw water withdrawal	R\$/ m^3	0.01
Raw water consumption	R\$/ m^3	0.02
Organic load release	R\$/kg of BOD	0.07

Source: CBHSF Resolution n°40/2008 (CBHSF, 2008).

RESULTS AND DISCUSSION

Assessment of user participation in the amounts charged and by type of use

It was analyzed the participation of user segments in relation to the use for withdrawal, consumption and organic load discharge in the basin, as well as the amounts charged.

In this study, the amounts charged by the PISF were considered entirely for the purpose of the sanitation sector since the corresponding grant refers to human and animal consumption.

The charged amounts were obtained based on the information provided in reports by AGB Peixe Vivo and approved by the ANA.

As follows, Figures 2 to 5 represent, respectively, the percentage distribution for the amounts charged, volumes withdrawn, volumes consumed and organic load discharged by the major user sectors in the period of 2011 to 2015.

It is observed in Figure 2, a large representation of the sanitation sector in the amounts charged, participating with a percentage of approximately 82% of the total, followed by irrigation with about 9.8%. Nevertheless, in Figures 3 and 4, it can be seen that the irrigation sector has the largest number of users and is also largely responsible for water withdrawal and consumption with percentage above 84 and 93% of the total, respectively. Although most water use is for irrigation, this is not reflected in the amount charged in the basin by the use of this sector. This fact is explained by the implementation of pricing mechanisms, more precisely the coefficient K_t , which concedes the irrigation sector a discount of 97.5% when compared to other users.

Regarding organic load discharge (kg of $BOD_{5,20}$), the sanitation sector corresponds to 93.7% of the total, followed by aquaculture and the industrial sector, with far less significant values.

Figures 6 and 7 shows the percentage of participation of users in relation to the percentage of usage charge and of the total accumulated withdrawn volumes for the year of 2015, since this is the most recent period for representation of the information.

What can be shown in Figure 6 is that about 10% of users account for 93% of the total amount charged in the São Francisco River Basin. In this context, special attention should be given to the PISF with the North Northeast Hydrographic Basins, representing a revenue of over 50% of the total amount charged in the basin. With regards to the volume withdrawn for the same number of users, this percentage decreases to 83%.

In this context, it is important to note that 10% of users that have the largest withdrawal flows are not the same as the 10% of users participating in the largest amounts charged, as it can be seen in Figures 8 and 9.

Comparative analysis: amount billed vs amount collected

Amounts billed and collected between the years of 2010 and 2013 are shown in Figure 10.

It is important to note that the Public Unit Prices were not been subject to any changed since its establishment, unlike what happened in the Paraíba do Sul, PCJ and Doce Rivers basins, the

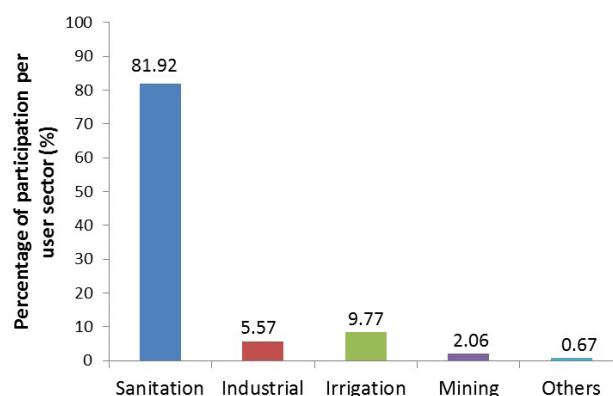


Figure 2. Amounts charged by user sectors from 2011 to 2015. Source: Adapted from the AGB Peixe Vivo (2016).



Figure 3. Volume withdrawn by user sectors from 2011 to 2015. Source: Adapted from the AGB Peixe Vivo (2016).

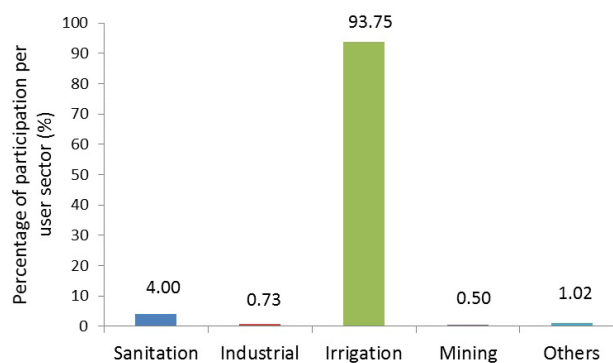


Figure 4. Volume consumed by user sectors from 2011 to 2015. Source: Adapted from the AGB Peixe Vivo (2016).

latter two have allowed for the escalation of public unit prices in the periods of 2014 to 2016 and 2012 to 2015 respectively.

Figure 10 shows that the non-payment with regards to the amount charged decrease since 2010, according to the percentage ratio between the amounts collected and billed for the years of 2010, 2011, 2012 and 2013 were respectively: 24.5%, 9.53%, 10.03% and 8.75%. In this case, the difference between the total amount billed and the payments for the period of 2010-2013 sums up to approximately R\$ 9.3 million.

In light of what was observed, one can note the occurrence of the reduction of non-payments during this period and an increase in the level of acceptance by the paying users, as the habit of paying for the use of water becomes more consolidated.

The summary of the total revenue data, which also considered late payments of previous years and the interest for late payment by user sector in the period, is shown in Table 3.

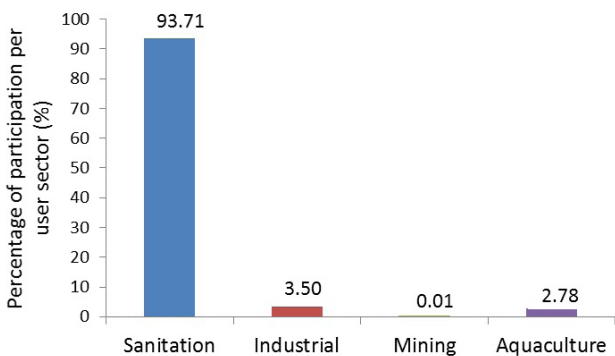


Figure 5. Organic load discharged by user sectors from 2011 to 2015. Source: Adapted from the AGB Peixe Vivo (2016).

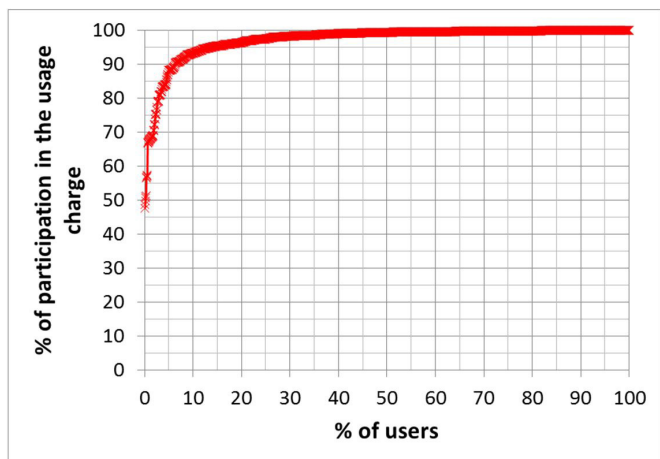


Figure 6. Relative participation of users in the amounts charged in 2015. Source: Adapted from the AGB Peixe Vivo (2016).

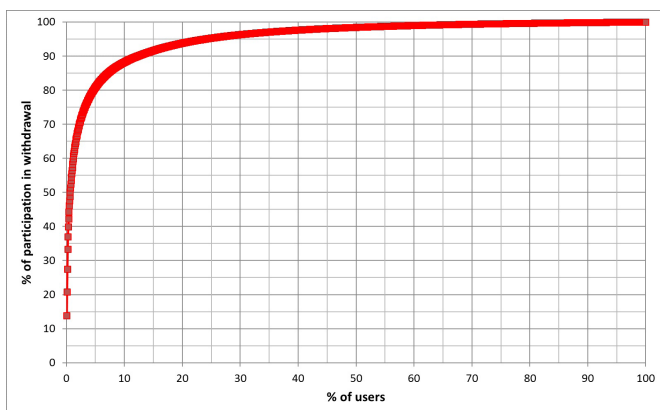


Figure 7. Relative participation of users in water withdrawal in 2015. Source: Adapted from the AGB Peixe Vivo (2016).

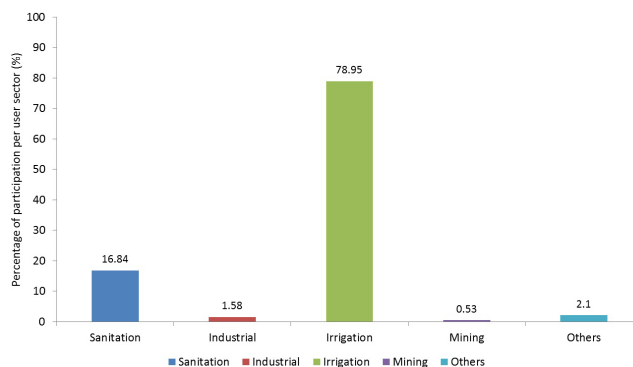


Figure 8. Breakdown of the top 10% users with the largest withdrawal flows in 2015. Source: Adapted from the AGB Peixe Vivo (2016).

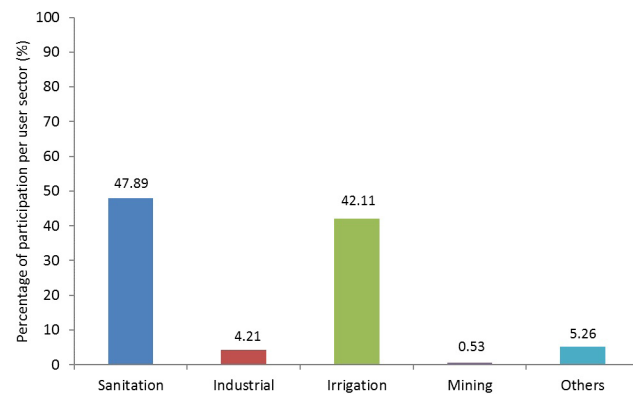


Figure 9. Breakdown of the top 10% users with the largest amounts charged in 2015. Source: Adapted from the AGB Peixe Vivo (2016).

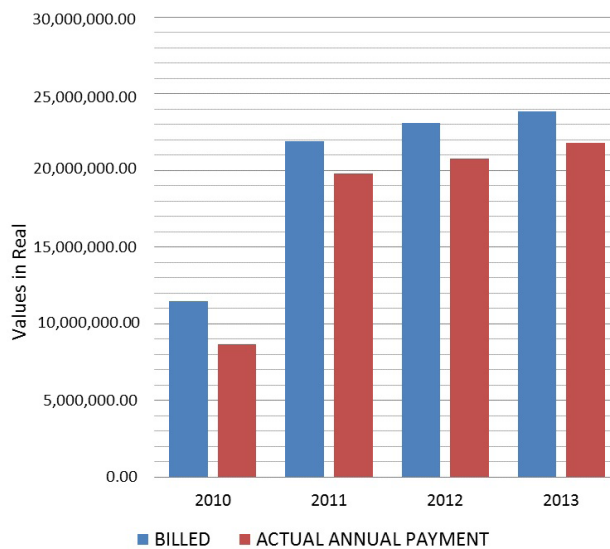


Figure 10. Billing and actual annual payment for the use of water resources in the Nation's domain in the São Francisco River Basin from 2010 to 2013. Source: Adapted from the ANA (2016b).

In November 2011, intermediate milestones were established in the CBHSF Resolution No. 64 (CBHSF, 2011) to meet the commitments made in the Charter of Petrolina to promote the revitalization and improvement of life of the population of the basin. In this decision it was pointed out the need for investments of around R\$ 10.6 billion (adjusted by the IGP-M for January 2014) to achieve the following milestones:

- Provide each physiographic region, as referred to in the Basin Plan, with an average level of 90% total coverage of water supply;
- Increase by, at least, 20% of the water supply ratio to the districts, villages and other rural settlements in each physiographic region;
- Reach all the scattered population by means of the Brazil without Poverty Program / Water for All Program with the construction of at least 50 thousand new water tanks;
- Provide each physiographic region with an average ratio of 70% of total wastewater collection and reach 10% of wastewater treatment of all counties;
- Provide each physiographic region with an average ratio of 90% of urban waste collection and increase by 20% the number of counties with adequate final disposal;
- Make sustainable investments of constructions for collection, infiltration and drainage of rainwater in, at least, 10% of the number of counties that have occurrence of overflows or floods in the last 5 years;
- Promote actions for the recovery of 15 thousand hectares of degraded areas in the basin;
- Promote actions for the recovery and protection of 320 springs distributed in the physiographic regions;
- Carry out 4 pilot projects of payment for environmental services (PSA), such as ANA's Water Producer Program, being one project per physiographic region, as referred to in the Basin Plan.

Starting from the values shown in Table 3 and by making a projection with the values collected from 2011 to 2014, it results in an average annual income of R\$ 21.8 million and estimated revenue of R\$ 87.2 million by 2014, which in percentage values would represent less than 1% of the resources needed for the implementation of these goals.

Although the amount collected in the São Francisco River Basin are significant, they are still much lower than the financial resources needed to enable the recovery and conservation actions of the basin.

Analysis of the expenditure of raised funds

The Management Contract n° 14/ANA/2010, between ANA and AGB Peixe Vivo, ensures the transfer of the amounts collected from usage charges in the São Francisco River Basin for the basin Agency, who must apply the resources from water usage charges to finance activities and actions set out by the Application Plan.

The disbursement of the collected funds transferred by ANA to AGB Peixe Vivo in the period 2010-2015 is summarized in Table 4.

From these funds it will be implemented actions set out by the BHSF Multi-Year Application Plans – PAP (for its acronym in Portuguese), which includes funding for research, programs, projects and works included in the basin's water resource plan, as well as the payment of implementation and administrative costs of the basin's Agency.

The amounts disbursed by AGB Peixe Vivo for the period 2010-2012 were invested as shown in Table 5.

In 2010 investments for management actions, in general, considered legal advice activities. In this initial phase, low investments were motivated by the need to enable the legal procedures for planning, organizational structure and operation of the agency.

In 2011 the resources for investment were used to fund the members of the Committees, expenses related to plenary sessions, meetings, events, installation and maintenance of the Regional Advisory Councils – CCRs (for its acronym in Portuguese), as well as expenses with signed contracts. In the same year, a consulting firm was hired to technically enable 22 hydro-environmental projects approved by the São Francisco River Basin Committee – CBHSF (for its acronym in Portuguese), whose actions include the construction of contour lines, palisades, terraces and dams to contain rainwater; ecological improvements of local roads; plant recovery; fencing springs, as well as setting off community awareness around environmental education initiatives.

In 2012, funds were invested as follows:

- Management Actions: Carried out plenary meetings, technical chambers, regional advisory chambers, workshops and seminars;

Table 3. Revenue data in the period of 2010 to 2015.

Year	Amount collected
2010	R\$ 8,631,051.38
2011	R\$ 20,923,090.74
2012	R\$ 21,500,946.04
2013	R\$ 21,756,468.25
2014	R\$ 23,078,290.97
2015	R\$ 22,490,082.50
TOTAL	R\$ 118,379,929.88

Source: Adapted from the ANA (2016b).

Table 4. Amounts transferred and disbursed in the period of 2010 to 2015.

Period	Transferred to AGB Peixe Vivo, including earnings	Total disbursement by AGB Peixe Vivo
2010	2,384,267.08	392,187.27
2011	29,538,055.71	3,620,845.00
2012	22,320,282.06	8,060,331.76
2013	23,903,792.57	16,230,763.83
2014	29,509,744.95	16,459,975.42
2015	24,115,086.83	20,637,481.00
TOTAL	131,771,229.20	65,401,584.28

Source: Adapted from the ANA (2016a).

- Planning Actions: Contracted project management, technical and operational advisory services companies for the project development and supervision;
- Structural Actions: Initiated the works of eight hydro-environmental projects and disbursing R\$ 1,472,965.58.

In 2013, the expense with defrayal, management and planning were similar to the previous year. In structural actions, there was an increase in construction activities including 19 hydro-environmental projects. This justifies the increase in capital expenditure for the year of 2012 as shown in Table 5.

In the year 2014 the expense with defrayal, management and planning remained as a whole similar to the year 2013. The investment actions considered the undertaking of 22 hydro-environmental works, as well as the contracting of 19 basic sanitation county plans distributed in 4 physiographic regions.

Regarding the expenditure of raised funds, it can be noted that in the period of 2010 to 2014 there was an increase in investment actions which significantly increased the financial resources invested in actions at BHSF.

Another aspect to be considered is that in 2015, according to Table 4, the amounts disbursed by AGB Peixe Vivo were equivalent to about 85% of funds transferred by ANA, which shows the improvement in performance of the basin agency for the implementation of actions of the BHSF water resources plan and sets out as an alternate action for counties in the basin to obtain environmental projects and basic sanitation county plans.

Assessment of the evolution of uses: withdrawal, consumption, organic load discharge

For analysis of the evolution of water use in the São Francisco River Basin, it was used a sample of 315 users who were charged from 2011 to 2015, so that the results would not suffer interference from entering and exiting of other paying users during the period. The year of 2010 was not considered for this analysis since the usage charge started from July of that year. It is important to note that this sample is about 86% of the volume withdrawn and 82% of the amount charged.

The withdrawal flows for the industrial, irrigation, sanitation, mining and aquaculture sectors in the mentioned period are shown in Tables 6 to 10.

Given the results, it is observed, in Table 7, that with regards to the irrigation user sector, it appears that during this period, the flow of annual withdrawal increased 3.88%, suggesting that in terms of rational use, these users were not affected by the usage charge. Regarding consumption for the same industry, there is a similar behavior with a 4% increase in the consumption flow for the same period.

For the sanitation sector, the withdrawal use, and organic load discharge showed an increase in the period of 2011 to 2015 of 17.5% and 14.2%, respectively, however for consumption, there is a reduction of 12.2%. Regarding the discharge of organic load, there is a decrease of 3.47% between 2011 and 2012, growth of 33.86% between 2012 and 2014 and a decrease of about 11.6% in 2015. Despite the uneven progress of water use for the sanitation

Table 5. Distribution of Investments in the period of 2010 to 2014.

Period	Planned investments for actions related to water resources	AGB Peixe Vivo operating expenses
2010	71,240.67	320,946.60
2011	**1,526,347.77	*2,094,497.23
2012	5,336,409.72	2,723,922.04
2013	13,725,825.60	2,504,938.23
2014	13,906,533.70	2,553,441.72
TOTAL	34,566,357.46	10,197,745.82

*It was added R\$ 100,000.00 related to deposit refund. **It was added R\$ 51,220.49 related to labor benefits and salary payment from 2010/12 to 2011/01. Information concerning the operating expenses and 2015 investments were not made available. Source: Adapted from the ANA (2016a).

Table 6. Evolution of water used by the sanitation sector in water bodies of the Nation's domain in the São Francisco River Basin from 2011 to 2015.

Year	Sanitation		
	Withdrawal (m ³ /s)	Consumption (m ³ /s)	CO flow (tons of BOD _{5,20} /year)
2011	9.41	1.88	4,613.10
2012	9.79	1.91	4,453.01
2013	9.74	1.89	4,658.67
2014	11.10	1.68	5,961.05
2015	11.06	1.65	5,270.92

Source: Adapted from the AGB Peixe Vivo (2016).

Table 7. Evolution of water used by the irrigation sector in water bodies of the Nation's domain in the São Francisco River Basin from 2011 to 2015.

Year	Irrigation		
	Withdrawal (m ³ /s)	Consumption (m ³ /s)	CO flow (tons of BOD _{5,20} /year)
2011	76.45	61.02	0.00
2012	76.68	61.21	0.00
2013	77.13	61.56	0.00
2014	78.51	62.74	0.00
2015	79.42	63.46	0.00

Source: Adapted from the AGB Peixe Vivo (2016).

Table 8. Evolution of water used by the industrial sector in water bodies of the Nation's domain in the São Francisco River Basin from 2011 to 2015.

Year	Industrial		
	Withdrawal (m ³ /s)	Consumption (m ³ /s)	CO flow (tons of BOD _{5,20} /year)
2011	0.59	0.23	122.65
2012	0.59	0.34	68.14
2013	0.59	0.34	122.65
2014	0.91	0.54	102.94
2015	0.91	0.77	78.34

Source: Adapted from the AGB Peixe Vivo (2016).

sector, there is a considerable growth in the organic load discharge in the period of 2011 to 2015.

As for the industrial sector, as shown in Table 8, there is an increase for the uses of withdrawal and consumption of

54.2% and 235%, respectively. For organic load discharge, there is a decrease of 36.1% for the period of 2011 to 2015.

The Aquaculture and Mining user sectors, according to Tables 9 and 10, there are no significant changes, remained virtually constant.

In general, for the sample of users and considering that the usage charge started in 2011, it is observed that for organic load discharge the sanitation sector did not have a behavior change with regards to this use considering that there was an increase in water use for this purpose, unlike the industrial sector.

Regarding the withdrawal use it is noticeable that the irrigation, sanitation and industrial sectors were not affected by the pricing mechanism as it can be seen in Tables 6, 7 and 8 where the withdrawal flows increased in this period.

Similarly, the consumption flows increased from 2011 to 2015 for the irrigation and industrial sectors, however there was a reduction in the sanitation sector.

Analysis of pricing methodologies applied to the main uses in São Francisco, Paraíba do Sul, Piracicaba-Capivari-Jundiá and Doce rivers basins

The Paraíba do Sul River Basin is the pioneering in implementing water usage charge in the country, a process that started in 2001 with the proposal for a pricing model and effectively adopted in 2003.

The second initiative to adopt usage charge in the Nation's domain rivers was in the Piracicaba, Capivari and Jundiá – PCJ basins, which apparently was inspired by the criteria implemented

Table 9. Evolution of water used by the aquaculture sector in water bodies of the Nation's domain in the São Francisco River Basin from 2011 to 2015.

Year	Aquaculture		
	Withdrawal (m ³ /s)	Consumption (m ³ /s)	CO flow (tons of BOD _{5,20} /year)
2011	1.653	0.07	390.39
2012	1.657	0.07	391.30
2013	1.653	0.07	390.39
2014	1.611	0.07	390.39
2015	1.653	0.07	391.62

Source: Adapted from the AGB Peixe Vivo (2016).

Table 10. Evolution of water used by the mining sector in water bodies of the Nation's domain in the São Francisco River Basin from 2011 to 2015.

Year	Mining		
	Withdrawal (m ³ /s)	Consumption (m ³ /s)	CO flow (tons of BOD _{5,20} /year)
2011	0.01	0.004	0.00
2012	0.01	0.004	0.00
2013	0.01	0.004	0.00
2014	0.01	0.004	0.00
2015	0.01	0.004	0.00

Source: Adapted from the AGB Peixe Vivo (2016).

by the Paraíba do Sul River Hydrographic Basin Integration Committee -CEIVAP (for its acronym in Portuguese) (LANNA; LAIGNEAU, 2010).

According Lanna and Laigneau (2010), in the development of a pricing model for BHSF, it was considered the experiences already implemented in Brazilian federal rivers and, as a result, it shows similar aspects to the criteria adopted by CEIVAP and by the PCJ, with some simplification.

The Doce River Basin Committee was the fourth to deploy the water usage charge in the Nation's domain rivers after the pricing criteria was approved in 2011. Unlike the aforementioned basins, the usage charge for the Doce River Basin does not consider the portion for consumption.

The pricing mechanisms and criteria adopted for the uses of withdrawal, consumption and organic load discharge will be presented comparatively through Tables 11, 12 and 13.

Concerning the formula for usage charge of the Paraíba do Sul, PCJ and Doce River shown in Table 11, it is necessary to point out the following conditions:

- a) $Q_{cap\ med}/Q_{cap\ out} > 0.7, K_{out} = 0.2, K_{med} = 0.8 \text{ e } K_{med\ extra} = 0;$
- b) $Q_{cap\ med}/Q_{cap\ out} < 0.7, K_{out} = 0.2, K_{med} = 0.8 \text{ e } K_{med\ extra} = 1;$
- c) $Q_{cap\ med}/Q_{cap\ out} > 1, K_{out} = 0, K_{med} = 1 \text{ e } K_{med\ extra} = 0;$

This formula establishes a balance between the granted and measured annual withdrawal flows. If the withdrawal flow used is above the granted flow, the user must immediately request a review, with the risk of penalties determined by law, as there is no economic incentive to encourage this adjustment of the grant.

If you user consumes a lower flow than it was granted, it will pay both for the actual withdrawn flow, weighing 80%, as well as for the granted, weighing 20%.

Table 11. Pricing mechanisms for annual withdrawal of raw water.

Basin	Usage Charge for Withdrawal
Paraíba do Sul River	Valuecap = [Kout x Qcap out + Kmed x Qcap med + Kmed extra x (0.7 x Qcap out - Qcap med)] x PPUcap x Kcap class
Piracicaba-Capivari-Jundiá Rivers	Valuecap = [Kout x Qcap out + Kmed x Qcap med + Kmed extra x (0.7 x Qcap out - Qcap med)] x PUBcap x Kcap class
São Francisco River	Valuecap = Qcap x PPUcap x (Kcap class x Kt)
Doce River	Valuecap = [Kout x Qcap out + Kmed x Qcap med + Kmed extra x (0.7 x Qcap out - Qcap med)] x PPUcap x Kcap

Valuecap = Annual payment for water withdrawal; Kout = Weight given to the annual withdrawal granted volume; Qcap out = Annual volume of withdrawn water according to the grant; Qcap = Annual volume of withdrawn water according to values indicated in the grant or metered by responsible authorities, in the regulation process; Kmed = Weight given to the annual withdrawal metered volume; Qcap med = Annual volume of withdrawn water, according to metering; Kmed extra = Extra multipliers that will be a unit (1) when the annual metered volume is below 70% of the grant and zero in all other cases; PPUcap = Public unit price for each type of use; PUBcap = Basic unit price for each type of use; Kcap classe = Coefficient related to the water body class at the point of withdrawal; Kcap = Coefficient that considers specific objectives of withdrawal; Kt = Coefficient that considers the good use and conservation practices. Source: Adapted from Lanna and Laigneau (2010).

Table 12. Pricing mechanisms for the annual consumption of raw water.

Basin	Usage Charge for Consumption
Paraíba do Sul River	Value cons = $(Q_{cap}T - Q_{lan\zeta}T) \times PPU_{cons} \times (Q_{cap} / Q_{cap}T)$
Piracicaba-Capivari-Jundiá Rivers	Value cons = $(Q_{cap}T - Q_{lan\zeta}T) \times PUB_{cons} \times (Q_{cap} / Q_{cap}T)$
São Francisco River	Value cons = $(Q_{cap} - Q_{lan\zeta}) \times PPU_{cons} \times K_t$
Doce River	Not determined

Value cons = Annual payment for water consumption; PPUcons = Public Unit Price for water consumption; PUB = Basic unit price for each type of use; Qcap = Annual volume of withdrawn water in the rivers in the Nation's domain; Qlanç = Total annual discharged volume, in m3; QcapT = Total annual volume of water withdrawn in m3 (same as Qcap med or same as Qcap out when there is no metering in the water bodies of the Nation's and States' domain and those directly withdrawn from water distribution systems network); QlançT = Total annual volume of water discharged, in m3, (in bodies of water in the States' and Nation's domain or in public sewage networks); Kt = Coeficient that takes into account good water use and conservation practices. Source: Adapted from Lanna and Laigneau (2010).

Table 13. Pricing mechanisms for annual organic load discharge.

Basin	Usage Charge for Organic Load Discharge
Paraíba do Sul River	Value BOD = $CBOD \times Q_{lan\zeta} Fed \times PPUBOD$
Piracicaba-Capivari-Jundiá Rivers	Value BOD = $CBOD \times Q_{lan\zeta} Fed \times PUBBOD \times K_{lan\zeta} classe \times KPR$
São Francisco River	Value BOD = $CBOD \times Q_{lan\zeta} \times PPULan\zeta \times K_{lan\zeta}$
Doce River	Value BOD = $CBOD \times Q_{lan\zeta} Fed \times PPULan\zeta$

Value BOD = Annual payment for BOD5,20 load discharge; CBOD = Mean annual concentration of BOD5,20 of the wastewater discharged; Qlanç Fed= Annual volume of discharged water, in m3/year; PPUBOD = Basic Unit Price for BOD5,20 load discharge; Klanç classe = Coeficient that takes into account the receiving water body classification; PUBBOD = Basic Unit Price for BOD5,20 load discharge; KPR = Coeficient that takes into account the percentage of removal (PR) of organic load (BOD5,20), in the Wastewater Treatment Station – ETEL (for its acronym in Portuguese); Qlanç = Annual discharged volume; PPULanç = Basic Unit Price for the BOD5,20 load discharge; Klanç = Coeficient that considers the specific objectives of discharge. Source: Adapted from Lanna and Laigneau (2010).

Thus, the amounts to be paid increase as the difference between the actual and granted withdrawal flow also increases (LANNA; LAIGNEAU, 2010).

If the measured withdrawal is less than 70% of the granted amount, the factor $(0.7 \times Q_{cap} out - Q_{cap} med)$ is applied, which increases the amount to be paid and encourages the user to request a review of the grant.

With regards to the usage charge for water withdrawal from the São Francisco River, the methodology establishes that that the withdrawal flow is determined by the granted flow, that is, no matter the flow that it uses, the usage charge remains the same. It should be stressed here, as a positive factor, that this method tries induce the user who uses withdrawal flow lower than the granted to request the review of grant. On the other hand, users who use up the granted flow will not pay more for it,

therefore the necessary review of grant for these cases depends on the enforcement capability of the governing body and user's environmental awareness. Another problem is that the checking of flow rates is hampered by the lack of incentives to purchase flow meters and by the considerable size of the basin.

Given all these pricing mechanisms, it can be noted that the usage charge models for water withdrawal for the Paraíba do Sul, PCJ and Doce Rivers, are more comprehensive, by distinguishing the granted and used flows, since this an important aspect to better control the access to water in a setting of increasing scarcity and provide an actual control of the flow rates used.

In Table 12, it is observed that with regards to the Paraíba do Sul and PCJ Rivers basins, the value for the volume consumed, also considers the relationship $(Q_{cap}/Q_{cap}T)$ aiming to establishing a balance in usage charge between the Nation and the States, given that many users withdraw from water bodies of different domains, thus allowing the consumption calculation to be carried out in an integrated manner considering the rivers that contribute to the basin (ACSELRAD; CARVALHO; THOMAS, 2007).

In the São Francisco River Basin the portion relative to consumption has a very simplified formula. The equation adopted by BHSF assumes that the water withdrawn from rivers in the Nation's domain do not require the proportion specified in the previous cases.

For the Doce River Basin, the pricing mechanism eliminated the payment for consumption but compensated this deficit by increasing withdrawal price. This measure has simplified operating procedures, as well as making the usage charge by the paying user easier to understand and at the same time not reducing the revenue.

As shown in Table 13, the usage charges for wastewater discharge is related to estimates of Biochemical Oxygen Demand after 5 days at 20 °C (BOD). There is no fee for other pollutants. The equation for pricing of the Paraíba do Sul River Basin does not consider the class of the receiving water body (Klanç) and only in the PCJ basin considers the organic load treatment efficiency, according to the following conditions:

- a) For PR = 80%: $KPR = 1$;
- b) For $80\% < PR < 95\%$: $KPR = (31 - 0.2 \times PR) / 15$;
- c) For $PR > 95\%$: $KPR = 16 - 0.16 \times PR$

Starting from 80% removal, the KPR is gradually reduced until reaching the value of 0.8, when removal is 95%.

The Klanç values are, in the basins that considers them into their equations, the same as the unit, without varying with the environment class of the receiving water body.

When comparing the pricing models for organic load discharge, it is understood that the PCJ methodology includes a more favorable use of a coefficient which considers the water quality target at the releasing point, taking into account the percentage of removal of pollutants promoted by the treatment plant.

This feature could be studied in the BHSF usage charge model, which in addition to considering the environment class of the receiving body, could bring another technical and economic reference variable to contribute in the environmental recovery actions of the basin.

In this context, another topic that deserves to be emphasized is the development of studies aiming at the inclusion of new parameters that include other pollution elements. According to Lanna and Laigneau (2010), the consideration of parameters such as phosphorus, nitrogen and coliform that are critical, due to their impacts on water resources; for these parameters, the modulation of the usage charge depending on the characteristics of the receiving environment is very important for its effectiveness. As an example, it can be mentioned a greater usage charge in places with eutrophication problems in France.

CONCLUSIONS AND RECOMMENDATIONS

Regarding the advancement of the uses in the period of 2011 to 2015, it is noticed that the usage charge had no effect on the sample users, as the withdrawal flows have increased over the years.

In relation to consumption, except for the sanitation sector which showed sensitivity to the usage charge, the industrial and irrigation sector users had an increase in the flow of consumption.

Concerning the organic load allocation for the sanitation and industrial sectors in the period from 2011 to 2015, there was an increase and a decrease in the amounts of organic load discharge, respectively. It can be concluded that there was an effect of the usage charge over the industrial users.

The relationship between the amounts billed and collected has decreased as a whole since the employment of the usage charge, which suggests an increasing acceptance by users.

With respect to revenue, the usage charge fulfills its role to ensure financial resources as the goals set by the investment plan, but does not fully satisfy the actual demands of the basin. Still, there has been a considerable improvement in disbursements and investments starting from 2012, for the hydro-environmental recovery actions and development of municipal sanitation plans.

It is recommended a review of the criteria for reference flow and water usage charge parameters. Thus, it is suggested the study of the mechanisms of the usage charge model of the PCJ and Paraíba do Sul rivers basins, which distinguishes the granted flow from the used flow to improve the current BHSF usage charge model.

In this context, the gradual increase in public unit prices would increase the annual revenue amount and also the necessary investments in the basin from its own resources.

For the irrigation sector, in addition to the aspects mentioned above, sustainable practices of reuse and adoption of more efficient irrigation techniques should be encouraged, such as micro sprinkler and drip systems, among others, in order to reduce water waste and increase availability of water in the basin. These incentives could be linked to a new pricing mechanism for this sector using multipliers related to the irrigation system used.

The growth and development of industrial, agricultural and mining activities require the need for studies aiming to formulate a proposal for usage charge for the discharge of effluent parameters, such as BOD, heavy metals, dyes and pesticides.

In terms of control, it is necessary to structure an integrated system at the state and federal levels connected to environmental

management to act towards irregular use, application of penalties and monitoring of the quality and quantity of water.

Since it is relatively new, the results of usage charge regarding the encouragement of rational use of water have not affected withdrawal use. It is observed minor results, but positive cases for consumption and organic load discharge.

Financial resources from the usage charge enable the financing of studies, projects and works of environmental recovery and conservation in the BHSF, demonstrating its contribution to the social and economic development, although alone it is not able to solve the sustainability challenges.

With all being said, charging for the use of water resources must be encouraged and periodically reviewed to consolidate and gradually strengthen the participation of users.

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Leonardo Henrique Andrade Vera: gathering and organization of the information; organization of data; organization of the methodology; interpretation of results and conclusion of the text.

Suzana Maria Gico de Lima Montenegro: discussion of the results, text structuring and collaboration in writing.

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