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# Assessment of community-managed water systems in rural areas of Espírito Santo, Brazil, using the SIASAR tool

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## ABSTRACT

Rural communities usually are poorly covered by basic services, including water supply services (WSSs). Within this context, community management of water is a promising alternative to address this issue, with many successes all over the world. This approach also contributes to the achievement of Sustainable Development Goal (SDG) 6, which intends to universalize water access. This paper evaluates the WSSs provided by eleven rural community organizations from Espírito Santo, Brazil. All of those participate in the sanitation program "Pró-Rural" created by Cesan (Companhia Espiritosantense de Saneamento), the state water concessionaire, to reach small-sized rural settlements. For this purpose, Siasar was used, an informational tool that enables the identification of elements in the rural water supply systems (RWSSs) that can enhance or hinder their performance. The results verified that the communities were able to maintain a satisfactory level of quality of the WSSs, although there were perceptible fragilities regarding the distance between internal (communities and service providers) and external (technical assistance providers) actors that can decrease the quality of the WSS or even lead to its interruption if not addressed.

**Keywords:** community management, rural communities, water supply.

# Avaliação de sistemas de água geridos por comunidade em áreas rurais do Espírito Santo, Brasil, utilizando a ferramenta SIASAR

## RESUMO

Comunidades rurais são geralmente cobertas de forma precária por serviços básicos, incluindo serviços de abastecimento de água (SAAs). Neste contexto, a gestão comunitária da água é uma alternativa promissora para tratar essa questão, com muitos casos de sucesso pelo mundo. Essa abordagem também contribui para atingir o ODS (Objetivo do Desenvolvimento Sustentável) 6, que pretende universalizar o acesso à água. Este artigo visa avaliar os serviços de abastecimento de água prestados por onze organizações comunitárias do Espírito Santo, Brasil. Todas as comunidades participam do programa de saneamento "Pró-Rural" criado pela Cesan (Companhia Espiritosantense de Saneamento), a concessionária de água do estado, a fim de alcançar comunidades rurais de pequeno porte. Para isso, o Siasar foi utilizado, uma ferramenta de informação que permite a identificação de elementos nos sistemas de abastecimento de água rurais (SAARs) que melhoram ou fragilizam a sua performance. Como resultado, foi verificado que as comunidades eram capazes de manter um nível satisfatório de qualidade dos SAAs, entretanto havia fragilidades relacionadas a atores internos (comunidades e prestadores de serviço) e externos (prestadores de assistência técnica), que podem reduzir a qualidade do SAA ou até mesmo levar a sua interrupção caso não tratadas.

**Palavras-chave:** comunidades rurais, fornecimento de água, gestão comunitária.

## 1. INTRODUCTION

Water is essential to human life. Its consumption and usage for daily tasks and for personal hygiene require basic treatment in order to maintain safety. Different papers report several waterborne diseases in regions where drinking water standards are not reached (Jalan and Ravallion, 2003; UNICEF and WHO, 2009; Grigg, 2018). It was also verified that diseases related to water pollution are the major cause of death in the world, and more than half of hospital beds host people suffering from these (Hunter *et al.*, 2010; Palacio, 2009). Hence, concerns regarding safe drinking water provision and access arise. International efforts have been attempted to address this issue, such as the Millennium Development Goals (MDGs), supplanted in 2015 by the SDGs. The sixth objective (SDG 6), intends to ensure access to drinkable water and sanitation for all by 2030, and target 6.1 addresses particularly access to drinkable water (United Nations, 2018).

The task becomes more challenging regarding rural locations, especially in low- and middle-income countries. Their distance from urban areas hinders operation and maintenance of the system by suppliers (Barde, 2017). From an economic point of view, the implementation of the system is unfeasible, as it does not return investments made by private companies (Alves and Araújo, 2016; Ataíde *et al.* 2012; Calzada *et al.*, 2017), as inhabitants with low-incomes cannot afford the high costs to maintain a quality service and the complex logistics required to support it in those areas (RWSN, 2014; Kayser *et al.*, 2015; Calzada *et al.*, 2017; United Nations, 2018).

According to the Pesquisa Nacional por Amostra de Domicílio (IBGE, 2016), in Brazil urban areas are greatly covered by water services, with approximately 93.9% of households connected to distribution systems. Nevertheless, rural areas remain poorly covered, with approximately 34.5% of rural households not connected to any kind of reliable water source.

However, efforts are being made to address this. In December 2019, building on the efforts of multiple stakeholders (federal, state and municipal levels, researchers, experts and those in the rural context, such as community organizations and social movements), the Programa Nacional de Saneamento Rural (PNSR) was formulated (Funasa, 2019). It is a federal program that intends to develop sanitation procedures in rural areas aiming to universalize water access (Funasa, 2017).

A relevant strategy to deal with such issues in those areas is community management of water supply systems. This is a participatory approach, i.e., the target community is responsible for operating, maintaining and managing the water plants, built with assistance of external actors that must provide constant financial, technical, institutional and political support to guarantee the systems' functionality (Kleemeier, 2000; Whittington *et al.*, 2009; Hunter *et al.*, 2010; Hutchings *et al.*, 2015; Behnke *et al.*, 2017).

This tactic has been employed in many countries around the world, namely Brazil, Chile, Peru, Finland, Nepal and Nigeria (Heller and Pádua, 2006; Whittington *et al.*, 2009; Opare, 2011; Borja-Vega *et al.*, 2017; Calzada *et al.*, 2017; Chukwuma, 2018; Rautanen and White, 2018). Among them, both successes and failures have been reported in the literature. Rautanen and White (2018) demonstrated a successful case in Nepal, where a combination of community engagement and financial transparency were deemed key factors to the sustainability of this model. Chukwuma (2018) presents case studies in Nigeria, where community management could not improve communities' quality of life due to weak institutional and political support. In the same way, Harvey and Reed (2007) observed that governmental policies were responsible for creating a scenario of isolation of rural communities through weak political representation, which contributed to several failures in water supply systems in Africa.

The state where the studied communities are located, Espírito Santo, is composed of 74 municipalities, of which 52 have the water supply services granted by a covenant with Cesan, a mixed capital company created in 1967, that delivers drinking water to 93.2% of inhabitants from the municipalities under its concession (Cesan, 2019a).

To increase the pace of rural communities towards access to drinkable water, in 1991 Cesan created Pró-Rural, a program implemented in small and remote communities (between 50 and 1,500 inhabitants), where it is economically untenable for Cesan to operate and manage the water systems (Cesan, 2019b).

This paper evaluates community management of water supply systems in eleven communities of Espírito Santo, Brazil. The evaluation is supported by Siasar, a tool that enables the systematic data collection of the water treatment plant (WTP) and stakeholders relating to the community's WSS. Based on that, it is possible to suggest measures that could contribute to the improvement of the systems' performance.

## 2. METHODOLOGY

### 2.1. Study area

The study area includes eleven rural communities distributed in Boa Esperança, Venda Nova do Imigrante and Conceição do Castelo, three municipalities of Espírito Santo state.

Boa Esperança was the first municipality visited, in August 2016. The communities selected were Prata, Bela Vista, Cruzeiro, Km 20, Santo Antônio do Pouso Alegre, Sobradinho and Garrucha. Their choice was based on the method of simple sampling (Morettin and Bussab, 2014).

In February 2018, the research was performed in Camargo (Venda Nova do Imigrante) and Indaiá (Conceição do Castelo). Those were chosen due to logistical reasons and technical recommendations received from the state staff.

Finally, in August 2018, also in Conceição do Castelo, the communities Mata Fria and Santa Luzia were visited. Their choice considered accessibility matters, as rural communities of the southern region of Espírito Santo are widely dispersed and have limited access due to the low quality of roads.

The eleven communities were chosen because they participate in the Pró-rural program and consequently are managed by a neighborhood association, whether formally recognized or not. Figures 1, 2 and 3 represent Conceição do Castelo, Boa Esperança and Venda Nova do Imigrante, respectively.

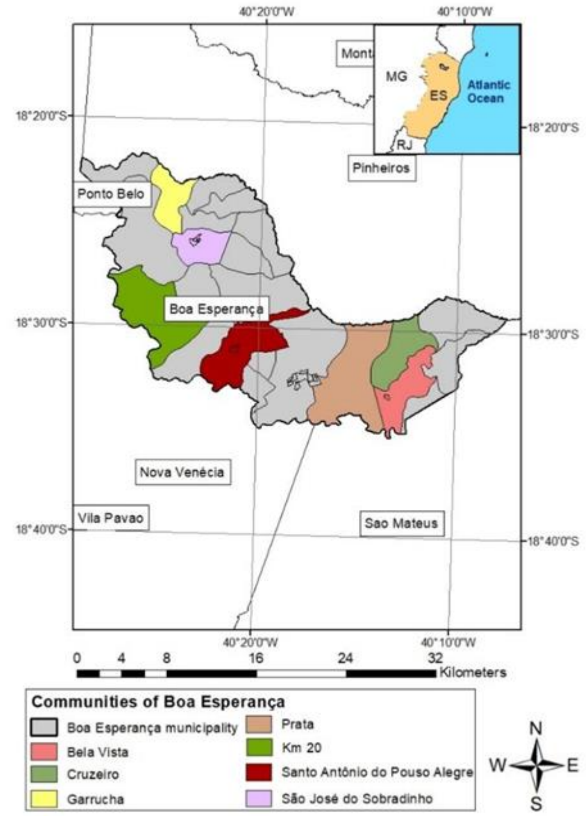


**Figure 1.** Map of Boa Esperança.
**Source:** Based on Geobases data.

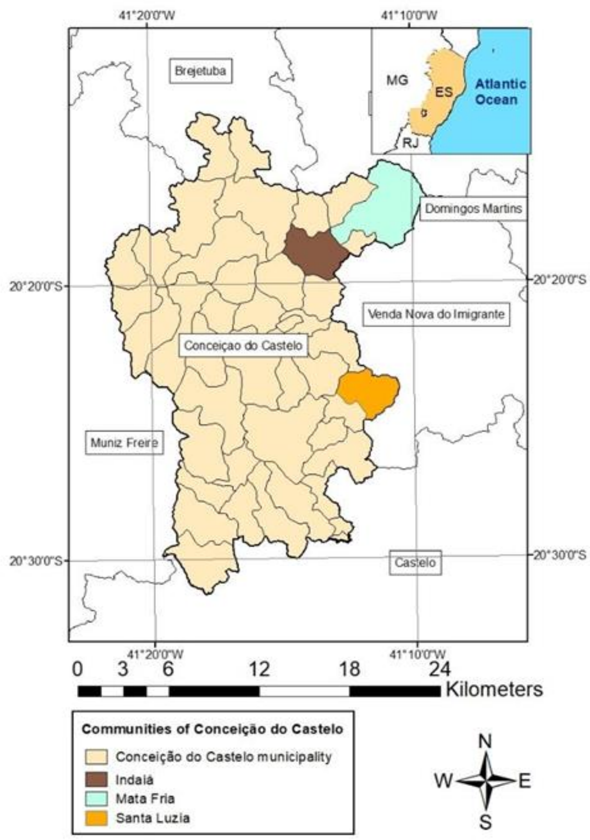


**Figure 2.** Map of Conceição do Castelo
**Source:** Based on Geobases data.

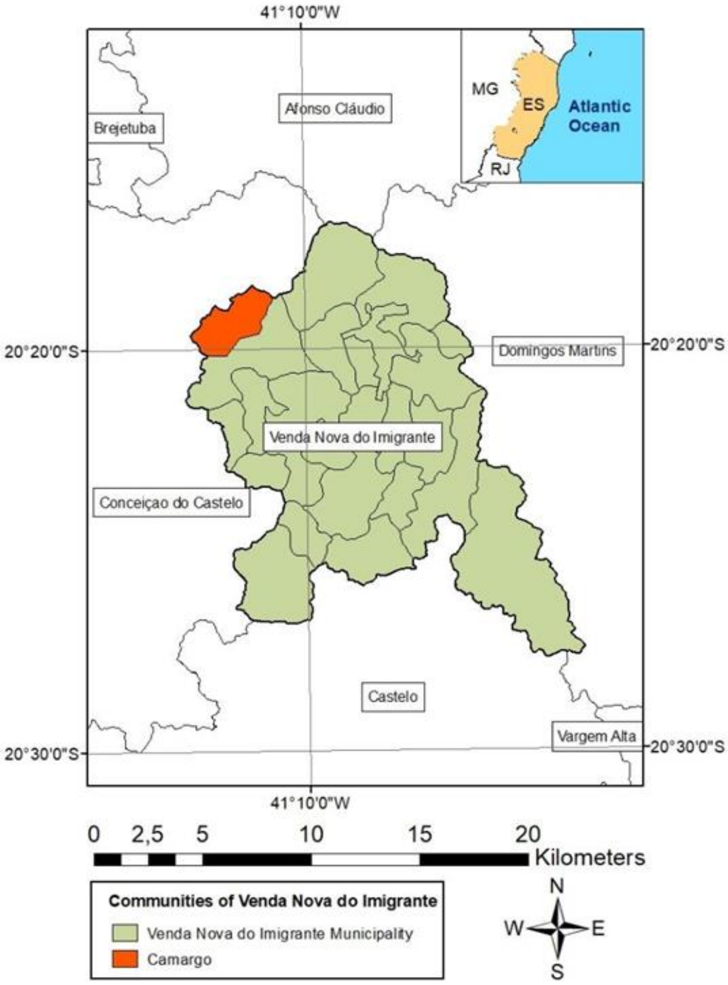


**Figure 3.** Map of Venda Nova do Imigrante.
**Source:** Based on Geobases data.

## 2.2. Siasar

Siasar is an informational tool, developed by a joint initiative between the governments of Honduras, Nicaragua and Panamá (Siasar, 2012).

This tool allows the identification of gaps and failures capable of leading to the breakdown of water systems, and the quantification of different elements that influence its sustainability. This method evaluates four main actors defined by Siasar (2016) as follows:

- Water system: The infrastructure of the water supply system, composed of catchment structure, water treatment plant and distribution system.
- Service provider: Entity responsible for providing water service to users.
- Technical assistance provider: Public or private entity responsible for offering technical support to the service provider.
- Community: Rural settlement composed of users of the water service.

Each actor has indicators that mirror their performance. Hence, the four actors are individually assessed through specific questionnaires. For this study, the 2012 version of the questionnaires was used.

The actors' classification is based on the respective indicators' score, ranging from 1 (worst situation) to 4 (best situation). The corresponding classification for community, water system and service provider is given respectively in Tables 1 and 2.

The technical service provider was not evaluated due to the non-existence or lack of periodicity of this service verified in the communities.

**Table 1.** Community and service provider classifications according to their average score.

| Average score | Classification |
|---|---|
| 3.50 - 4.00 | A* |
| 2.50 - 3.49 | B |
| 1.50 - 2.49 | C |
| <1.49 | D |

**Source:** Adapted from Siasar (2012).
***If** any indicator receives a score of 1, the service provider is classified as B, even when the average score is between 3.5 and 4.0.

**Table 2.** Water system classification according to its total score.

| Total | Classification |
|---|---|
| ≥25 | A |
| 17 - 24 | B |
| 9 - 16 | C |
| ≤8 | D |

**Source:** Adapted from Siasar (2012).

The community evaluation also considers the Water Service Sustainability Index (WSSI), based on the water system and the service provider classifications to depict the current physical, financial and managerial conditions of the RWSS being assessed. The WSSI results from Equation 1:

$$WSSI = \frac{\sum N^{o}\ of\ households\ connected\ to\ the\ water\ system}{N^{o}\ of\ households\ in\ the\ community} \times RW_{system} \times RW_{service\ provider} \quad (1)$$

RW is the relative weight attributed to the water system and to the service provider. Therefore, it can be observed that the sustainability of the RWSS is closely attached to the performance of those actors. Table 3 shows the correspondence between the final classification of the water system and service provider and the RW.

**Table 3.** Correspondence between the final classification of the water system and service provider and the RW.

| Classification | RW |
|---|---|
| A | 1.00 |
| B | 0.66 |
| C | 0.33 |
| D | 0.00 |

**Source:** Adapted from Siasar (2012).

### 2.3. Surveys and data collection

The survey was carried out based on overt direct observations and interviews. It used 3 types of Siasar questionnaires to evaluate each system, “water system”, “service provider”, and “community”.

The interviewees were community council members, operators or persons responsible for the treatment plant, mostly chosen according to their availability, since not everyone could be previously contacted. Researchers used semi-structured interviews, in order to allow the inclusion of questions according to the context.

Consent forms were elaborated by researchers in order to notify interviewees of the nature of this research, to assure their anonymity in any publication and to have their compliance. The forms were physically signed by both respondents and researchers and archived for further needs.

This research uses information collected in the field; therefore, it shows local perceptions and shares lessons learned in that reality. However, on some occasions it was necessary to rely on information given by community managers and operators, who have limited knowledge of hydraulic and water resources. Further, since data collection was performed on the spot, it was unfeasible to visit a great sample of communities.

Another aspect is that information regarding households and social care centers required by Siasar was also provided by interviewees, since they were not available in discrete form for every community.

To close this section, due to the large number of pages of the questionnaires, it was not possible to attach them to this paper. They may be found in Siasar’s web page for July 2016: http://www.siasar.org/en/content/technical-documentation.

# 3. RESULTS

The overall actors’ evaluation for each community using parameters of Siasar is shown in Table 4. Regarding the community actor, the classification of which is affected by the water systems and the service providers, about 54% achieved a “B” classification. 27% percent of the communities obtained an “A” classification. “C” and “D” classifications were both achieved by 9.5%.

**Table 4.** Communities scoring and classification.

| Community | Water System | Service Provider | Community |
|---|---|---|---|
| Bela Vista | A | B | B |
| Camargo | B | C | B |
| Cruzeiro | - | D | D |
| Garrucha | A | B | B |
| Indaiá | A | B | A |
| Km 20 | B | C | B |
| Mata Fria | A | B | B |
| Prata | B | D | C |
| Santa Luzia | A | B | A |
| Santo Antônio do Pouso Alegre | B | B | A |
| São José do Sobradinho | B | B | B |

The evaluation process which leads to the classifications displayed in Table 4 is described in the following items. The information is indexed according to the parameters used by Siasar to qualify each actor (water system, service provider and community).

## 3.1. Water System evaluation

The indicators used to evaluate the water systems were: water intake flow, catchment structure, pipes, reservoirs, distribution system, reservoir volume, river basin and residual chlorine. Those are discussed in the following sections, focusing on the issues found.

The total scores obtained by communities regarding this actor were: Garrucha (28), Sta

Luzia (27), Bela Vista (26), Indaiá (26), Mata Fria (26), Km 20 (24), Camargo (24), Stº Antônio do Pouso Alegre (24), São José do Sobradinho (24), Prata (24) and Cruzeiro (-). Since no type of treatment was performed in Cruzeiro when the research was conducted, this community was not evaluated in this actor.

### 3.1.1. Water intake flow

This indicator is linked to the capability of the water intake flow to meet the demand for the same. Most of the systems could provide drinkable water throughout the year. Only Santa Luzia, Camargo and Prata had issues during the drought season in maintaining the water supply.

In Santa Luzia, water scarcity was addressed by building a dam to stock the water conducted to it by a second channel. Camargo builds a sandbag dam in the river where water intake occurs during dry seasons. Prata did not develop any procedure to deal with the water shortage during winter besides reducing the number of hours the pump operated.

### 3.1.2. Catchment structure

The intake point indicator refers to the physical conditions of the catchment structures. The water catchment occurs in different ways among the communities. Indaiá, Camargo, Santa Luzia and Mata Fria employed a superficial water catchment, while in the communities of Boa Esperança water collection relied on wells. Only Bela Vista has a superficial intake and another approach using a well. The necessity of a second intake in Bela Vista arose from the long drought periods in the region. This expansion was financed by the municipality as well as the community association.

Mata Fria, Santo Antônio do Pouso Alegre and São José do Sobradinho presented issues regarding the catchment structure. In Mata Fria, there was the necessity of relocating and reconstructing the catchment system due to the constant displacement of the screen grid by the strong water flow. In Santo Antônio do Pouso Alegre, the pump in operation was borrowed from another community. Finally, São José do Sobradinho requires the building of a new intake. The prior well became inoperative due to the continuous drought in the region. To mitigate the situation, an inhabitant allowed water collection from a well at his estate. In exchange, users pay the electricity costs for the pump usage. It is worth highlighting that this water is also used for watering the property owner’s crops, which increases the electricity expenses paid by the community. New catchment, treatment and distribution systems are in the construction phase (this labor is funded by Funasa's Pró-Rural program).

### 3.1.3. Pipes

This indicator refers to the physical conditions of the pipes leading the water from the intake points to the WTPs or to the reservoirs that were reported. In none of the communities were found disconformities regarding this element at the time of the study.

### 3.1.4. Reservoirs

This indicator refers to the physical conditions of the reservoirs. The communities with hurdles to overcome related to the reservoirs were Prata, Km 20 and Camargo. Prata’s reservoir displayed excess rust and damage in the walls. A new one was being built at the time of this research. At Km 20, a new reservoir is available to replace the damaged one, although there is not enough budget for the installation. Finally, in Camargo the operators reported that during their 2 years of service in the treatment plant, no cleaning was performed on either the reservoirs or the filters.

### 3.1.5. Distribution system

This indicator corresponds to the physical conditions of the system of pipes, valves and structures responsible to conduct the water from the reservoirs to the households. Prata’s distribution system featured rust and damage. For the reservoir, a new distribution system was under construction. São José do Sobradinho also has a damaged distribution system; like Prata, a new one was under construction, as mentioned in 3.1.2.

### 3.1.6. Reservoir volume

The capability of the reservoir volume to meet the inhabitants' needs is reported by this indicator. Only Prata's reservoir was incapable of meeting demand. The system was initially built to supply the community's school, although the number of connections to the system increased due to community's growth. As mentioned in Section 3.1.4, a new storage system was under construction at the time of this research.

### 3.1.7. River basin

This indicator corresponds to the preservation status of green areas surrounding the intake and to the basins' protection against animals and contamination sources. It also considers how these affect the water system. Most of the communities were next to plantations, representing a risk of contamination due to pesticide leaching.

No information about the surroundings of the spring could be verified in Santo Antônio do Pouso Alegre. In all the RWSSs aside from Mata Fria, risk of contamination due to chemicals used on plantations near the spring and the presence of animals was found.

In Mata Fria, there was moderate degradation of the riparian zone due to the occupation of the margins. No information about the surroundings of the spring could be verified in Santo Antônio do Pouso Alegre.

### 3.1.8. Residual chlorine

This indicator analyzes the quantity of chlorine measured in the WTP's discharge in mg/L. Table 5 shows the values measured at the time of data collection and the treatment method employed by each system.

**Table 5.** Residual chlorine in the outbound and treatment method of each community.

| Community | Residual chlorine (mg $L^{-1}$) | Treatment method |
|---|---|---|
| Bela Vista | 0.2 | Chlorination and filtration |
| Camargo | 1.0 - 1.5 | Conventional treatment* (except fluoridation) |
| Cruzeiro | Does not apply | No treatment performed |
| Garrucha | 0.2 | Chlorination and filtration |
| Indaiá | 0.2 - 1.0 | Conventional treatment (except fluoridation) |
| Km 20 | 0.2 | Chlorination |
| Mata Fria | 0.2 - 1.0 | Conventional treatment (except fluoridation) |
| Prata | 0.2 | Chlorination |
| Stª Luzia | 1.0 - 1.5 | Conventional treatment (except fluoridation) |
| Stº Antônio do Pouso Alegre | 0.2 | Chlorination, filtration and flocculation |
| São José do Sobradinho | 0.2 | Chlorination |

*According to Heller and Pádua (2006), conventional water treatment comprises the coagulation, flocculation, sedimentation, filtration, disinfection, pH correction and fluoridation phases.

Points to acknowledge: In the communities where conventional treatment is employed, fluoridation is not performed due to poor technical training of operators. In São José do Sobradinho, besides chlorination, fluoride application used to be performed; however, the supply was interrupted (the product used to be provided by Cesan). In Bela Vista, there is no need to apply fluoride, since the substance is naturally present in the spring in the concentrations required (according to the operator).

According to Siasar, to receive the maximum score in this indicator, the concentration of residual chlorine must be between 1.0 mg/L and 1.5 mg/L, concentrations below 0.2 mg/L receive the lowest score and those between 0.2 mg/L and 1.0 mg/L receive score 2.

### 3.2. Service provider evaluation

The service provider's indicators used to evaluate the communities are: management of community organization, operation and maintenance (O&M), basin protection, financial stability and tariff. This actor's score was calculated by the average of the indicator's grades. The average of the communities by this actor is: Garrucha (3.40), São José do Sobradinho (3.20), Indaiá (3,00), Santa Luzia (3.00), Santo Antônio do Pouso Alegre (3.00), Bela Vista (2.60), Mata Fria (2.60), KM 20 (2.40), Camargo (1.60), Prata (1.40) and Cruzeiro (1.20).

#### 3.2.1. Management of community organization

The existence of a strong and well-structured community organization is essential to strengthen community-managed water systems. Among the studied RWSSs, Bela Vista, Km 20, Garrucha, São José do Sobradinho and Santo Antônio do Pouso Alegre counted with a formal organization. The communities Mata Fria, Santa Luzia, Indaiá and Camargo possess informal organizations. Prata and Cruzeiro had no kind of community organization.

From the RWSS managed by community organization, no regular meetings performed with any of the stakeholders were reported. In Siasar, an adequate number of meetings is four per semester. Also, in only São José do Sobradinho, Km 20 and Bela Vista, all positions in the council board were filled.

Another important factor related to the service provider is accountability. This indicator evaluates the accounting organization. All the discussed communities reported to the users their expenditures, aside from Prata and Cruzeiro, which did not have any form of community organization, formal or not.

From the service providers that provide accountability for users, in Mata Fria, Santa Luzia and Camargo it is performed according to users' requests. Indaiá submitted their reports at public places, such as churches. Bela Vista does it at assemblies, even though they do not occur frequently.

#### 3.2.2. Operation and Maintenance (O&M)

This indicator considered the staff available to execute O&M activities in the WTP. Mata Fria, Camargo and São José do Sobradinho had 2 operators for O&M. Prata did not have operators; the school staff performed the maintenance of the system. The same occurs in Cruzeiro, where the inhabitants perform small repairs and take turns to switch the pump on and off. Preventive and corrective measures are performed in all communities, except for Prata and Cruzeiro.

#### 3.2.3. Basin protection

This indicator evaluates the efforts made to protect the basin, such as in Section 3.1.7. Most of the communities had a basin affected by agriculture neighboring the intake point, enabling agrochemical contamination. In addition, Mata Fria and Santa Luzia have a riparian forest degraded by human occupation. One of the houses in Mata Fria has a dam for water catchment upstream of the intake point, decreasing the river flow and the WTP catchment. Further, there is no fence protecting the riverbank in Cruzeiro and Sao José do Sobradinho, allowing cattle invasion and degradation. The basin of São José do Sobradinho is on private property, with no protection or fiscalization, and the water is used for property planting and irrigation.

### 3.2.4. Financial stability

Regarding the financial balance of the communities, only Mata Fria, Santa Luzia, Camargo and Indaiá reported that the revenue from water fees collection is greater than the water systems' operational costs. Also, it allows cost recovery and generates enough funds to cover O&M costs and other expenses. Every community, other than Prata and Cruzeiro, keeps accounting records.

### 3.2.5. Tariff

Regarding finances, all of the communities charge users a tax, but only Mata Fria, Santa Luzia, Indaiá, Bela Vista, Garrucha, São José do Sobradinho and Santo Antônio do Pouso Alegre had a tariff based on user's consumption, due to the installation of water meters. But in Santo Antônio do Pouso Alegre, about 10% of the households did not have the device installed yet. Water meters were also being installed in Km 20. The communities where a high number of defaulting users were verified were Km 20, São José do Sobradinho and Santo Antônio do Pouso Alegre.

The tariffs, their sufficiency to guarantee cost-recovery, and an emergency fund are displayed in Table 6. For the communities unable to self-sustain, and hence receive subsidies, the type of support and its provider are also displayed.

### 3.3. Communities evaluation

The indicators used to evaluate the communities were: improved water system coverage, improved sanitation system coverage, WSSI, coverage of sanitation hydraulic system, coverage of social care centers by improved drinking water, coverage of social care centers by improved sanitation, and healthy environment and good practices in hygiene. This actor's score was calculated by the average of the indicator's notes. The average of the communities by this actor is: Santa Luzia (3.90), Indaiá (3.80), Camargo (3.60), Garrucha (3.46), Bela Vista (3.33), São José do Sobradinho (3.30), Mata Fria (3.00), Santo Antônio do Pouso Alegre (3.00), KM 20 (2.78), Prata (2.13) and Cruzeiro (1.13).

### 3.3.1. Improved water system coverage

This indicator represents the percentage of households covered by improved drinking water. In Cruzeiro, no water treatment is employed; therefore, no household is covered by improved drinking water. Regarding the other communities, each water system can provide 100% coverage.

### 3.3.2. Improved sanitation system coverage

The coverage of households by improved sanitation facilities[1] is evaluated by this indicator. The sewage from Mata Fria, Santa Luzia, São José do Sobradinho, Camargo, Santo Antônio do Pouso Alegre and Bela Vista is disposed of in septic tanks. In Mata Fria, inhabitants could not remember the last time the septic tanks were inspected. In Santa Luzia, there was a specialized company to clean them regularly. In Santo Antônio do Pouso Alegre, 90% of households have septic tanks and filters. In Camargo, all of the household sewage is sent to a septic tank and then discharged into a nearby river (the conditions of the septic tank could not be verified).

In Indaiá and Km 20, sewage is discharged into the nearest stream without treatment. Each household from Garrucha and Prata had rudimentary cesspits. Finally, the resident interviewed could not provide information for this indicator's evaluation in the Cruzeiro community.

[1] Siasar considers 2 types of improved sanitation facility. Type 1 uses a facility with water discharge (manual or automatic), where feces are conveyed to a piped sewer system or a septic tank. Type 2 uses a ventilated improved pit latrine, pit latrine with slab or composting latrine/toilet (Siasar, 2016).

**Table 6.** Tariff, cost-recovery, emergency fund and external supply at the communities.

| Community | Tariff | Cost - recovery | Emergency fund | Continuous subsidies |
|---|---|---|---|---|
| Bela Vista | \$1.80 the first m³ and \$0.18 each extra m³ | No | No | Municipality pays electricity bills and the operators' salary. |
| Camargo | \$5.16 | Yes | No | None |
| Cruzeiro | \$2.58 | No | No | Maintained by the municipality |
| Garrucha | \$4.63 the first 10000 m³ and \$0.51 each extra m³ | No | Yes | Municipality pays electricity bills and buys salt to produce chlorine |
| Indaiá | \$5.92 the first 15 m³ and \$0.26 each extra m³ | Yes | Yes | None |
| KM 20 | \$3.86 | No | Yes | Municipality pays electricity bills |
| Mata Fria | \$6.44 the first 15 m³ and \$1.29 each extra m³ | Yes | No | None |
| Prata | \$1.29 | No | No | Maintained by the municipality |
| Santa Luzia | \$6.44 the first 15 m³ and \$1.29 each extra m³ | Yes | Yes | None |
| Santo Antônio do Pouso Alegre | \$5.15 the first 10m³ and \$0.51 each extra m³ | No | No | Municipality pays electricity bills |
| São José do Sobradinho | \$3.86 the first 10m³ and \$1.17 each extra m³ | No | No | Municipality pays electricity bills |

### 3.3.3. WSSI

The Water Service Sustainability Index obtained by each community using the correspondence shown in Table 4 and the WSSI's formula is displayed in Table 7.

**Table 7.** Communities' WSSI.

| Community | WSSI |
|---|---|
| Bela Vista | 0.66 |
| Garrucha | 0.66 |
| Mata Fria | 0.66 |
| Stª Luzia | 0.66 |
| Indaiá | 0.61 |
| São José do Sobradinho | 0.44 |
| Stº Antônio do Pouso Alegre | 0.44 |
| Km 20 | 0.22 |
| Camargo | 0.19 |
| Prata | 0 |
| Cruzeiro | 0 |

### 3.3.4. Coverage of sanitation hydraulic system

This indicator refers to the percentage of households and other buildings connected to the system with sanitation facilities with adequate equipment for personal hygiene. Every household in each community has these facilities, therefore fulfilling the indicator.

### 3.3.5. Coverage of social care centers by improved drinking water

This indicator comprises social care centers (educational and health facilities) covered by the RWSS. Every community's social care centers are supplied by the water system. Aside from Cruzeiro, which does not have those facilities.

### 3.3.6. Coverage of social care centers by improved sanitation

It was not possible to visit every social care center in the communities. Therefore, it was considered that the same sanitation facilities attending households also attended social care centers.

### 3.3.7. Healthy environment

This indicator considered factors that lead to environmental degradation and raised public health risks. In Mata Fria, there was a contamination risk due to sewage disposal in equipment without proper maintenance. In Garrucha and Prata, rudimentary cesspits also represent risks of soil and water table contamination. In Camargo, effluents are discharged into water bodies without treatment.

Regarding solid waste collection and disposal methods, Indaiá, Camargo, Mata Fria e Stª Luzia have waste collection; the disposition method is unknown. In Bela Vista, Km 20, São José do Sobradinho and Stº Antônio do Pouso Alegre, there is also waste collection and the final disposition is a dump. In Garrucha there is no waste collection, hence, garbage is burned. No information about waste collection and disposal in Prata and Cruzeiro was gathered.

## 3.4. Good practices in hygiene

This indicator evaluates the usage of bathroom sinks, safe water management and garbage treatment in households. Every community related compliance with this indicator (it was considered each situation).

## 4. DISCUSSION

This chapter is included in order to evaluate the results found by the Siasar tool in light of other papers that considered community water supply management. The scope of this evaluation considers technical, financial, institutional and social elements to detect potential threats to the RWSSs' functionality. These elements, verified through the assessment of the actors according to different papers, influence the water treatment system's sustainability (Kativhu *et al.*, 2017).

Overall, communities have managed to achieve high scores in the water system evaluations, between A and B (regardless of Prata, that was not evaluated in this category, as it did not have a WTP, just water intake). Even though the Siasar tool allocated high classifications to this actor, there are still adjustments which could provide major improvements to the quality of service. Those adjustments are linked to needs of refurbishment, rebuilding and major repairs, which realization is hindered or even infeasible due to budget deficits and low-skilled operators, factors that reflect disorders related to the service provider and the technical assistance provider.

The service providers achieved classifications between B and D. A common factor among communities was a low number of seats occupied in the community organization and infrequent meetings between participants. As seen in Braimah *et al.*, (2016), meeting frequency was related to faster problem solving, implying positive outcomes. The small number of members in the community organization could potentially contribute to a burden of responsibilities to individuals. Also, given the voluntary nature of the job, members usually avoid the labor (Leclert *et al.*, 2016). As verified by Harvey and Reed (2007), Leclert *et al.*, (2016) and Lockwood and Smits (2011), this avoidance results in difficulties to ensure the RWSSs' sustainability. Moreover, this is a recurrent problem in this type of management, as reported by other researches (Braimah *et al.*, 2016; Foster *et al.*, 2018; Harvey and Reed, 2007; Lockwood and Smits, 2011; Osumanu, 2010).

Another factor is the informality of community organizations, also considered a problem that undermines rural WSS (Moriarty *et al.*, 2013; Borja-Vega *et al.*, 2017; Leclert *et al.*, 2016). This characteristic hinders the professionalization of the service provider, which could result in loss of efficiency in the long-term. Also, the legal status of service provider gives it access to benefits, such as discounted electricity, greater trust in tariff collection (Borja-Vega *et al.*, 2017), as well as access to credit or legally contract support services (Leclert *et al.*, 2016). It becomes even more worrying in cases where there is not an organization focused on the WTP, as in the case of Prata (where school staff manage the WTP) and Cruzeiro (where inhabitants take turns to switch the pump on and off).

The tariff scheme is also a concern, since cost-recovery by means of water fees is feasible in 36% of the communities, the same percentage for those able to nourish an emergency fund. Therefore, service providers lack sufficient budget to perform major repairs and system refurbishment, which constitutes an important aspect to ensure long-term sustainability as stated by Rivas *et al.* (2014). All those communities whose revenue is not enough to assure cost-recovery reported a level of dependency on external supporters to cover O&M expenses. Even though external financial support is a critical part of community managed RWSS, its extent must be calculated thoroughly. As claimed by Madrigal *et al.*, (2011), the provision of excessive financial resources could generate an undesired dependency of community organizations. Therefore, less efforts from local managers would be directed towards improvements to create financial self-sufficiency of the RWSS. Behnke *et al.* (2017) highlight the necessity of local authorities to promote capacity-building on financial planning, allowing community organizations to gather the required knowledge to maintain a stable financial scheme and minimally depend on external financial aid. Rivas *et al.* (2014) state that financial schemes must go beyond cost recovery and be established to guarantee future system refurbishment when necessary. It is also important that community organizations can identify the costs of O&M and to select the appropriate tariff scheme for the locality (Moriarty *et al.*, 2013). That, plus accountability, affects the commitment of users to pay the water tariff (Chowns, 2015; Harvey and Reed, 2007; Lockwood and Smits, 2011; Madrigal *et al.*, 2011; Schouten and Moriarty, 2004).

The distance between communities and technical assistance providers weakens the quality of the WSS. No community reported regular contact with this actor. The basic training regarding O&M and management given by technical assistance providers before handing-over the WTP is not enough (Leclert *et al.*, 2016). To generate the best outcomes in the RWSSs and ensure its sustainability, it is important to strengthen the relationship between external agencies and the communities (Smits *et al.*, 2013; Kayser *et al.*, 2014; Schouten and Moriarty, 2004). As observed, some communities' operators did not perform the fluoridation step of the treatment owing to insufficient training. In São José do Sobradinho, fluoridation was not performed since Cesan no longer provides the product needed. The cleaning of reservoirs and filters in Camargo was compromised because operators only received training 2 years after their hiring.

The community actor evaluation was mostly reduced due to the potential risks related to irregular wastewater disposal and unimproved or improperly maintained sanitation facilities. Additionally, evidence of community participation was found in any community. Barde (2017) found that implementation and community management of rural WSS projects have a growth of 6% greater than those without users' involvement. User participation and sense of ownership towards the water system are considered essential to maintain the systems' functionality and ensure the success of the approach (Kelly *et al.*, 2017; Kleemeier, 2000; Rautanen and White, 2018). Moreover, technical assistance providers have a responsibility in the processes of creating an efficient enabling environment, where there is environmental awareness, and the empowerment and communities' engagement are feasible and stimulated. The enabling environment in the RWSS context consists of institutional and political conditions that promote the sustainability of the RWSSs. These conditions are achieved through the creation of legislation, policies, funding mechanisms and supporting programs that allow community managed RWSSs to operate sustainably (Lockwood and Smits, 2011). It has been recognized by Amjad *et al.* (2015) and Moriarty *et al.* (2013) that the enabling environment is a fundamental element to ensure positive outcomes from drinking water supply systems. By these means, the rural WSS is strengthened without creating dependence on external agency subsidies that, according to Madrigal *et al.* (2011) weaken or eliminate local contributions.

## 5. CONCLUSION

All the communities studied could maintain an acceptable level of functionality of the water supply systems. However, the verified failures represent threats to the systems' sustainability in the long-term. Therefore, the need for adopting measures to improve the performance of the systems and avoid prospective collapses and breakdowns arises. In the case of the considered sample of RWSSs, those measures are mostly related to needs of technical and operational support, which can be set-up as managerial assistance from state or municipal spheres. This assistance may be implemented as collaboration networks between close communities and government, so that they can support each other when needed, and exchange solutions and qualified labor supply to assist the WSS. Thus, it is possible to troubleshoot faster.

This paper found that the major threat to communities is the lack of continuous and systematic presence of the technical assistance provider, which hinders the development of a more sustainable service. This actor plays an important role in lining the other actors up in order to increase the quality of the WSS. Examples of this role based on the results presented by this study are: continuous capacity building of managerial and technical skills of local communities to promote the definition of more efficient tariff schemes. These schemes should be affordable for users in order to decrease defaulting and also to improve revenue for covering O&M costs; stimulate service providers to undergo the process of legalization, which increases professionalization and the quality of service and promotes environmental awareness throughout the community, sensitizing users regarding the necessity of adequate and continuous sanitization.

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