The impact of household connection to public network wastewater systems: regulatory impact assessment

Bruno Eustaquio de Carvalho, Samuel Alves Barbi Costa, Rui Cunha Marques and Oscar Cordeiro Netto

ABSTRACT

Brazil faces a severe lack of wastewater coverage. Even in urban areas, wastewater is directly disposed of in watercourses without any treatment for a large part of the population. Although the federal, state, and local governments have invested in water and wastewater services (WWS), the expected results have not been achieved. To overcome this problem, the present paper provides an opportunity to observe an ex-ante regulatory impact assessment (RIA) as a policy tool in Brazil. The regulatory policy options will be appraised through the multiple criteria decision analysis (MCDA) according to the following objectives: (i) protect the customers with respect to social aspects; (ii) safeguard the economic, operational and infrastructure sustainability; and (iii) protect the environment. The results show that by making decisions based on evidence, policy makers should reduce the households not connected to wastewater services by 75% and for that they should incur BRL 33 million to the year 2023. Hence, the extra revenues to be obtained with these new connections are capable of making a surplus estimated as BRL 42 million for the same period. This study promotes the use of RIA as a rational, robust and transparent decision framework by the regulatory agencies worldwide.

Key words | multiple criteria decision analysis, regulatory impact assessment, wastewater services

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INTRODUCTION

Access to safe water and wastewater is essential for health, security, livelihood, and quality of life. In 1977, during the United Nations Water Conference, the international community declared the 1980s as the International Drinking Water Supply and Wastewater Decade; the goal was to ensure that all people worldwide would have access to clean water and wastewater by the end of the decade. However, more than 30 years later, almost 40 percent of the world's population remains without improved wastewater infrastructure.

In developing countries, (i) the lack of infrastructure for wastewater collection and treatment, (ii) the great resistance from users to connect to public wastewater systems because of the link between services and higher tariffs, and (iii) the indirect perception of the importance of those services are the cornerstones of many current development strategies. Such a deficit has had a negative impact on people's quality of life, as it directly affects their health, the environment and the services' economic sustainability in the medium and long term.

In Brazil, despite the gap in water and wastewater coverage (16.7 and 49.7%, respectively) (SNIS 2015), the adoption of (i) the national legal enforcement regarding household connection (Law no. 11445/2007, art.45) and (ii) the regional legal norms of the state of Minas Gerais (MGS) (Law no. 13317/1999, art. 48) have not contributed, as it was expected, to improve this situation. In fact, the major concern is not only the investment but the need to adopt good governance practices and regulations such as the Regulatory Impact Assessments (RIA).

According to (Berg 2013), the substance in regulation is defined as the tools and rules available to regulators. Herein, the authors refer to the RIA as an important substance to improve the knowledge basis and regulatory governance of public utilities (Berg 2013; Meuleman 2015; Carvalho *et al.* 2017; Marques & Pinto 2018). The absence

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of the RIA may contribute to an irrational decision process, especially with respect to water and wastewater services (WWS). Any strategy adopted by governments (primary law) or regulators (secondary law) could imply behavior changes either in public or private entities acting within the referred sector (Massarutto *et al.* 2013).

Although there are some academic RIA evaluations of Brazil's WWS (Carvalho *et al.* 2017), to the best of our knowledge, none of the national regulators have used the RIA in practice. From this perspective, the main objective of this paper is to oversee a case study that employs a RIA framework capable of supporting a regulatory decision process in a context where such a frame can upgrade the outcomes (Oldford & Filion 2013). This approach could enrich research originality and provide an opportunity for the Water and Wastewater Regulatory Agency of Minas Gerais state (ARSAE in Portuguese) to expand its knowledge, increase its power to access data and improve its regulatory function.

The authors believe that this scenario can provide an opportunity to observe the RIA in practice following three steps, namely, (i) the status quo, (ii) an assessment using a multiple criteria decision analysis (MCDA), and (iii) a consultancy. The reason for doing so is that the WWS policy or regulation involves several objectives which require MCDA combined with the judgments of decision makers (DMs) to enhance the quality of information throughout the decision-making process. This work represents the first known effort to apply the RIA in the Brazilian wastewater sector.

In this paper, the authors implement the MCDA modeling method using an interactive approach through a categorical-based evaluation technique, which assesses the impacts of each option offering cost-benefit analysis at the end. This method was developed by adopting a specified evaluating structure to assess the various possibilities (Pinto & Marques 2016). The criteria and options were defined by a focus group comprised of regional and local stakeholders who were regarded as experts in the field. A conference panel and a web survey were used to obtain value functions and weights of the criteria. Sensitivity, robustness and cost-benefit analysis were used to indicate the most adequate policy option.

The remainder of this paper is organized as follows. The next section discusses the current wastewater sectors in Brazil and, particularly, in the state of Minas Gerais. The following section describes the RIA framework as an innovative approach, and the methodology is detailed in the subsequent section. The next section then provides an example of the RIA application and the corresponding implications. The subsequent section presents the discussion and the last section draws the paper conclusion.

WATER AND WASTEWATER SERVICES: BRAZIL

In terms of structure, the WWS, together with solid waste management and rainfall drainage, is classified in Brazil as part of a broader concept called 'basic sanitation'. Currently, the sector is decentralized into municipal jurisdictions in which local administrations are responsible for providing these services. A few regulatory agencies for water supply and wastewater services were created after 1997, and Law no.11445/2007 formalized their activities. Until 2014, 50 regulatory agencies were established for WWS, of which 22 were state agencies, one was a district agency, 24 were municipal agencies and three were municipal consortia (micro-regional) (ABAR 2015).

Brazil faces a historic deficit in basic services that fosters inequities and enhances social gaps (Carvalho & Sampaio 2015). Approximately 6.9% of the urban population have no access to the water supply network, while 42% have no access to the wastewater network. In the state of Minas Gerais (MGS), specifically in the Belo Horizonte metropolitan region (BHMR), between 30% and 46% of the urban population has no access to the water supply or to the wastewater network (SNIS 2015). There are two main reasons for the wastewater treatment deficit in the MGS, namely, (i) a lack of coverage caused by investments below the desired levels and (ii) a portion of the population that refuses to connect to the public wastewater network to avoid paying for the service. As previously mentioned, investment levels in Brazil and MGS are inferior to those required for the universalization of wastewater services. Nevertheless, when the investments are made, household connections fail to accomplish the expected levels.

Federal Law no.11445/2007 and State/Regional Law no.13317/99 provide legal safeguards for investments made by providers by defining obligatory connections to households in which the public WWS network is currently available. However, these laws have not been effective in enforcing the connection to the public wastewater system that mandates regulatory enforcement.

The regulator involved in such an analysis is ARSAE. It was created by Minas Gerais state Law no.18309/2009 and has been responsible for regulating state (COPASA and COPANOR) and local companies (CESAMA-Juiz de

Fora, SAAE-Itabira, SAAE-Passos). ARSAE regulates approximately 3.5 million households through mandatory laws and specific agreements. Due to its importance in the national background, such proposed academic exercise is a great opportunity to spread the use of the RIA's framework as support for rational decision processes.

ARSAE is not legally allowed to inspect non-connected households, nor can it compel the population to fulfill legal requirements as these mandates are exclusively given by municipal power. Nevertheless, the agency can act within the parameters of its rules, mainly through the design of tariff mechanisms that are capable of promoting the desired outcomes that highlight the importance of the proposed analysis.

Importantly, the WWS infrastructure deficit has a negative impact on Brazilians' quality of life as it directly affects the health, economy and environment and undermines sustainable development. Finally, the debate regarding investments and household connections reveals itself as a productive effort to overcome obstacles that limit the universal access to WWS.

THE RIA FRAMEWORK

The use of a formal and explicit RIA method was initiated in the USA over 45 years ago. Canada followed this initial example by the end of the 1970s, and Germany, Australia, the UK and the Netherlands adopted the RIA in the mid-1980s. Currently, the RIA represents an unusual coherent policy argument from the perspective of the agency issuing the regulation (Desmarais & Hird 2014).

In this paper, the authors refer to the RIA as a policy tool that systematically evaluates the potential impact arising from government regulation and allows for the broad collaboration of stakeholders according to (i) status quo, (ii) assessment, (iii) consultancy, and (iv) review or final step (Carvalho *et al.* 2017). The RIA method may facilitate regulators as they make rational decisions that are supported by data and evidence. Some methods can contribute to the RIA process (Carvalho *et al.* 2017), such as: (i) monocriterial, i.e., MCDA and risk methods enable the impact assessment of policy options; (ii) Monte Carlo simulation and integrated sensitivity analysis; and (iii) conference panel, nominal group technique and Delphi, which aid methods that allow for the description of policy problems, identification of criteria, development of alternative scenarios, and support of the analytical methods in a different way (Carvalho *et al.* 2017).

Among the experts, the RIA is generally understood as a means to improve regulatory quality (Carvalho *et al.* 2017). Arguably, the RIA would contribute to decision-making processes by making them more rational, integrated, robust and transparent. Hence, the use of the RIA can improve the regulator's human resources managerial and regulatory capacity as well as the knowledge basis (Dunlop & Radaelli 2016), particularly during periods of economic recession and crisis (Tetlow & Hanusch 2012; Carvalho *et al.* 2017). Hence, it is fair to argue that there is a consensus in the literature regarding the positive balance of the RIA as a policy tool, although it does not reflect the practical use of the RIA in OECD countries and elsewhere (Adelle *et al.* 2015; Dunlop & Radaelli 2016).

Finally, this adoption of the RIA represents an important academic exercise where theory and practice are put side by side to support WWS as a driver of governance in the decision-making process, thus improving regulatory principles at the administrative level and requiring government accountability.

METHODOLOGY

To measure the impact assessment of household connections, the article implements the RIA framework as a policy tool to improve regulatory decision making in practice. A focus group comprised of individuals who represented the stakeholders involved in the process was brought together to participate in the discussion. The MCDA was used as an assessment method to support our analysis. Figure 1 and Appendix 1 (available with the online version of this paper) present the details of the RIA framework.

Status quo

First, the authors examined the status quo of a small group of cities, namely, Belo Horizonte, Betim, Contagem and Ribeirão das Neves (hereafter, BBCR), of which approximately 3.85 million people have wastewater system coverage (Instituto Trata Brasil 2015). Moreover, the gap regarding non-connected households exceeds 365,000 inhabitants.

At this stage, the objective was to identify regulatory alternatives that allow DMs to address the current problem and formulate the criteria. The focus group; that is, the ARSAE, academics, and local government members, discussed the following proposals (for detailed information visit Appendix 1): (i) strong infrastructure diffusion;

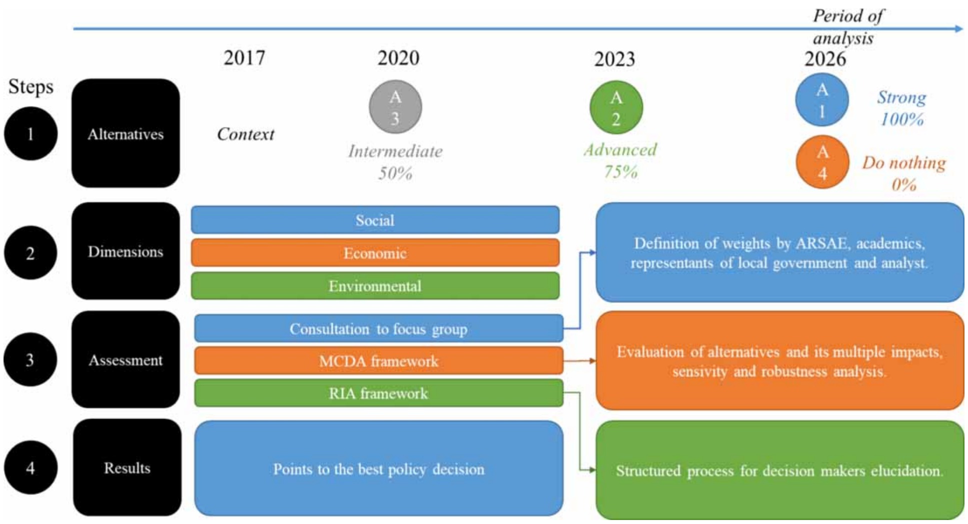


Figure 1 | RIA's framework to evaluate 'household connections'.

(ii) advanced infrastructure diffusion; (iii) intermediate infrastructure diffusion; and (iv) do nothing. These proposals were developed by a variety of functional forms, including linear ones (Reynaud 2016) performed by Equation (1).

$$Y = \beta_0 + \beta_1 X_i + \epsilon_i \tag{1}$$

where ϵ_i is the random error in Y for observation I; β_0 is the y-intercept, which is, in this case, the value for each criterion; and β_1 denotes the slope, which is the correlation between the criterion's value and time based on the ratio of these variables. These are all constants to be estimated. The coefficients of determination (Equation (2)) and the confidence interval, which reflect the uncertainty associated with each parameter value (Equation (3)), were adopted to verify the statistical influence.

$$R^2 = 1 - (SS_{res}/SS_{tot}) \tag{2}$$

where SS_{res} corresponds to the residual sum of squares and SS_{tot} denotes the total sum of squares.

$$\xi = t_{95\%}\sqrt{1 + \frac{1}{n} + \frac{(\bar{x} - x_0)^2}{\sum x_i^2 - n\bar{\bar{x}}^2}\hat{\sigma}^2} \tag{3}$$

where $t_{95\%}$ corresponds to the value of Student's *t*-test distribution (with 2 degrees of freedom for the 95% confidence interval), n corresponds to the total of the sample, $\bar{x}$ denotes the average, x_i is the observed value, and x_0 represents the estimated value. Finally, $\hat{\sigma}^2$ refers to the variance of a random variable. The projection, performed by MATLAB® software (license available at IST, Lisbon, Portugal), was considered as an input of each regulatory policy option (RPO); that is, do nothing.

For all hypothetical alternatives, the authors considered that the deployment cycle will occur within seven years (2016 to 2023). To implement the MCDA modeling method, the core of the RIA framework, some criteria were required. The authors, supported by the ARSAE, detailed the objectives for protecting customers' interests, safeguarding the economic sustainability and protecting the environment in five criteria and descriptors. The focus group identified three dimensions of the analysis; namely, (i) social, (ii) economic and (iii) environmental. Alternatives and details of the proposed objectives are available in Appendix 1.

Concerning the social perspective, the authors argue that there is substantial literature establishing the harmful effects of the lack of wastewater on health outcomes, particularly in urban areas. Approximately 88% of all infectious diarrhea illnesses worldwide is attributed to unsafe water supplies, the lack of safe hygiene practices, and inferior wastewater infrastructure (Evans *et al.* 2004). Accordingly, safe hygiene practices and improved wastewater can have a significant impact on health threats for children under five (Hutton & Haller 2004; Waddington & Snilstveit 2009). Indeed, the authors contend that there is a fundamental relation between a non-connected household (CSo_1) to the public wastewater system and a substantial impact on waterborne disease avoidance (CSo_2) that requires a sensible analysis of the outcomes provided by the model.

Regarding the economic perspective, it is essential to guarantee the sustainability of wastewater services using a rational stimulus from the regulator, even though costs alone may not be a sufficient criterion to induce system changes (Maurer *et al.* 2005). Accordingly, the revenue (CEc_1) generated by the tariffs must be sufficient to cover capital and operational costs while providing adequate profits to remunerate shareholders related to the capital cost (investments and their remuneration) and operational costs (marginal costs) necessary to reach each of the alternatives given in the RIA process.

Finally, as far as the environmental perspective is concerned, all benefits from wastewater treatment are linked to improvements in water quality through the removal of various polluting substances. However, these benefits are less visible to individuals and more difficult to assess in monetary terms. To address this challenge, the option was to model the amount of sludge (CEn_1) that could be driven out of the environment by connecting households to the public wastewater system.

Assessment

The assessment step consists of analyzing alternatives for each criterion that impacts profit-and-loss value functions. A review of the MCDA modeling approaches led to differentiating the types of results that the analyst may consider in relation to the methods clearly associated with them (Roy & Słowiński 2013).

The Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) method is a particularly simple and well-known MCDA modeling method for evaluating options based on qualitative judgments regarding their attractiveness to a DM (Greco *et al.* 2016). Regarding the RIA, the MACBETH method was selected based on the following aspects (Roy & Słowiński 2013; Greco *et al.* 2016): (i) type of problem (P. α); (ii) acceptance of utility score; (iii) type of scale (non-original); (iv) preference of decision maker; and (v) resources required.

The objective function of the problem was to maximize $RP\Phi(o_1)$, where $RPO\Phi(o_1)$ is the score of the most attractive regulation policy option o_1 (Ishizaka & Nemery 2013) implemented by Equation (4):

$$\text{Max RPO}\,\Phi(o_1) \leq \sum_{j=1}^{n} c_j.s_j \text{RPO}\Phi(\text{o}1) \quad (4)$$

where c_j is the weighting coefficient of criterion j, and $s_j\Phi(\text{o}1)$ is the score of each regulatory policy option $\Phi(\text{o}1)$ for criterion j. The values were obtained through using the M-MACBETH® software.

Consultation: focus group

One of the core domains in the RIA is open government, in which regulators must adhere to principles of transparency and participation in the regulatory process to ensure that the regulation serves the public interest (OECD 2012). Such a concern is central to evaluating household connections because this domain; that is, open government, must provide reliable information during the decision process (Montibeller & von Winterfeldt 2015) and allow policymakers to recognize the participation of all non-neutral stakeholders in the utility agenda (Carvalho *et al.* 2017).

In this article, the authors implemented a consultation process based on three stages: (i) structuring issues, (ii) scale transition and (iii) weighting coefficient procedure. Initially, the regulatory policy options were performed, and for each criterion, reference levels were required. Second, the transition scale from ordinal to cardinal was performed to cope with the concept of strength preference. Finally, the M-MACBETH required the variation of the coefficient weights. A focus group meeting and a web survey supported all the steps.

The results, as obtained with M-MACBETH, were discussed based on their weighting references, sensitivity, performances, profiles, robustness and cost-benefit analysis.

RESULTS ACHIEVED

The authors chose the BBCR to apply the RIA and evaluate the household connection gap while taking into account social, economic and environmental aspects. Table 1 summarizes all aspects of each policy alternative. Figure 2 represents an example of how the gap coverage was calculated (the remainders are available in Appendix 2, available with the online version of this paper).

The authors used the M-MACBETH® to assess the different possibilities of proposed alternatives/policy options related to the gap and adopted an interactive approach that required several interactions among the focus group to evaluate the criteria, assign value functions, and establish their weights. Due to the characteristic of an ex-ante proposed analysis, caution must be taken in the use of proxy indicators (Pinto & Marques 2016). In this paper, the authors chose the sensitivity and robustness analysis.

Table 1 | Aspects of all alternatives (2017–2026)

Alternatives	Criteria	A_1	A_2	A_3	Do nothing
% coverage (in terms of current non connected households		100	75	50	Current
Social No. of households non-connected Hospital stay/year	CSo_1 CSo_2	0 10.7	26,768 11,1	53,537 11.6	107,074 12.6
Economic Average tariffs Capex and opex (million)	CEc_1 Infra	99 352	74 264	45 166	68 157
Environmental kg/year (million)	CEn_1	38	40	47	73

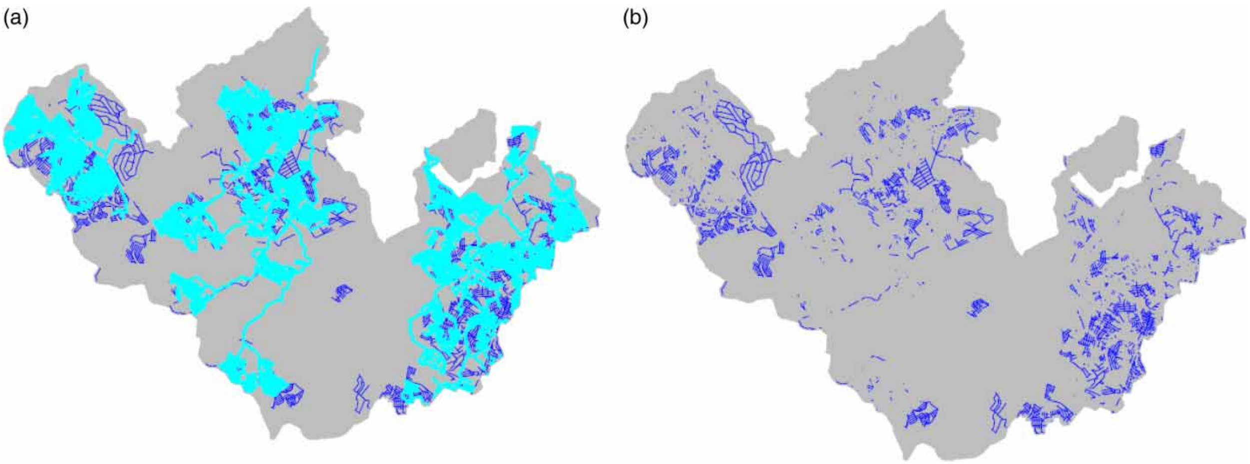


Figure 2 | Street map: (a) area covered (Ribeirao da Neves) by wastewater services and (b) area non-covered.

Structuring issues and scale transition

The first step was to create the definition of scale attractiveness (value functions) for each criterion and then convert the performance levels into a local score; that is, lower (neutral) and upper (good) references considering each criterion's performance.

Hence, the modeling of DM's preferences was performed to translate impacts into value scores that indicated the degree of attractiveness of an impact when compared to the reference levels. Figure 3 presents the preference scale necessary to overcome the gap with respect to household connection.

Note that the maximum score according to the focus group corresponds to reducing the gap from 120,000 to 30,000 connections. Each difference among 'good, neutral and intermediate' levels reflects the degree of difficulty associated with coping with the gap in each criterion adopted in this analysis. The value reminder functions are presented in Appendix 3 (available online). Although interactions among the focus group were frequent, it took 30 days to complete this stage, which consisted of the introduction of the approach, the analysis and the validation step.

Weighting coefficients

The focus group qualitative judgments regarding the differences in criteria swings were repeated row by row until the weighting matrix was filled. The differences between neutral and good attractiveness for every pair of criteria were obtained from the most to the least attractive criteria swing. From each perspective, the focus group was asked to examine and confirm the weighting coefficients to validate the matrix. This stage took 15 days, and it included the reasoning of the proposed analysis and a validation period for the results achieved.

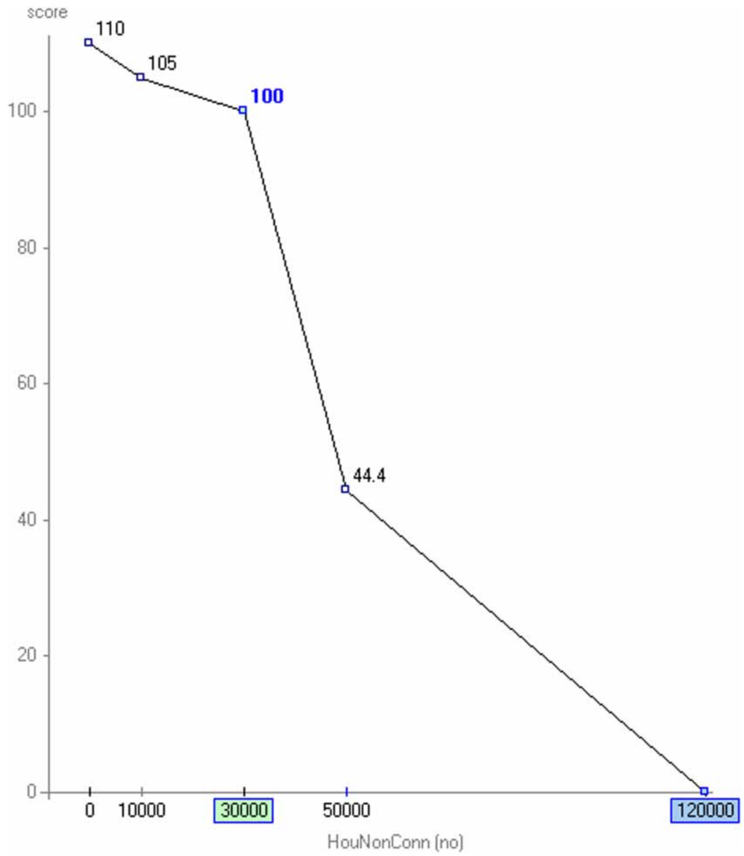
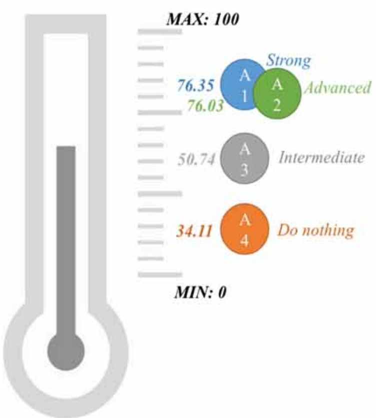


Figure 3 | Value function for household connection gap criterion.

Based on consensus, the goal to expand wastewater services access (CSo_1) was evident and was consistent with the main proposed idea of the ARSAE's intervention. In this research, the externalities measured by health issues (CSo_2) and environmental (CEn_1) criteria are based on less relevant positions in relation to the infrastructure (Infra) and its correspondent revenues (CEc_1). Accordingly, this shows the importance given to economic issues when there are multiple challenges.

Policy options

According to Figure 4, which provides an overall score for each policy option studied, there was no policy option for



Id	Alternatives	Overall	SCORE				
			Social		Economic		Environmental
			Household non-connected (CSo1)	Waterborne diseases avoidance (CSo2)	Incomes (CEc1)	Costs (Infra)	Sludge (CEn1)
A1	Strong infrastructure diffusion	76.35	110.00	38.18	108.86	13.48	94.00
A2	Advanced infrastructure diffusion	76.03	100.81	24.54	99.28	38.82	89.80
A3	Intermediate infrastructure diffusion	50.74	42.16	8.18	58.85	71.63	82.40
A4	Do nothing	34.11	8.20	-16.36	-	120.00	5.76
Weights		-	0.433	0.100	0.1667	0.267	0.003

Figure 4 | Overall thermometer and scores of each policy option.

all upper among the focus group alternatives. This finding is consistent given that overcoming the household connection gap demands a substantial increase in costs (Infra). The marginal expansion of infrastructure tends to be widespread in peripheral areas that are frequently not regulated by local public authorities. In addition, as the revenue in these areas is not properly insured, people can still refuse connection even if it is provided by the public wastewater network.

According to this RIA frame, the overall score between alternatives A_1 and A_2 was similar in terms of CSo_1, CEc_1, and CEn_1. Such a situation is not a problem because this approach revealed that two alternatives could be better understood by an additional analysis of sensitivity, robustness, and cost benefits, which encourages DMs to choose the best policy option.

The overall performance distance between (A_1 and A_2) and A_3 was significant with respect to the social aspects, thus indicating their rejection in such an analysis. Finally, all alternatives proposed have an overall score higher than A_4, i.e., do nothing, which encourages DMs to act towards the other available alternatives while taking into account the current conditions of wastewater services in the surveyed region.

Additional analysis

A sensitivity analysis on weighting was conducted between A_1 and A_2 concerning the non-connected households (see Appendix 4a) (Appendix 4 is available online).

By performing a sensitivity analysis on the weight of CSo_1 between the $A_1 \times A_2$ policy options, it was observed that its variation, maintaining identical proportions for the weights of the remaining criteria, only introduced changes in the ordering of the best option when it decreased to a level below 41%, as presented in Figure 4. When $A_1 \times A_2$ policy options were compared regarding CSo_2, CEc_1, Infra, and CEn_1, the variation of the final results achieved was CSo_2 and CEc_1 decreased to levels below 7.8% and 13.7%, respectively. With respect to the Infra criterion, the variation between the final results is achieved when the weighting of the criterion increased to higher than 27.6%. With respect to CEn_1, the absence of an intersection indicates that A_1 is always more attractive than A_2, regardless of the weight of the mentioned criterion. Hence, applying this same logic among the other policy options, $A_2 \times A_3$, $A_2 \times A_4$ and $A_3 \times A_4$, the authors verified that A_1 overpowered all alternatives and that A_2 was closer to A_1 and further from A_3. Thus, A_2 appears as a potential alternative for consideration as a final intervention by the ARSAE.

Robustness is an important factor when choosing scenarios because of the previous expectation that customers with different behavioral characteristics are affected differently. A global comparison table of the actions was integrated into the M-MACBETH® software. To explore the extent to which assumptions could be made based on varying amounts of different imprecision/uncertainty degrees, the robustness analysis proposed is carried on the ordinal, MACBETH and cardinal information. When no uncertainty is involved in the procedure of the impact estimation, an impact table can provide an overview of the options impacts on the criteria proposed (Appendix 5, available online). In this scenario, A_2 is more attractive than A_3. Considering the cardinal of local information and global information, A_1 dominates A_3, and A_1 is globally more attractive than all other policy options. However, changing only 1% on the cardinal or global scale is enough to denote incomparability between A_1 and A_2. This situation allowed us to confirm that A_1 is sensitive to weights, and it is not robust with respect to uncertainty.

Such vagueness forced us to invest in a cost-benefit analysis in which the proposed policy options were assessed through the groups of criteria. Thus, the cost of each intervention (only household connection) was contrasted with the benefits of all adopted aspects; that is, social, economic, and environmental (Figure 5).

All options are either on the efficient frontier or are nondominated. However, by focusing only on the comparison between A_1 and A_2, the authors found that while their benefits are similar, they bear different costs. This situation confirms our expected additional analysis, which indicated that A_2 was the adequate intervention based on the alternatives of the portfolio. When extending such cost-benefit analysis to social and environmental objectives, the authors found that the overall scores between A_1 and A_2 and A_1, A_2 and A_3 remain low. Furthermore, such analysis, which takes into account the costs of an additional connection to the WWS public network, results in a greater distance between A_2 and A_1.

In summary, the cost-benefit analysis identifies A_2 as the best alternative. As such, it represents the solution that has benefits similar to those of A_1, such as strong infrastructure diffusion (A_1) of WWS, but substantially lower costs. During periods of financial crises, which Brazil and MGS had been facing over the last years, this analysis is a fruitful and practical RIA outcome. The remainder of the cost-benefit analysis graph is available in Appendix 6 (available online).

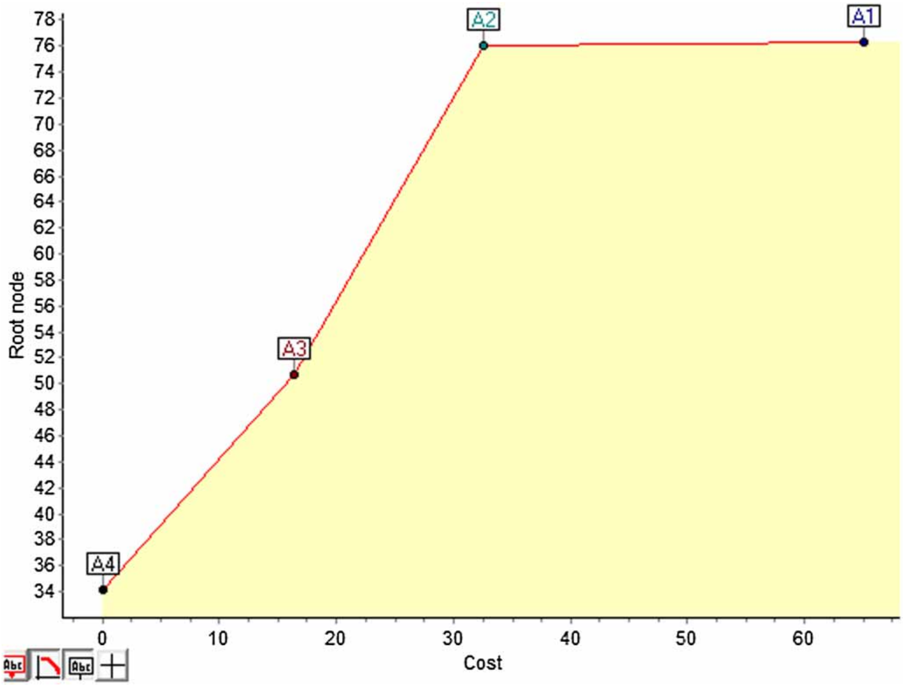


Figure 5 | Cost-benefit analysis.

PATH FORWARD

As previously highlighted, the use of the MCDA model in the RIA assessment step offers an ideal approach to evaluate complex problems, mainly those shaped by a political background that is associated with several, and often conflicting, social, economic and environmental objectives.

Even though the lack of infrastructure for the collection and treatment of wastewater has contributed to the gap in such services with respect to quantity and quality, better regulations should be a reasonable agenda item for improving performance, especially against the background of economic constraints. From this perspective, the RIA is a central approach and should create the possibility of assessing profits and losses resulting from future government interventions in that sector.

Regarding the results analysis, the weight sensitivity analysis did not support the superiority of A_1, which reinforces the need to address incomplete, imprecise and uncertain information. The robustness analysis of the outputs denoted that any time there is a change in the local cardinal information percentage, the best policy option falls to the second position in the final portfolio. Such additional analysis highlights the advanced infrastructure diffusion alternative (A_2), and the cost-benefit analysis also reinforces A_2 as the best solution when the cost of household connection is confronted with the benefits of all proposed objectives.

The results of this RIA approach are limited to the municipality of the BBCR and to certain classes of aspects, criteria, and descriptors. Therefore, it is not possible to generalize or directly infer outcomes regarding other regions. If misinterpreted, such an analysis could possibly lead to erroneous policy decisions. A good RIA practice must be tailor-made and must observe the specific political background and available data.

Despite the previously highlighted limitations, this RIA approach suggests the following:

- The universalization of services (only in that surveyed region) represented by A_1 has a high cost that would not be readily justified by the group of benefits assessed.
- A_2 corresponds to a reduction of the non-connected household gap of 75% throughout the period of analysis. This was the best available option, as its costs were almost 50% less than those of A_1, but they revealed highly similar benefits.
- A_3 (50% reduction in the mentioned gap) was considered a viable alternative given its costs and benefits. However, the focus group perceived A_3 as less desirable than A_2.
- A_4, the 'do nothing' option, is an option without costs; nonetheless, such a situation corresponds to a loss of

potential revenue based on the provider's perspective. Additionally, it extends and intensifies social and environmental damages as a result of a non-provision of services to the customers who are currently on the outskirts of the public wastewater system.

This RIA exercise creates positive conditions and arguments to improve the discussion regarding the ARSAE regulatory function in terms of wastewater services diffusion. This study posits that the agency can play an important role in overcoming the identified obstacles by designing tariff mechanisms that are able to promote the investments necessary to achieve the best alternative (A_2). Furthermore, the institution should support local governments in enforcing connection laws where the infrastructure is available. The intention is not to punish the reluctant population that refuses to adhere to the WWS but rather to create incentives and conditions capable of reversing the current situation.

These utilities record massive amounts of data, accounting for wastewater, volume, energy bills, and others (Chini & Stillwell 2017). Moreover, it is possible to stimulate the ARSAE to invest in building a reliable database to reduce information asymmetry compared to other regulated companies. The authors highlight that when the focus group does not involve representatives of all possible decision makers, such as environmental and water resource entities, their opinions should have some impact on the weighting process. Hence, this should be considered relevant and investigated in future studies.

CONCLUSION

This study promotes the use of a Regulatory Impact Assessment (RIA) as a rational, robust and transparent decision framework by the regulatory agencies worldwide. This paper examined the practical application of the RIA method against an authentic background: the municipalities of Belo Horizonte, Betim, Contagem and Ribeirão das Neves (BBCR), regulated by ARSAE.

Four policy alternatives were evaluated in order to reduce the non-connected household gap to sewage services taking into account: strong infrastructure diffusion (100%); advanced infrastructure diffusion (75%); intermediate infrastructure diffusion (50%) and do nothing (0%), which emphasize the tradeoff between investment allocation and subsidy policies.

Results show that the most indicated political decision is intermediate infrastructure diffusion (A_2). To promote a 75% reduction of non-connected households until the year 2023, a BRL 33 million expenditure is expected. Hence, the extra revenues to be obtained with these new connections are capable of making a surplus estimated at BRL 42 million in the same period. Also, the decision could minimize the amount of sludge disposed of in watercourses by 17,414 tons and improve avoidance of waterborne diseases by 12.5%. In a scenario of fiscal constraints, choosing the best alternative is essential as correct decisions present effective results and save time and resources. The RIA is an excellent tool to provide accountability and effectiveness to the public decision process.

This *ex ante* analysis allows a critical assessment of the household connection gap, although there is clear room for *ex post* analysis. Furthermore, this study is considered as a starting point to promote discussion and to attract public interest in the RIA framework applied to the wastewater sector.

In times of national constraints, as faced in Brazil, those are extremely relevant aspects in defining a political agenda. The findings empower ARSAE with a better understanding, based on data, to go beyond current policy decision practices.

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