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Governance and efficiency in the inter-municipal water management model in Alto Alentejo

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Abstract: There has been a growing trend towards delegated management in the provision of retail water services. In light of this trend, this article assesses the efficiency of the process of aggregating ten municipalities in Alto Alentejo (NUT III) into an inter-municipal company. To this end, the contracts of other similar companies were compared, the indicators that most influence the efficiency of water service provision were characterized using the Analytic Hierarchy Process and a composite indicator was constructed using an Extended Goal Programming model. The results show that direct management by municipalities performs better in terms of accessibility and safety indicators and that corporate management (private or public) is better at controlling non-invoiced water and water losses.

Key words: delegated management; water; inter-municipal companies; analytic hierarchy process; extended goal programming

1 Introduction

Water management is one of the biggest challenges in public policy today, where the criteria of quality and rationality are very much present and dominate the guidelines in the sector. It's not enough for systems to be efficient and universally accessible; management gaps and environmental externalities are also on the agenda. As stated in the International Water Association's 2019-2024 Strategic Plan, "the reality of water scarcity, punctuated by the marked frequency and severity of extreme droughts and floods, encourages the water sector to lead in innovation, finding ways to boost the circular economy" (International Water Association, 2019, p. 5).

Municipalities have natural limitations in the direct management of water supply and waste services, which derive from their nature and institutional framework and management models. Delegated management in the provision of water and waste services is a growing trend, stemming from the need for greater efficiency and cost recovery. This solution can include various legal-formal configurations, either through the aggregation of municipalities or the entry of private partners.

There are several recent studies on efficiency in water supply and distribution (Walter et al., 2009; Byrnes et al., 2010; See, 2015). One of the limitations of these studies is that they are mostly aimed at the most populous municipalities. Beneto et al. (2019) also evaluated water efficiency in small municipalities using a Data Envelopment Analysis (DEA) model and, contrary to the dominant position in the literature, recommend the involvement of local authorities in the operation of water supply services. Walter et al. (2009) conclude that efficiency studies rarely result in regulatory objectives, and that there is a need for studies that incorporate both structural and water quality variables. According to the same authors, economies of scale and the density of distribution networks dominate water supply decisions, although their effects are only visible at certain levels.

Given this problem and the lack of studies on the aggregation of water management entities, the main objective of this article is to analyze the efficiency of the management model of the Alto Alentejo Intermunicipal Community (CIM). This model involves aggregating and delegating the water management of ten municipalities in Alto Alentejo (NUTS III) to an inter-municipal company (EIM), with exclusively municipal capital. In this context, the aim is to analyze, from an institutional point of view, the models of aggregated management of entities already created that cover several municipalities, to characterize the criteria and indicators of water management, as well as to evaluate the efficiency of low water management entities based on a composite indicator.

To carry out this study, interviews were first conducted in order to carry out an institutional analysis and determine the relative importance of the indicators in water supply management. The Analytic Hierarchy Process (AHP) was used. Subsequently, in order to assess the efficiency of the management models, a composite indicator was constructed using an Extended Goal Programming (EGP) model.

This study is one of the few in the literature on the management of water supply and distribution, which is aimed at sparsely populated municipalities and first carried out in the Alentejo. It is also one of the few studies that considers both structural and water quality variables when analyzing the efficiency of water supply and distribution. Another important contribution of this article is the use of PGE to construct a composite indicator. In this case, PGE proved to be more appropriate for analyzing the efficiency of the water management model than traditional DEA, because it allows alternative target scenarios to be specified for the different criteria and indicators, which represent the structural and water quality variables considered (Jones et al., 2016).

As far as organization is concerned, in addition to the introduction, this article is organized into four more sections. The second section provides a framework, with some considerations about governance and performance in the water supply sector. The third section is dedicated to material and methods, where the research methodology is presented. The fourth section deals with the presentation and discussion of results, where an institutional analysis of the aggregated intermunicipal systems and an efficiency analysis based on a composite indicator are presented. Finally, the fifth section presents the conclusion of the study.

2 Governance and performance in the water supply sector

The state is the main operator of water supply systems and there is specific regulation for the sector, which is carried out by the Water and Waste Services Regulatory Authority (ERSAR).

By law, water supply and waste services belong to the municipalities, which can concede or entrust others to manage them. The possibility of delegation or concession of the service has been further developed recently. This process can be framed within the framework of New Public Management or New Public Governance. Among the various management models that follow this trend in the water sector, the recent trend of aggregating municipal systems into corporate entities stands out.

However, despite this trend towards new forms of management, the majority (60%) of water supply management entities are municipalities that directly manage the systems. It should also be noted that of the 23 municipal or inter-municipal companies presented in the *2019 Annual Report on Water and Waste Services in Portugal*, only two are inter-municipal companies: Vimágua and Águas do Ribatejo (ERSAR, 2019).

Although there are still many inefficiencies in the system, in recent years there have been significant improvements in the provision and quality of the water supply service, to which the measurement of indicators and the mitigation of environmental externalities have contributed (Magalhães & Bessa, 2012). Some of these improvements are also attributed to the opening up of the system to private law entities. It should be noted that since the legislative change in 1993, with

Decree-Law no. 379/93 of November 5, there has been a change in the profile and configuration of the management of Water Supply and Wastewater Sanitation Services (SAASAR).

Currently, all the high-speed services operate under a corporate regime and the low-speed services, over the years, have been "opting for corporate management models, with particular emphasis on the model of delegation to a municipal company" (Marques, 2017).

Public service obligations are embodied in legislation, through Law 58/2005 (*Water Law*), Law 23/1996 of July 26 (*Essential Public Services Law*), amended by Law 10/2013, and Decree-Law 243/2001, revised by Decree-Law 306/2007 of August 27 (*Quality of Water Intended for Consumption*). The three models allowed and typified in national law are direct management, delegation and concession. Although direct management is the formula used by municipalities (Table 1), in recent decades there has been a marked growth in business management models, which now cover almost 50% of the population, with the private sector and in particular concessions already accounting for close to 20% of the Portuguese population (Marques, 2017).

Table 1. Management models in water supply services

Model	Management entity
Direct Management	Municipal services
	Municipalized services
	Inter-municipal services
	Association of municipalities
Delegation	Company set up in partnership with the state (part of the local or state business sector))
	Local business sector company without state participation (may include a minority private shareholding)
	Parish council
Concession	Dealership company

Source: Andrade, 2016

According to the OECD (2004), policymakers must consider the impact of their choices on the functioning of markets, such as incentive mechanisms, the efficiency of self-regulation systems and systemic conflicts of interest. Using the OECD *Principles for Water Governance* (2015), there is a need to increasingly orient public policies in the water sector towards results, based on the scarcity of the resource. In this context, the financial regime of Portuguese municipalities establishes through Law 73/2013 that water prices and tariffs must not be lower than the direct costs of providing water services.

Although there is no clear evidence that the presence of private individuals in governance models favors the level of efficiency (Romano, Salvati, & Guerrini, 2018), there is a trend in Portugal towards delegated management - in public companies. Decree-Law 194/2009 establishes that a municipality, an association of municipalities or a metropolitan area can delegate the operation, maintenance and conservation of the system, as well as the construction, renovation and replacement of infrastructure, to a company in the local business sector. A delegated management contract is signed between the parties for a period of no less than 10 years, which must include the scope, rules and tariffs for providing the service.

The 2019 Annual Report on Water and Waste Services in Portugal already shows two entities of this nature and mentions five in the process of aggregation and another under study at an advanced stage. This reality is somewhat innovative in the administration of water supply in Portugal and brings numerous challenges for the future.

In order to affirm efficient water management models, it is necessary to have clear and concrete goals and objectives (Ferrão & Paixão, 2018), including continuous evaluation indicators for monitoring. In this sense, users' perceptions must also be met, as well as overcoming the tension between efficiency and equity. Water supply and sanitation services are repeatedly referred to in their mission as being conducive to not generating inefficiencies in the system (Pereira, Afonso, Arcanjo, & Santos, 2009).

Efficiency can be assessed from both the output and input sides (Brito, 2017). From this perspective, the capacity of entities to generate productive processes is decisive for its assessment. To do this, they need to be able to generate new customers, which in the water sector is only possible if there is an increase in population, or be able to minimize the resources consumed and control externalities.

The circular economy and projects to make the most of the urban water cycle are fostering good practices in the sector. In Decree-Law 119/2019 of August 21, which defines the various types of water and their application, the legislator also sought to promote the use of water in its urban cycle.

With regard to the system's ability to monitor unbilled water, Naik & Glickfeld (2017) point to the need for meters to be progressively installed in public places of consumption, so that use can be measured in these spaces, given that most of the volume of water for self-consumption by municipalities is not measured. In this sense, we can see that the strategies for the sector have been promoting cooperation, in the form of aggregation of the downstream systems, since the upstream activity has long been aggregated (Andrade, 2016).

The program of the XXII Constitutional Government itself foresees the achievement of "economic and financial balance of municipal systems, namely through the aggregation of smaller systems" (XXII Constitutional Government , p. 74). The aim is to increase the capacity, resilience and efficiency of the management entities. Based on this strategy and th*e Strategic Plan for Water Supply and Wastewater Sanitation 2020* (PENSAAR 2020), 61 municipalities have recently decided and created the conditions for the aggregation of their low-level systems.

3 Material and methods

The aim of this work is to analyze the efficiency of the management model of the Alto Alentejo Intermunicipal Community (CIM), which provides for the aggregation and delegation of water management for ten municipalities in this area. To this end, a theoretical framework of analysis based on a mixed approach was used, which includes several stages, as shown in Figure 1.

The first stage includes an institutional analysis, in which the aggregate systems are identified and characterized. The second stage aims to characterize each of the ten municipalities under study, as well as the intermunicipal water supply management system. The third stage involves an analysis of efficiency and sustainability, in which a composite indicator based on a target-based programming model is constructed to compare the performance of the ten municipalities and the intermunicipal aggregate management system, taking into account established targets.

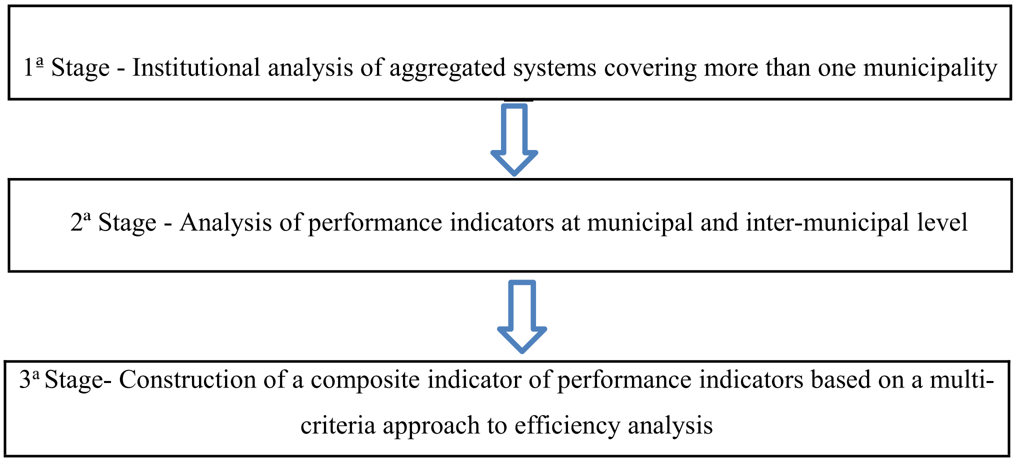

Figure 1. Theoretical framework for analysis

The ten municipalities of Alto Alentejo under study (Alter do Chão, Arronches, Castelo de Vide, Crato, Fronteira, Gavião, Marvão, Nisa, Ponte de Sor and Sousel) belong to a predominantly rural area, which makes water supply management more complex. These are ten municipal systems, where in addition to low-level operation, there are also some high-level points, as well as wastewater treatment. In this case, the analysis focuses on the low water system. In addition to the ten municipalities under study and the inter-municipal entity that is to be created to aggregate water supply management, seven aggregated systems were also taken into account in the study.

The institutional analysis of the systems was based on a documentary analysis of the aggregated entities or systems and 13 interviews were conducted with relevant experts in the water supply sector. The purpose of the interviews was to understand the relative importance of the main management indicators and their perspective on the phenomenon of the aggregation of management entities in the water supply sector. This was a structured interview in which five open questions and one closed question were asked about the relative importance of management indicators, using the Saaty scale (2008).

The targets established in the delegated management contracts are based on improving a set of service indicators for water supply, wastewater and solid waste, which are presented in ERSAR (2019). Given the purpose of this work, it was decided to work only with the following indicators related to water supply, which reflect structural and water quality variables: physical accessibility; adequacy of human resources; unbilled water; safe water; coverage of expenses; real water losses.

The physical accessibility of the service gives us an idea of the system's coverage in the territory. This indicator represents the percentage of the total number of dwellings located in the management entity's area of intervention that benefit from the water distribution service infrastructure. Safe water is the percentage of controlled water of good quality. The expenditure coverage indicator is the percentage of the ratio between income (tariffs, other income and investment subsidies) and total expenditure. Unbilled water is the percentage of water entering the system that is not billed. In other words, the water that is purchased by the downstream management entities from the upstream services is not billed because it is lost in the system. The adequacy of human resources corresponds to the total number of full-time employees assigned to the water supply service per 1,000 branches. Finally, the indicator of real water losses is defined as the volume of real water losses per branch.

Composite indicators are an approach increasingly used in the formulation of public policies, particularly in the environmental, economic, social and technological areas (Singh, H.R. et al., 2012). Water governance is no exception and a number of studies have also been carried out that seek to create a composite indicator based on multi-criteria analysis. In this case, an AHP (Poonia & Punia, 2018) was carried out initially to determine the relative weight of each of the analysis indicators, based on the Saaty scale, as shown in the following table.

Table 2. Saaty scale

Importance	Definition
1	equal importance
3	slightly greater importance of one criterion over the other
5	strongly superior importance
7	recognized dominance
9	dominance confirmed

Source: adapted from Saaty, 2008

Once the relative importance of the indicators/criteria had been defined, i.e. the weight of the criteria in the AHP, a composite indicator was constructed, which was used to draw up a ranking that took into account the ordering of all the management entities in the Alentejo Region (NUTS II) and included the ten municipalities in Alto Alentejo that are the subject of the study, as well as the new intermunicipal entity (EIM) that is to be created.

The construction of the composite indicator was based on the work of Xavier et al. (2018) and Voces et al. (2012). According to these authors, the process takes place in two phases. The first phase concerns the normalization of the indicators, given that each one is presented in different units, which makes it impossible to compare and subsequently aggregate them. The second phase involves formulating an Extended Goal Programming (EGP) model to calculate the value of the composite indicator, which is determined in terms of minimizing deviations from the targets set for each of the criteria.

The normalization of each indicator *i* in entity *c* with the R*ic* value is done as follows:

$$\bar{R}_{ic} = \frac{R_{ic}-R_{*i}}{R_i^{*}-R_{*i}} \quad \forall i \in \{1,2,\ldots,I\} \text{ e } c \in \{1,2,\ldots,C\} \qquad (1)$$

where, R_i^* is the best value of indicator i (ideal value) and R_{*i} is the worst value of indicator i (anti-ideal value).

It is therefore also necessary to define the value of the targets and normalize them. Since tg_i is the target value for indicator i, $tg(U)$ is its ideal value and $tg(L)$ is its anti-ideal value, the normalization is given by:

$$\overline{tg}_i = \frac{tg_i-tg_{(L)}}{tg_{(U)}-tg_{(L)}} \quad \forall i \in \{1,2,\ldots,I\} \qquad (2)$$

The PGE model used to calculate the composite indicator follows the formulation of Xavier et al. (2018), adapted to the study of water management efficiency. This formulation is different from other previous studies, such as Voces et al. (2012), and its main advantages are the lower computational load and the ability to simultaneously solve large data sets, automatically providing the results of all units. The Voces et al. (2012) model, unlike that of Xavier et al. (2018), calculates the index for each unit, choosing the units individually. This solution, in addition to requiring a greater computational burden, is unfeasible for large data sets. It should be noted that the study by Voces et al. (2012) also contributes by introducing a regression to identify the explanatory factors of the indices obtained. This author was based on other authors who use binary goal programming, namely Diaz-Baltero and Romero (2004). Another study based on goal programming that also uses a different methodology to Xavier et al. (2018) is the study by Diaz-Baltero et al. (2017). Therefore, the PGE model has the following formulation:

$$Min_{CI} = \sum_{c=1}^{C} CI_c \quad (3)$$

s.t.

$$CI_c = (1-\lambda)D_c + \lambda \sum_{i=1}^{I} (\alpha_{ic} p_{ic} + \beta_{ic} n_{ic}) \quad \forall c \in \{1,2,\dots,C\}\ e\ \lambda \in [0,1] \quad (4)$$

$$\bar{R}_{ic} - p_{ic} + n_{ic} = \overline{tg}_i \quad \forall i \in \{1,2,\dots,I\}\ e\ c \in \{1,2,\dots,C\} \quad (5)$$

$$(\alpha_{ic} p_{ic} + \beta_{ic} n_{ic}) - D_c \le 0 \quad \forall i \in \{1,2,\dots,I\}\ e\ c \in \{1,2,\dots,C\} \quad (6)$$

$$p_{ic}, n_{ic} \ge 0 \quad (7)$$

Where, CI_c is the objective function representing the composite indicator that will define the position of entity c in the ranking; p_{ic} and n_{ic} are the variables relating to the accounting of positive and negative deviations in entity *c* for criterion *i* in relation to the goals set for $\overline{tgi}$; αic and βic are the relative weights of the indicators *i* corresponding to p_{ic} and n_{ic} that were previously defined in the AHP analysis; Dc is the maximum deviation for criterion *i* in entity c.

The objective function is shown in equation (3) and represents the minimization of the aggregate composite indicator, which is calculated in equation (4) for each entity c as the undesired deviations, i.e. the deviations from the established targets. For λ=1 the model's solution is the most efficient, as it is the one that values the aggregate (best aggregate solution), while for λ=0 the model's solution is the most balanced, as it seeks to minimize the maximum deviation. For values of λ between 0 and 1, the model's solutions represent compromises between these two situations. Equation (5) defines the targets, i.e. it is in this equation that the positive or negative deviations of the value of indicator i in entity c in relation to the respective target set for i are calculated. Equation (6) calculates the maximum deviation *D*. Finally, equation (7) represents the non-negativity conditions which ensure that positive deviations (p_{ic}) and negative deviations (n_{ic}) are positive.

The data on the value of the indicators for the NUTS II Alentejo management units was obtained from the *Annual Report on Water and Waste Services in Portugal*, published by ERSAR, and refers to the average values for the period from 2014 to 2018, in order to obtain intra-regional comparisons. However, the six indicators in the study have different directions, so it was necessary to analyze their meaning to determine which ones positively or negatively influence the construction of the indicator.

The PGE model was solved using the "General Algebraic Modelling System (GAMS)" software and the following alternative scenarios were considered for the management indicator targets: EIM Alto Alentejo - with the targets that the company intends to achieve after its creation, within 5 years; Regional targets - with the reference values and regional averages contained in the latest *Annual Report of the Water and Waste Services*; National targets (mainland) - with the reference values and national averages contained in the latest *Annual Report of the Water and Waste Services*. Once the indices were obtained in GAMS, they were sorted using Microsoft Excel functions (see Xavier et al., 2018).

4 Results

In this section dedicated to the presentation and discussion of the results, the institutional analysis of the aggregated intermunicipal systems is presented in the first section, and in the second section, efficiency is analyzed on the basis of a composite indicator created.

4.1 Institutional analysis of aggregated intermunicipal systems

This study analyzed the following intermunicipal systems, which correspond to the aggregated systems to date: Vimágua E.I.M., S.A.; Águas do Ribatejo; Águas do Alto Minho; Tejo Ambiente; Empresa Intermunicipal de Ambiente do Pinhal Interior (APIN); Águas do Interior - Norte; Águas do Baixo Mondego e Gândara (ABMG).

Of these, only Águas do Alto Minho has a state shareholding, through the Águas de Portugal Group. The other entities are owned exclusively by the member municipalities. This demonstrates the municipalities' ability to incorporate knowledge of the sector and management. As well as supplying water, these companies also collect solid waste, which gives them another source of funding. In terms of the size of both the companies and the boards of directors, these companies comprise between three and eleven municipalities and the boards of directors vary between three and five members

According to the interviews conducted with key figures in the sector and the documentary analysis carried out, several advantages and disadvantages were identified in the process of aggregating municipal systems and in particular the entities analyzed.

The first advantage identified concerns business growth, through gains in scale, a proportional increase in activity and a reduction in operating costs. With increased scale, these entities gain greater financial availability, as well as negotiating capacity, which allows for better quality control and long-term strategic planning. From the outset, therefore, it seems that aggregation processes make it possible to improve efficiency by making the most of resources and standardizing methods. The specialization of these entities is also mentioned as a way of training human resources, solving problems and investing in research and development. Another positive point mentioned is the ability of these companies to be instruments of regional development, above all because of their turnover and ability to generate new jobs.

With regard to the disadvantages of aggregating water supply systems, we can start by mentioning the difficulty in standardizing systems that are at different stages of development, as well as the complexity of harmonizing tariffs. The loss of autonomy for local authorities and the proximity contacts they used to have with users are also mentioned. The risks of privatizing these systems are also mentioned, since these are public systems that will be privately managed.

In the case of Águas do Alto Alentejo, E.I.M., S.A., which is in the process of being merged and approved, its operating and organizational model is similar to that of the entities analyzed above. The company's draft articles of association state that it will provide services of general interest in public water supply and sanitation in the area of the municipalities of Alter do Chão, Arronches, Castelo de Vide, Crato, Fronteira, Gavião, Marvão, Nisa, Ponte de Sor and Sousel, which hold 100% of the capital. Organizationally, the company will have a board of directors with three members appointed by the municipalities, a technical director and three operational directors. The term of office of the company's governing bodies will coincide with that of the members of the municipal authorities, which is a novelty and a way of periodically legitimizing the company's members.

The inter-municipal entity to be created in the Alto Alentejo region envisages improvements in the efficiency of the systems. Table 3 shows the values of the performance indicators in the current situation and those contained in the draft delegated management contract (CIMAA, 2020).

Table 3. EIM targets

Indicators	Current reality (5-year average)	EIM AA targets
Physical accessibility of the service:	91,6%	92%
Safe Water:	99%	99%
Expense Coverage:	73,9%	107%
Unsaturated water:	44,9%	32%
Adequate human resources:	1.7 employees per 1000 users	1.18 employees per 1000 users
Real water losses:	118 l/ramal.dia	100 l/ramal.dia

Source: RASARP 2015-2019 and Draft Delegated Management Contract - Águas do Alto Alentejo EIM

The goals set for the EIM are to be achieved within five years and mainly translate into economies of scale, specialization and dedicated management in the water sector. Associated with the improvement in efficiency reflected in these goals, the establishment of the EIM entity foresees an investment of 20 million euros in the short term, which will essentially be used to renew the infrastructure network.

4.2. Efficiency analysis based on a composite indicator

According to the proposed methodology, the first line of analysis was to determine the weights assigned by the experts to the six performance indicators, which are nothing more than management criteria. The following table shows the results of the AHP carried out for this purpose. In this analysis, the consistency indices of the preference matrices were calculated, and the values obtained slightly exceed the Saaty limits for consistency ratios (CR < 0.1). However, the weights obtained for each indicator are adequate given the objectives of the work.

Table 4. Relative weights of water management indicators

Indicator	Physical accessibility	Adequacy of HR	Non-invoiced	Safe water	Covering expenses	Real water losses
%	7,25	14,95	13,96	26,90	14,57	22,37

Source: Interviews and AHP analysis results

The results of the AHP show that there is a direct concern with water quality issues and their environmental consequences, given that the criterion of safe water was the most heavily weighted (26.9%).

Once the relative weights of the management criteria had been determined, reflecting the priorities in the implementation of the strategy, the composite indicator was calculated for all the water supply management entities in NUTS II Alentejo, as well as the respective rankings. As mentioned above, the composite indicator results from aggregating the normalized values of the following indicators:

- Physical accessibility of the service - More is better (+)
- Safe water - More is better (+)
- Coverage of total spending - More is better (+)
- Unbilled water - Less is better (-)
- Adequate human resources - Less is better (-)
- Real water losses - Less is better (-)

To calculate the composite indicator, the normalized five-year average values (2014-2018) of the management entities in NUTS II Alentejo, available in RASARP (2019) and the EIM values resulting from the aggregation of the 10 municipalities of Alto Alentejo, were considered. To build the composite indicator, three target scenarios were considered, which gave rise to three rankings. Table 5 shows the target values and indicators for each of the three scenarios considered, where it can be seen that the EIM targets are generally more demanding than those of the other scenarios.

Table 5. Targets set for the management indicators studied

Scenarios	Physical accessibility of the service%	Water safety %	Coverage of total expenditure %	Unbilled water %	Adequacy of human resources (/1,000)	Real water losses (l/ramal.dia)
EIM Alto Alentejo	92	99	107	32	1,18	100
Regional targets	92	98,76	79	40,5	2,2	129
National targets (continent)	92	98,76	109	29,4	2,3	128

Source: Draft Delegated Management Contract - Águas do Alto Alentejo EIM and RASARP 2019

Table 6 shows the top twenty water supply management entities ranked according to the EIM target scenario, taking into account various simulations of the λ parameter, where λ=1 represents the best aggregate solution and λ=0 represents the most balanced solution and the remaining values of λ represent intermediate situations. Appendix 1 shows the results for the entire ranking.

Taking as a starting point the simulation in which λ=1, EIM appears in 14th place in the ranking of regional water management entities.

In the case of the municipalities clustered in Alto Alentejo, it is important to understand which contribute positively or negatively to achieving the targets. The municipality of Ponte de Sor, which is the largest of the ten, occupies the best position in the ranking with 4th place.

From the perspective of the analysis of aggregation processes, it is essential to note that one of the oldest Intermunicipal Companies comes in 2nd place in the ranking - Águas do Ribatejo - which illustrates the suitability of the proposed management framework and the feasibility of the model under analysis. For this performance, it is important to highlight the coverage ratio of total expenses, which stands at an average of 128% over the last five years, with a relatively low average of unbilled water of around 33%.

Table 6. Ranking of the EIM goals scenario for the top 20 entities

Rank	λ =1	λ =0.7	λ =0.5	λ =0.3	λ =0.0
1º	Águas de Santarém	Águas de Santarém	Águas de Santarém	Águas de Santarém	Águas de Santarém
2º	Águas do Ribatejo	Águas do Ribatejo	Águas do Ribatejo	Águas do Ribatejo	Águas do Ribatejo
3º	CM de Sines	CM de Sines	CM de Sines	CM de Sines	CM de Sines
4º	CM de Ponte de Sor	CM de Ponte de Sor	CM de Ponte de Sor	CM de Ponte de Sor	CM de Ponte de Sor
5º	CM de Sousel	CM de Sousel	CM de Sousel	CM de Sousel	CM de Sousel
6º	SMAT de Portalegre	SMAT de Portalegre	SMAT de Portalegre	SMAT de Portalegre	CM de Vidigueira
7º	CM de Rio Maior	CM de Rio Maior	CM de Rio Maior	CM de Rio Maior	CM de Reg. de Monsaraz
8º	CM de Vendas Novas	CM de Vendas Novas	CM de Vendas Novas	CM de Vidigueira	SMAT de Portalegre
9º	CM de Fer. do Alentejo	CM de Vidigueira	CM de Vidigueira	CM de Reg. de Monsaraz	CM de Rio Maior
10º	CM de Vidigueira	CM de Reg. de Monsaraz	CM de Reg. de Monsaraz	CM de Vendas Novas	CM de Vendas Novas
11º	CM de Reg. de Monsaraz	CM de Fer. do Alentejo	CM de Fer. do Alentejo	EMAS de Beja	EMAS de Beja
12º	CM de Golegã	CM de Golegã	CM de Golegã	CM de Golegã	CM de Golegã
13º	EMAS de Beja	EMAS de Beja	EMAS de Beja	CM de Fer. do Alentejo	Águas da Azambuja
14º	EIM	EIM	Águas da Azambuja	Águas da Azambuja	Aquaelvas
15º	CM de Cuba	Águas da Azambuja	EIM	EIM	CM de Fer. do Alentejo
16º	Águas da Azambuja	CM de Cuba	CM de Cuba	CM de Estremoz	CM de Castro Verde
17º	CM de Borba	CM de Borba	CM de Estremoz	CM de Cuba	CM de Estremoz
18º	CM de Estremoz	CM de Estremoz	CM de Borba	CM de Viana do Alentejo	EIM
19º	CM de Viana do Alentejo	CM de Viana do Alentejo	CM de Viana do Alentejo	Aquaelvas	CM de Alter do Chão
20º	CM de Castelo de Vide	CM de Castelo de Vide	CM de Alter do Chão	CM de Alterdo Chão	CM de VilaViçosa

Source: EGP model results

We can see that the indicators that support the top positions in the ranking of the EIM target scenario are mainly based on the systems' management performance. In this sense, "Unbilled water" and "Real water losses" are decisive for the efficiency sought.

With regard to the simulation for λ=0, the EIM's position in the ranking drops to 18th place, but the top positions don't change, with the municipalities of Ponte de Sor and Sousel maintaining their top positions. Thus, the municipality best classified below the EIM is Alter do Chão, which appears in the next position in the ranking (19th place). Among the 10 municipalities involved in the aggregation process, the municipality of Nisa continues to be the worst performer.

Table 7 shows the top twenty water supply management entities ranked according to the regional target scenario. Appendix 2 shows the results for the entire ranking.

In this scenario, the direct management of municipalities shows good performance, above all due to the results in "Physical accessibility" and "Safe water". These indicators, while not the subject of a major strategic rationale, are evidence of public pressure to provide universal, quality services.

In the extreme situation of λ=0, the results continue to be in favor of direct management by municipalities, despite EIM improving its position in the ranking (10th place).

Table 7. Ranking of the regional targets scenario for the top 20 entities

Rank	λ =1	λ =0.7	λ =0.5	λ =0.3	λ =0.0
1º	CM de Cuba	CM de Fronteira	CM de Fronteira	CM de Fronteira	CM de Fronteira
2º	CM de Fronteira	CM de Cuba	CM de Cuba	CM de Cuba	CM de Cuba
3º	CM de Borba	CM de Borba	CM de Borba	CM de Borba	CM de Borba
4º	Águas de Santarém	Águas de Santarém	Águas de Santarém	CM de Castelo de Vide	CM de Castelo de Vide
5º	CM de Sines	CM de Monforte	CM de Monforte	Águas de Santarém	CM de Monforte
6º	CM de Monforte	CM de Sines	CM de Castelo de Vide	CM de Monforte	CM de Castro Verde
7º	CM de Fer. do Alentejo	CM de Fer. do Alentejo	CM de Sines	CM de Castro Verde	Águas de Santarém
8º	CM de Alvito	CM de Castelo de Vide	CM de Fer. do Alentejo	CM de Sines	CM de Crato
9º	CM de Rio Maior	CM de Castro Verde	CM de Castro Verde	CM de Fer. do Alentejo	CM de Sines
10º	CM de Castelo de Vide	CM de Crato	CM de Crato	CM de Crato	EIM
11º	CM de Crato	CM de Alvito	EIM	EIM	CM de Fer. do Alentejo
12º	CM de Castro Verde	CM de Rio Maior	CM de Alvito	CM de Sousel	CM de Sousel
13º	EIM	EIM	CM de Sousel	CM de Alvito	CM de Mourão
14º	SMAT de Portalegre	CM de Sousel	CM de Rio Maior	CM de Mourão	CM de Estremoz
15º	CM de Ponte de Sor	CM de Ponte de Sor	CM de Ponte de Sor	CM de Rio Maior	EMAS de Beja
16º	CM de Sousel	SMAT de Portalegre	SMAT de Portalegre	CM de Estremoz	CM de Alandroal
17º	CM de Vendas Novas	CM de Mourão	CM de Mourão	CM de Ponte de Sor	Águas do Ribatejo
18º	CM de Mourão	CM de Vendas Novas	CM de Estremoz	EMAS de Beja	CM de Serpa
19º	Águas do Ribatejo	Águas do Ribatejo	Águas do Ribatejo	Águas do Ribatejo	CM de Alvito
20º	CM de Estremoz	CM de Estremoz	EMAS de Beja	SMAT de Portalegre	CM de Rio Maior

Source: EGP model results

Table 8 shows the ranking of water supply management entities in the national targets scenario.

In this scenario, the targets set for some indicators are close to those considered in the EIM target scenario, with the most significant differences in the "Adequacy of human resources" and "Real water losses" indicators.

This ranking shows the importance of the scale factor in the performance of water management entities. The first three places in the ranking are occupied by the management entities of Santarém, Sines and Portalegre, i.e. three of the largest municipalities in the region. These entities manage to achieve very significant results in key efficiency indicators, such as "Unbilled water", with 5-year average values of 33.1%, 31.9% and 27.2%, respectively.

It should also be pointed out that the private operators mentioned in this sample perform very well in the "unbilled water" indicator, which is perfectly justifiable in light of the nature of these system concessions.

In the simulation for λ=0, EIM appears in the ranking in a top position, namely in 6th place.

Table 8. Ranking of the national target scenario for the top 20 entities

Rank	λ =1	λ =0.7	λ =0.5	λ =0.3	λ =0.0
1º	Águas de Santarém	Águas de Santarém	Águas de Santarém	Águas de Santarém	Águas de Santarém
2º	CM de Sines	CM de Sines	CM de Sines	CM de Sines	CM de Sines
3º	SMAT de Portalegre	SMAT de Portalegre	SMAT de Portalegre	SMAT de Portalegre	SMAT de Portalegre
4º	CM de Fer. do Alentejo	CM de Fer. do Alentejo	CM de Fer. do Alentejo	EMAS de Beja	EMAS de Beja
5º	CM de Fronteira	CM de Fronteira	CM de Fronteira	CM de Fer. do Alentejo	CM de Castro Verde
6º	Águas do Ribatejo	Águas do Ribatejo	EMAS de Beja	CM de Fronteira	EIM
7º	CM de Cuba	CM de Cuba	Águas do Ribatejo	CM de Cuba	CM de Fer. do Alentejo
8º	CM de Ponte de Sor	EMAS de Beja	CM de Cuba	Águas do Ribatejo	CM de Alvito
9º	CM de Borba	CM de Ponte de Sor	CM de Sousel	CM de Sousel	CM de Sousel
10º	EMAS de Beja	CM de Sousel	CM de Ponte de Sor	CM de Castro Verde	CM de Estremoz
11º	CM de Sousel	CM de Borba	CM de Borba	CM de Alvito	CM de Fronteira
12º	CM de Monforte	CM de Alvito	CM de Castro Verde	CM de Ponte de Sor	CM de Alandroal
13º	CM de Rio Maior	CM de Castro Verde	CM de Alvito	EIM	CM de Cuba
14º	CM de Alvito	CM de Rio Maior	CM de Rio Maior	CM de Borba	Águas do Ribatejo
15º	CM de Castro Verde	CM de Monforte	EIM	CM de Rio Maior	CM de Crato
16º	CM de Castelo de Vide	EIM	CM de Monforte	CM de Crato	Cartágua
17º	CM de Crato	CM de Crato	CM de Crato	CM de Estremoz	CM de Grândola
18º	EIM	CM de Castelo de Vide	CM de Castelo de Vide	CM de Monforte	CM de Rio Maior
19º	CM de Vendas Novas	CM de Estremoz	CM de Estremoz	CM de Castelo de Vide	CM de Borba
20º	CM de Golegã	CM de Vendas	CM de Vendas Novas	CM de Vendas Novas	CM de Castelo de Vide

		Novas			

Source: EGP model results

5 Conclusion

The aim of this article was to analyze the efficiency introduced by the intermunicipal low water management model in Alto Alentejo, through the creation of an intermunicipal company owned exclusively by the member municipalities. Associated with this intention, the governance issues of these entities were also addressed, especially from the point of view of the institutional framework. To analyze efficiency, a composite indicator was constructed using an Extended Goal Programming model.

The results show that the investment capacity of the inter-municipal entities is a point in favour of aggregation, especially in terms of improving the system and minimizing its externalities. From the point of view of the Alto Alentejo Intermunicipal Entity, the ambitious objectives associated with the investment intention presuppose an effective gain in service provision in that territory. This conclusion is corroborated by the results of the efficiency analysis, which indicate that the legal-formal business management configurations are generally efficient and achieve better results in the indicators of unbilled water and water losses. The results also show that not only is it important to specialize in the areas in which the administration operates and in the provision of public services, but it is also crucial that there are clear objectives and targets in each of these areas.

The business management model does not presuppose private ownership of the service and we can conclude that the hybrid entities (public with business management) are the ones that obtain the best combined performance, with scale being a determining factor.

The systematization of the indicators under study and the construction of a composite indicator are also a relevant contribution to the design and analysis of efficiency in the water supply sector and the monitoring of public policies in general.

Conflicts of interest

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

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