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Evaluating the policy of listening to customer claims in a drinking water utility using fuzzy-AHP approach and WASPAS method

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Abstract

The objective of this work is to develop a decision support methodology intended for drinking water utility managers in order to support them in the challenge of achieving better performance in the management of the customer area. This methodology requires the prior collection of data for the identification of registered claims. Subsequently, an evaluation of the performance of the customer area defined by the objective ‘Better listening to customer claims’ will be carried out; this requires the structuring of the objective in a hierarchy based on indicators and the adoption of two adequate decision support tools, a fuzzy-AHP for weighting the elements and WASPAS for calculating the performance of the objective. An application is carried out on the water utility of the Wilaya of Bejaia (Algeria). The data collection enabled the identification of 19 types of claims divided into three aspects. The combination of fuzzy-AHP and WASPAS allowed assessment of the performance of the objective during the period 2014–2018 and to make a judgment on the national policy established. The results are satisfactory. Progress has been made in claims management, but the major difficulty lies in the claims processing relating to the quantitative aspect.

Keywords: Assessment; Claim; Decision support tools; Fuzzy-AHP; Performance; WASPAS

Highlights

- Evaluation of the policy of listening to customer claims in a drinking water utility.
- Importance of the claims information source ensuring reliability and availability of practical data.
- Overall analysis of data through the identification of the claims’ nature.
- Choice of an approach that simplifies the system under a hierarchical tree structure.
- Choice of tools, fuzzy-AHP and WASPAS method for better performance evaluation.

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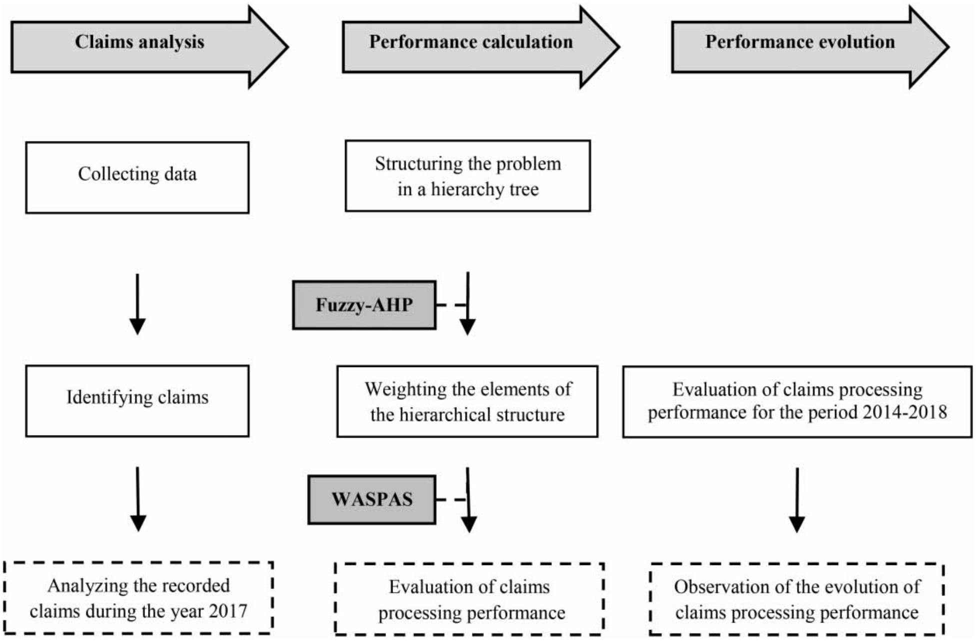
Graphical Abstract



1. Introduction

Algeria has ambitions in terms of access to water and improving the quality of the drinking water service provided to its populations. In actual fact, water service managers agree that they want to make listening to customer claims a tool for modernizing the public service. To do this, they are beginning to take a greater interest in the results and the ways in which they can contribute to improving them. Indeed, a strategy has been developed, and listening to the customer is one of the objectives of the public water sector reform program. Therefore, since the beginning of this century, the management of the drinking water utility in Algeria has undergone several reforms. At the organizational level, the year 2001 was marked by the creation of the water utility Algérienne Des Eaux (ADE). Since then, the management of the public drinking water utility has gradually been transferred from the country's municipalities to the ADE.

ADE is responsible for ensuring the implementation of the national drinking water policy. Its objective is to take charge of production, treatment, storage, supply, distribution, renewal, and development of related infrastructures. It is charged to initiate actions aimed at saving water, in particular by improving the efficiency of the networks efficiency and introducing all techniques for preserving water and fighting against wastage. ADE is also responsible for rehabilitating a public service, based on the concern of performance and definition of the means to be implemented in order to put it into practice. Indeed, at the beginning of the reforms, the management of urban drinking water networks was difficult and poorly done by the water utilities. In order to remedy the chronic shortcomings of local companies, Algeria is engaged with foreign private companies specialized in the management of drinking water utilities.

The aim of this partnership is to improve the provision of drinking water utilities in large cities. These reforms are necessary because of the deterioration of the public water utility in large cities and almost throughout the national territory. Public–private partnership (PPP) projects are forms of cooperation projects between the public and private sectors for financing, manufacturing, renovating, managing, and maintaining public infrastructure and providing services in sectors of the national economy where market liberalization is either impossible or undesirable (Kanakoudis & Tsitsifli, 2012). PPPs are also a form of privatization, referring to contractual arrangements in which private companies assume greater responsibility and/or risk, especially through concession contracts (Kanakoudis & Tsitsifli, 2014). This PPP aims to develop a high-performance utility, capable of meeting the needs of citizens to the level of their expectations (Kanakoudis & Tsitsifli, 2009).

These management contracts are based on an action plan covering several axes. These axes include: modernizing the water utility; modernizing customer service by establishing a customer area dedicated to listening to the customer; and modernizing human resources management by organizing training cycles that will be instituted to support the transfer of know-how in the field (Khelladi, 2010). This know-how was subsequently introduced in the other drinking water utilities managed by the ADE. Concerning the customer area, the ADE has deployed a network of 297 agencies to welcome citizens. In addition, in 2004, the Operational Telephone Reception Centre was set up with the aim of receiving citizens' claims 7 days a week in the national territory.

Therefore, the objective of this work is to develop a methodology that allows evaluation of the performance of the customer area taken care of by a drinking water utility. Indeed, it is important to concern oneself with claims; this will allow the implementation of several issues such as satisfaction, loyalty, image, and trust (Détrie, 2007). In addition, a good relationship with the customer increases his/her confidence and strengthens their willingness to pay their bills (Rouxel *et al*., 2008).

To this end, a methodological tool will be proposed to measure the performance of listening to the customer, based on a set of relevant indicators which serve for the identification of necessary measures (Kanakoudis *et al*., 2013). Indeed, the use of indicators is recommended and seen as a useful element in the development of decision support tools (Staben *et al*., 2010). They depend upon the reliability and availability of respective data, best adapted to local conditions (Kanakoudis *et al*., 2011a, 2011b). Consequently, performance measurement will allow an improvement in the management of the drinking water utility.

In the context of listening to the customer, several research studies have investigated the problem. The analysis tools used and the parameters analyzed are different. They mainly used questionnaires and surveys (Akpinar & Gul, 2014; Adams & Zulu 2015; Dziedzic & Karney, 2016). These studies have led to two approaches. In the first approach, known as the holistic approach, the analysis of claims is taken into account as an element in models for the overall assessment of the quality of the drinking water utility provided to the customer (Rouxel *et al*., 2008; Fattahi *et al*., 2011; Abubakar, 2016; Pinto *et al*., 2017). In the second, so-called specific approach, the analysis of claims is dealt with in a specific way. In this case, the questions asked take into consideration indicators of different natures. Examples are: analysis of claims on water bills (Rouxel *et al*., 2008; Fattahi *et al*., 2011); analysis of claims related to water quality (Dietrich *et al*., 2014; Webber *et al*., 2015); and analysis of claims on unscheduled water cuts (Molinos-Senante & Sala-Garrido, 2017).

The contribution is based on several important considerations resulting in a decision support tool to assist managers in the insightful management of the customer area through performance evaluation. The first support takes into account the importance of the information source on claims. For this purpose, the data collection will only be done at the level of the agencies that welcome customers and register their claims. This support is a guarantee of the reliability and availability of practical data and will reflect local conditions. The use of this information will allow the identification of the nature of the claims. These must include all dimensions acting in a drinking water service in relation to the customer area. The second support takes into account the choice of analytical approach. The proposed methodology will follow a specific approach of listening to the customer. This approach takes into consideration the different types of claims, providing a global view of the customer area. The third support takes into account the complexity of evaluating the performance of the customer area. To this end, the approach adopted simplifies the process of analyzing and evaluating performance by structuring the problem in a multi-level tree hierarchy and, at its base, the claims are represented by indicators. The latter, by reflecting all the claims, allow the identification of negative points in the management of the customer area and will be elements for a critical reflection on the corrective measures necessary in the improvement of the space dedicated to listening to the customer. The fourth support takes into account the choice of tools for better evaluation of the performance. To do this, fuzzy logic will be integrated in order to achieve a better weighting of the elements representing the system and adopt an effective decision support tool allowing the aggregation of the initial performance of the different claims towards the overall performance of the customer area. These considerations will constitute an insightful decision-making tool in the management of the customer area, through an evaluation of its performance.

The results of an application on the drinking water utility of the Wilaya of Bejaia (Algerian administrative province) will be presented, analyzed, and interpreted.

2. Methodology

The methodology developed aims to address the issue of customer area in a drinking water utility. Particular attention will be paid to its evaluation, which will be based on the use of indicators. They are defined in Lejars & Canneva (2012) as follows: ‘a performance indicator is a quantitative measure of a specific aspect of the operator’s performance or its level of service. Performance indicators are used as a decision support tool for managers as they facilitate the implementation of dashboards in order to improve performance’.

To this end, the research requires a pragmatic approach for collecting and analyzing data, particularly the evaluation of the performance of the customer area.

Data collection inevitably involves the contribution of drinking water managers. The aim is to make available to us the different data available in relation to the different claims recorded. From there, analyses can be carried out on the nature and extent of claims. The transformation of these data will provide a quantitative measure of each specific aspect of the claims represented by the indicator, as indicated by Lejars & Canneva (2012).

Evaluating the performance of the customer area is complex but very important. To achieve this, it is necessary to structure the problem taking into account all the elements in a hierarchy tree structure (Kanakoudis *et al*., 2014, 2015). Beforehand, the main objective studied will be defined by ‘Better listening to customer claims’. The latter will be subdivided into aspects which will be subdivided into criteria and the criteria subdivided into indicators. Subsequently, we will transform the data collected on performance scales to give the performance score of each indicator. The weighting and aggregation of the indicator performance scores will enable the performance of the criteria to be obtained. The aggregation of the criteria performance will provide the performance of the different aspects. Finally, the aggregation of the latter will provide the overall performance of the objective.

The methodology developed is intended to be a decision support tool for drinking water utility managers. The decisions to be informed deal with the management of the customer area within the framework of the national policy implemented in order to improve the quality of the water utility. This still meets the definition cited in Lejars & Canneva (2012). Finally, interest is paid to the evolution of the customer area performance, based on the exploitation of the data collected over a given period. This evolution will be like a barometer expressing the different variations that occurred when the objective was taken into account. It will reflect the success or failure of the strategy implemented by the public authorities to improve the customer area management quality.

2.1. Customer area

Nowadays, a company's sustainability depends on all aspects of its activity and its responsibility is broadened by including stakeholders who require to be heard. This listening becomes a vital aim for the sustainability of the company (Renaud & Berland, 2007). Indeed, the relationship that the company attaches to its societal environment must be taken into account. To ensure the proximity of customer-oriented services, customer areas are established. Their objective is to absorb all the frustration of the customer through the dissatisfaction observed and formulated by a claim. But what is the definition of a claim? In fact, there are several definitions. In general, a claim is due to a dissatisfaction evoking a painful feeling of being frustrated in one's hopes, one's rights. It bears a certain characteristic, based on a lived experience by the customer who is seeking for treatment. Claims reveal the main causes of dissatisfaction with the provided service and awareness in a water utility begin by giving special attention to these claims (Détrie, 2007).

In this case, the claim is a language of communication between two entities: the customer and the water utility manager. This language, simple in its content, can be conveyed individually or collectively in different forms, generally peacefully, with an important and vital expectation. In order to better convey this information, over the past year ADE has implemented a strategy allowing claims to be handled through the customer area. Its operation needs the intervention of different actors and requires a lot of resources, starting with the diversification of the recording device. However, its smooth operation requires harmonious work and the extent of the efforts to be made to communicate between the elements of the system are enormous. The vastness of the surface area occupied by a drinking water network and its intersections between the elements of the city make the management of urban networks very difficult (Pizzol *et al.*, 2013). The proximity of the customer to the water network is an element that contributes to the proper functioning of the whole system composed of the resource, the infrastructures, the administrative and legal organization, etc. It is then important to take the customer's opinion into consideration, hence the need to have a customer area to ensure that their expectations will be listened to.

2.2. Identification of indicators

The report that ADE has undertaken with its customers through the customer area requires evaluation. To achieve this, the methodology is based on the performance approach (Bonierbale, 2004). This methodology allows a simple representation of complex systems through the exploitation of a set of indicators. Their identification requires consultation of literature on the use and development of indicators as well as on the analysis of all claims raised by customers. This step will allow the customer area to be better defined and represented in a simple way through the identification of the set of indicators representative of the customer's needs and expectations.

Therefore, the reflections carried out allowed us to identify the major requirements of the customer. These requirements represent the important aspects that link the customer to the water utility. In fact, these requirements trace a customer's itinerary from their right to be connected to the network through a connection and a meter; thereafter, the customer's right to be supplied with good quality water in sufficient quantity and at the end their duty to ensure payment of water bills for the equivalent of the provided service. This will result in a win-win situation; in other words, a viable water utility and a satisfied customer. Subsequently, an in-depth analysis of each requirement has made it possible to identify the indicators that will allow us to assess the level with which each aspect will be accomplished. These indicators represent the different claims made by the customer. The indicators selected must therefore be available, measurable, representative, and relevant. Their use can describe the current context of customer area management (Morrison *et al*., 2001) and can be elements for critical reflection on the corrective measures needed to improve understanding and policy development (Hezri & Dovers, 2006).

2.3. Evaluation of performance

Performance is a notion used in managerial literature to evaluate the implementation by the company of announced sustainable development strategies (Capron & Quairel, 2006). In this work, the interest is focused on the evaluation of the strategy implemented by the public authorities dedicated to listening to the customer identified by the objective 'Better listening to customer claims'. The research based on the performance approach raises an irreducible question: how to evaluate the objective? For this reason, the methodology is intended to be simple and precise. In fact, by identifying all the indicators containing the claims relating to the different dimensions of the problematic, the data collected in the field will be transformed into a note of performance for each indicator. However, the use of the performance approach requires an identical evaluation scale for all elements of the hierarchical structure. Therefore, the estimated value of each indicator should be converted to a note on a standardized performance scale, then go back up to the other elements of the hierarchical structure up to the objective being studied. This methodology requires the use of certain decision support tools. The choice was made on the fuzzy-AHP method for weighting all the elements of the hierarchical structure and WASPAS aggregation method, allowing aggregation which gathers the indicators in criteria, then the criteria in aspects and, finally, the aspects in performance evaluation of the objective studied. In what follows, the methodology and tools used will be discussed.

2.3.1. Weighting. Weighting the elements of the hierarchical structure will be accomplished by exploiting the combination of two concepts, fuzzy set theory and the AHP method.

Analytic hierarchy process (AHP): the choice of the AHP method (Saaty, 1990) is justified by its capacity to simplify the organization of the decision problem under a hierarchical structure broken down into several levels. The highest level represents the objective and the lowest level represents the indicators. This arrangement will facilitate pair-wise comparison between the elements (Boukhari *et al*., 2018). In order to validate the calculated weight values, the consistency of the judgments must be checked, and this is done as follows:

• Calculating the consistency index: $CI = \frac{\lambda max - n}{n - 1}$ (1)

with λ_{max}: maximum eigenvalue corresponding to the pairwise comparison matrix and n: number of elements to be compared.

• Calculating the consistency ratio: $CR = \frac{CI}{RI}$ (2)

with *RI:* random index which depends on the matrix size.

• Verifying consistency: if *CR* is less than 0.1, pair-wise comparisons are consistent. If not, these comparisons should be revised.

Judgments in AHP are represented by an exact value called the crisp number in fuzzy logic (Chan *et al*., 2008). These judgments are expressed by experts who assess the importance of the criteria in pairs on the Saaty scale. In the majority of cases, the preference model is imprecise. Thus, it will be more reassuring for managers to assign fuzzy ratings than to give an exact value. This will be achieved by integrating the fuzzy sets theory concept. This choice will overcome the disadvantage of the AHP method and therefore reduce the imprecision in judgments.

***Fuzzy sets theory*: **fuzzy sets theory, proposed by Zadeh (1965), aims to deal with ambiguity and vagueness in human thought. In 1983, Van Laarhoven proposed the method based on fuzzy judgments using Zadeh's concept of fuzzy sets. It is based on pairwise comparisons of triangular fuzzy numbers (Van Laarhoven & Pedrycz, 1983).

Triangular fuzzy number: $M \in F(R)$ is a fuzzy number if it exists $x_0 \in R$ such that $\mu_M(x_0) = 1$ and for any $\alpha \in [0,1]$. Such as $A_\alpha = [x, \mu_{A\alpha} >= a]$ is a closed interval. *F(R)* represents all fuzzy sets and *R* is a real number set. The fuzzy number M on R is a triangular fuzzy number if its membership function $\mu_M(x)$: *R* [0,1] is equal to (Chang, 1996; Zhu *et al*., 1999):

$$\mu M(X) = \frac{x}{m-l} - \frac{l}{m-l},\ x \in [l, m],\ \frac{x}{m-u} - \frac{u}{m-u}, x \in [m, u], 0,\ otherwise \tag{3}$$

where $l \leq m \leq u$, *l and u* are '*the lower and the upper value*' of *M*, respectively, and *m* is '*the modal value*'. So, the triangular fuzzy number can be described by (*l*,*m*,*u*). *M* is the set of elements $\{x \in R \setminus l < x < u\}$. When $l = m = u$, it is a non-fuzzy number by convention.

The main operational laws of two triangular fuzzy numbers M_1 (l_1, m_1, u_1) and M_2 (l_2, m_2, u_2) are presented as follows:

$$\begin{aligned}
&M_1 + M_2 = (l_1 + l_2,\ m_1 + m_2,\ u_1 + u_2\\
&M_1 * M_2 \approx (l_1 * l_2, m_1 * m_2, u_1 * u_2)\\
&\lambda * M_1 = (\lambda * l_1,\ \lambda * m_1, \lambda * u_1),\ \lambda > 0,\ \lambda \in R\\
&M_1^{-1} \approx (1/u_1, 1/m_1, 1/l_1)
\end{aligned} \tag{4}$$

In the multiplication case, the triangular fuzzy numbers are positive.

Filling fuzzy judgment matrices with triangular fuzzy numbers requires the use of a scale. The triangular fuzzy scale was chosen (Figure 1).

δ is a representative sign of fuzzy judgment degree. A high value of δ means a high degree of fuzzy judgment with $0.5 \leq \delta \leq 1$, when $\delta = 0$ the judgment is nonfuzzy with $\delta = m\text{-}l = u\text{-}m$ (Kwong & Bai, 2003).

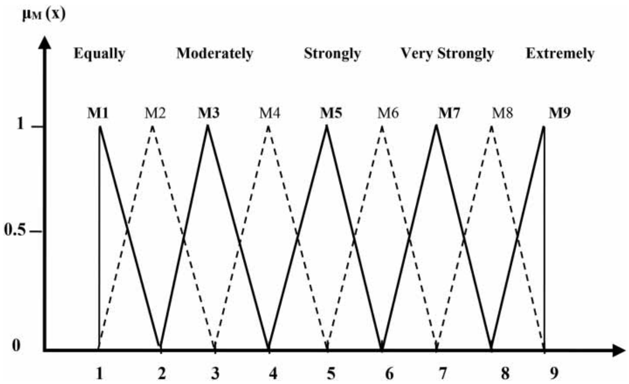


Fig. 1. The membership functions of the triangular numbers (Kwong & Bai, 2003).

The triangular fuzzy number can be defuzzified to a crisp number by applying the following ratio (Kwong & Bai, 2003):

$$M - crisp = \frac{(4m + l + u)}{6} \tag{5}$$

Buckley's method: calculating the elements weight of the hierarchical structure requires the integration of another method that will be combined with the fuzzy-AHP approach such as the fuzzy preference programming (FPP) method (Mikhailov & Tsvetinov, 2004) and extent analysis approach (Chang, 1996; Spiliotis & Skoulikaris, 2019). The choice adopted is Buckley's method. Its laws can be summarized in five steps (Buckley, 1985).

Step 1: creating the peer comparison matrix based on $\tilde{a}_{ij}\ (x_{ij};y_{ij};z_{ij})$, which represents the fuzzy triangular judgments of the i^{th} criterion in the row against the j^{th} criterion in the column as follows:

$$A = \begin{bmatrix} \tilde{a}_{11} & \cdots & \tilde{a}_{1n} \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \tilde{a}_{n1} & \cdots & \tilde{a}_{1n} \end{bmatrix} \tag{6}$$

Step 2: calculating the geometric mean of each criterion in the pairwise comparison matrix as follows:

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{a}_{ij} \right)^{1/n} \tag{7}$$

Step 3: calculating the fuzzy relative weight of each criterion in the pairwise comparison matrix as follows:

$$\tilde{w}_i = \tilde{r}_i * (\tilde{r}_1 + \tilde{r}_2 + \ldots + \tilde{r}_n)^{-1} \tag{8}$$

Step 4: calculating the non-fuzzy weight of each criterion, the weight value is obtained by defuzzifying the fuzzy weight vector by the center of area method using the following ratio:

$$W_i = \frac{lw_i + mw_i + uw_i}{3} \tag{9}$$

Step 5: calculating the normalization of the non-fuzzy weight of each criterion:

$$N_i = \frac{W_i}{\sum_{i=1}^{n} W_i} \tag{10}$$

2.3.2. Aggregation. WASPAS (weighted aggregated sum product assessment) is a combination of two methods, WSM (weighted sum method) and WPM (weighted product method). It was proposed in 2012 (Zavadskas *et al.*, 2012) as a multi-criteria decision support method with several advantages. Indeed, WASPAS is known for its efficiency, its mathematical simplicity, and provides more accurate results than the WSM and WPM methods (Chakraborty & Zavadskas, 2014).

WASPAS requires the calculation of the performance of each element of the hierarchical structure. By exploiting one of the principles of the WASPAS method (aggregation) the performance will go back from the initial performance of the different claims to the overall performance of the objective. Its application requires the use of two steps.

Step 1: linear normalization of the evaluation matrix elements. In this case, the calculation of the initial normalized performance of each claim requires the transformation of the raw data collected on different claims into a performance note (Figure 2(a)). The sum of the performance notes results in the total number of claims processed. The percentage of processing of each claim $P_{Processing}$ is obtained as follows:

$$\mathrm{P_{Processing}} = \frac{\text{Number of claims processed}}{\text{Number of claims received}} * 100 \tag{11}$$

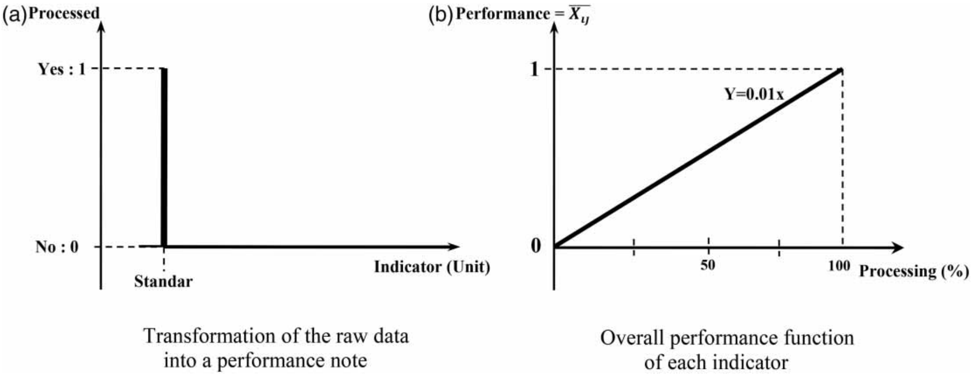


Fig. 2. Linear normalization of matrix elements.

$P_{Processing}$ will be projected on the performance function (Figure 2(b)) which is given by the following equation:

$$Y = 0.01\ x \tag{12}$$

It finds the normalized initial performance of each claim called $\overline{X_{ij}}$.

Step 2: calculation of the performance of the elements of the hierarchical structure using WASPAS method as follows:

$$Q_i = \lambda.Q_i^{(1)} + (1-\lambda).Q_i^{(2)} \tag{13}$$

with: $\lambda = 0,\ 0.1, 0.2, \ldots,\ 1$.

$Q_i^{(1)}$: performance of the elements of the hierarchical structure based on *WSM*. It is calculated as follows:

$$Q_i^{(1)} = \sum_{j=1}^{n} \overline{X_{ij}}.\mathrm{W_j} \tag{14}$$

where W_j is the weight (relative importance) of the j^{th} criterion.

$Q_i^{(2)}$: performance of the elements of the hierarchical structure based on *WPM*. It is calculated as follows:

$$Q_i^{(2)} = \prod_{j=1}^{n} \overline{X_{ij}}^{W_j} \tag{15}$$

The higher value of Q_i means a better performance of the evaluated element in the hierarchical structure.

For a given multi-criteria decision support problem, the optimal values of λ can be determined by searching for the following extreme function:

$$\lambda = \frac{\sigma^2(Q_i^{(2)})}{\sigma^2(Q_i^{(1)}) + \sigma^2(Q_i^{(2)})} \tag{16}$$

The variances $\sigma^2(Q_i^{(2)})$ and $\sigma^2(Q_i^{(1)})$ are calculated by applying the following equations:

$$\sigma^2(Q_i^{(1)}) = \sum_{j=1}^{n} W_j^2 \sigma^2(\overline{X_{ij}}) \tag{17}$$

$$\sigma^2(Q_i^{(2)}) = \sum_{j=1}^{n} \left(\frac{\prod_{j=1}^{n} \overline{X_{ij}}^{W_j} W_j}{\overline{(X_{ij})}^{W_j} \, \overline{(X_{ij})}^{(1-W_j)}} \right)^2 \sigma^2(\overline{X_{ij}}) \tag{18}$$

The estimated variance $\sigma^2(\overline{X_{ij}})$ is calculated as follows:

$$\sigma^2(\overline{X_{ij}}) = (0.05\,\overline{X_{ij}})^2 \tag{19}$$

3. Results and discussion

3.1. Data collection and analysis

The developed methodology will be performed on the drinking water utility of the Wilaya of Bejaia entrusted to the ADE. Bejaia is supplied by two supply pipes. The western one carries water from the Tichy Haff Dam and the eastern one carries water from the blue source and a set of drillings to Bejaia town. The ADE unit of Bejaia has 5 centers, 17 technical-sales agencies, and 20 intervention and maintenance teams. For the control of water quality, two teams of biologists and chemists ensure its quality according to the Algerian standard. The pipeline networks are composed of 377,000 lm of the supply network and 674,000 lm of the distribution network. The networks provide drinking water to 823,652 inhabitants with a connection rate of around 93%. The different communication channels offered by the ADE allow customers to make their claims through the Operational Telephone Call Center, the complaint registers, and the scheduling of reception days. The collaboration of ADE managers made it possible to gather data in relation to customer claims recorded at its five centers: Bejaia city, Tichy, Souk El Tenine (S-E-T), El-Kseur, and Akbou (Figure 3) for the period 2014–2018.

The overall analysis of these data enabled the identification of three important aspects of the claims: qualitative, quantitative, and commercial. With regard to claims relating to the water quality aspect, the water utility registers a quality criterion that includes organoleptic parameters. For claims related to the quantitative aspect of water, the water utility registers two criteria: lack of water and water leakage. On the other hand, for the claims relating to the commercial aspect, water utility registers only one criterion in relation to it. The recorded claims are related to: bills, meters, and connections. Thus, the different claims are ranked according to four criteria: water quality, lack of water, water leakage, and commercial.

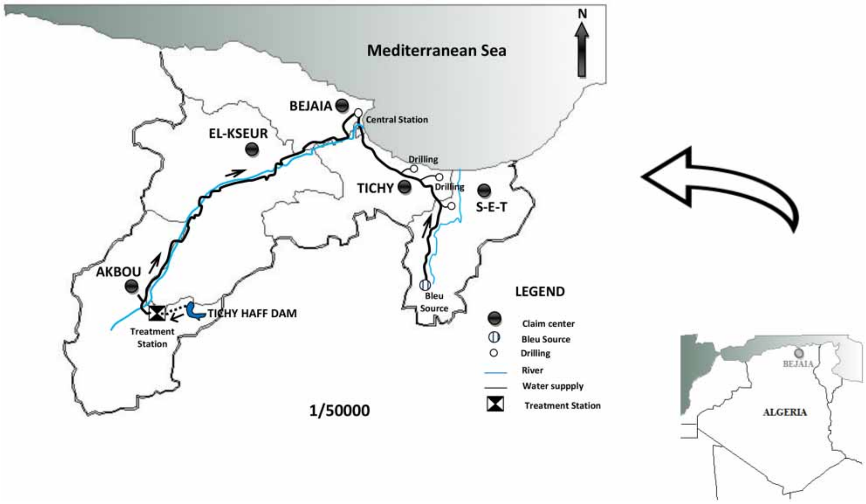


Fig. 3. Claims registration centers in the Wilaya of Bejaia.

Taking the year 2017 as an example, the overall statistics of registered claims are shown in Figure 4. A comparison of these four criteria reveals the predominance of commercial claims (5,055/57.78%), followed by leakage claims (2,262/25.86%), then lack of water claims (1,375/15.72%), and finally water quality claims (56/0.64%) (Figure 4(a)). It can be seen that the commercial registers more claims and the qualitative registers the lowest rate of claims. With regard to claims about leaks and lack of water, the opposite trend can be observed, as each time water is available the number of claims about leaks increases (Figure 4(b)). The monthly variation shows a maximum of claims in July and a minimum recorded in December (Figure 4(b)). The box plot shows a monthly average of 729 claims and the inter-quartile interval is between 641.50 and 772.00 (Figure 4(c)).

The total number of claims, 8,748, is very large. These findings are almost identical in other years. These data provide a view of the customer area in a drinking water utility. Indeed, the extent of claims is

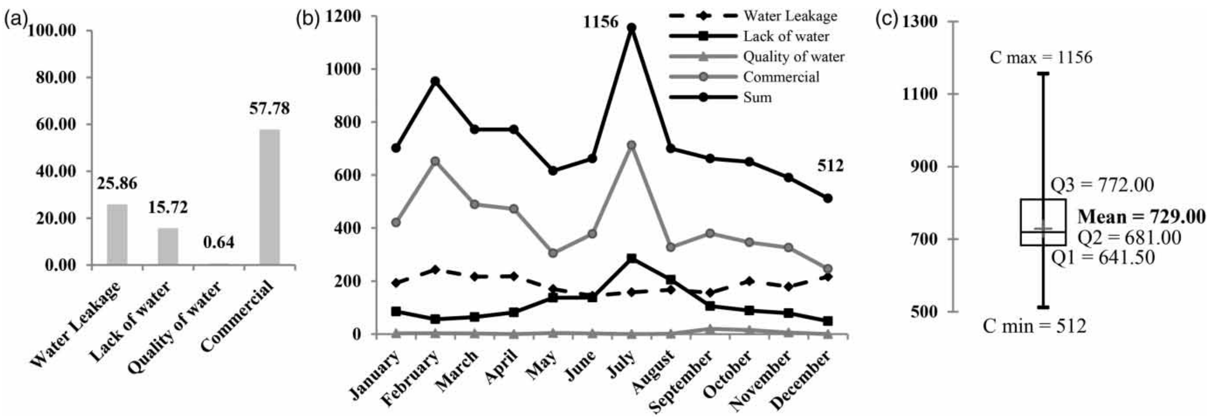


Fig. 4. Overall statistics of registered claims in 2017.

great and the customers' expectations are very high. Regarding the qualitative aspect, the ADE ensures the distribution of good quality water. On the quantitative aspect, the ADE finds it very difficult to manage. Regarding the commercial aspect, a significant number of complaints are registered. To this end, a question is put to the ADE managers; what is the cause of this large number of complaints? The answer given justifies this large number by the new organization of drinking water utilities in Algeria. Indeed, before the creation of the ADE, water management in cities was carried out by a Household and Industrial Water Distribution Company: EDEMIA (Entreprise de Distribution des Eaux Ménagère et Industrielle Algérienne). This company provides a service in return for a lump sum payment because customers are not equipped with meters. In rural areas the management is carried out by the commune's services and payment is almost non-existent. With the arrival of the ADE, the situation has changed in both cases. In terms of management, there is the passage from a management phase characterized by non-payment and lump-sum payment to another management phase characterized by payment on consumption. This shift has changed customers' habits and created some resistance on their part which ended with the acceptance of the reality of the payment. For customers who do not want to pay their water bills, the ADE uses several coercive measures respecting a chronological order going from the creation of cards to remind the customer of their unpaid bills, to formal notices, to the cutting of water connections and to cases referred to the courts. In administrative terms, the arrival of the ADE generated a considerable amount of work that has led to various errors and anomalies. This situation is increasingly under control thanks to the census established and the efforts made that have led to corrections on the names and addresses of customers. In terms of billing, some customers find the water bill complex. Indeed, the slice system used and its composition, which is the sum of water consumption and the different taxes, is not clear to all customers.

3.2. Performance assessment

The performance evaluation of the objective 'Better listening to customer claims', of all agencies, will begin with the development of its hierarchical structure. Indeed, it is composed of three main aspects defined by: 'Better processing of water quality claims', 'Better processing of water quantity claims', and 'Better processing of commercial claims'. Each aspect is subdivided into criteria. The first aspect consists of a single criterion that takes into account water quality claims. The second aspect consists of two criteria that include leakage claims and lack of water claims. The third aspect consists of a single criterion that incorporates commercial claims. All in all, 19 indicators reflect the different claims recorded. This step is carried out with the contribution of ADE managers.

In the next step of the evaluation process, the weights of all aspects, criteria, sub-criteria, and indicators should be derived from fuzzy pair-wise comparison matrices. These will be developed through the answers obtained based on a questionnaire sent to the managers of the water utility. The fuzzy comparison matrices developed for the different aspects, criteria, sub-criteria, and indicators are shown in Tables 1–4.

In this case, we assume that all paired comparative judgments are represented by fuzzy triangular numbers $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$, such that $u_{ij} > m_{ij} > l_{ij}$. Example Table 1 shows that the first aspect A1 is considered as the most important aspect, since all the fuzzy numbers in the first row are greater than one. Indeed, the qualitative aspect is evaluated as being about twice more important than the quantitative aspect and about three times more important than the commercial aspect.

Table 1. Fuzzy comparison matrix of aspects with respect to Objective O.

O	A1	A2	A3
A1	(1,1,1)	(1,2,3)	(2,3,4)
A2	(1/3,1/2,1)	(1,1,1)	(1,2,3)
A3	(1/4,1/3,1/2)	(1/3,1/2,1)	(1,1,1)

Table 2. Fuzzy comparison matrix of criteria with respect to aspects A1-A2-A3.

A1	Weight	A2	C2	C3	A3	Weight
C1	1	C2	(1,1,1)	(3,4,5)	C4	1
		C3	(1/5,1/4,1/3)	(1,1,1)		

Table 3. Fuzzy comparison matrix of indicators and sub-criteria with respect to criteria C1-C2-C3-C4.

C1	I11	I12	I13			
I11	(1,1,1)	(1,2,3)	(2,3,4)			
I12	(1/3,1/2,1)	(1,1,1)	(1,2,3)			
I13	(1/4,1/3,1/2)	(1/3,1/2,1)	(1,1,1)			
C2	I21	I22		**C3**	I31	I32
I21	(1,1,1)	(3,4,5)		I31	(1,1,1)	(2,3,4)
I22	(1/5,1/4,1/3)	(1,1,1)		I32	(1/4,1/3,1/2)	(1,1,1)
C4	SC1	SC2	SC3			
SC1	(1,1,1)	(1,2,3)	(2,3,4)			
SC2	(1/3,1/2,1)	(1,1,1)	(1,2,3)			
SC3	(1/4,1/3,1/2)	(1/3,1/2,1)	(1,1,1)			

Table 4. Fuzzy comparison matrix of indicators with respect to sub-criteria SC1-SC2-SC3.

SC1	I411	I412	I413	I414	I415
I411	(1,1,1)	(1,2,3)	(1,2,3)	(2,3,4)	(3,4,5)
I412	(1/3,1/2,1)	(1,1,1)	(1,2,3)	(2,3,4)	(3,4,5)
I413	(1/3,1/2,1)	(1/3,1/2,1)	(1,1,1)	(1,2,3)	(3,4,5)
I414	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1/3,1/2,1)	(1,1,1)	(3,4,5)
I415	(1/5,1/4,1/3)	(1/5,1/4,1/3)	(1/5,1/4,1/3)	(1/5,1/4,1/3)	(1,1,1)
SC2	I421	I422			
I421	(1,1,1)	(2,3,4)			
I422	(1/4,1/3,1/2)	(1,1,1)			
SC3	I431	I432	I433	I434	I435
I431	(1,1,1)	(1,2,3)	(1,2,3)	(2,3,4)	(2,3,4)
I432	(1/3,1/2,1)	(1,1,1)	(1,2,3)	(1,2,3)	(2,3,4)
I433	(1/3,1/2,1)	(1/3,1/2,1)	(1,1,1)	(1,2,3)	(2,3,4)
I434	(1/4,1/3,1/2)	(1/3,1/2,1)	(1/3,1/2,1)	(1,1,1)	(2,3,4)
I435	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1,1,1)

The weight vectors are obtained by exploiting the formulas of the fuzzy-AHP approach and Buckley's method described in the Methodology section. The weighting of the different elements of the matrix first requires a study of the consistency of the judgments. This study requires the calculation of the eigenvalue (*λmax)* obtained from the defuzzified matrix containing the crisp values. Taking the same example (*λmax* = 3.091), the consistency index CI $= \frac{3.091 - 3.}{3 - 1} = 0.045$. The consistency ratio CR $= \frac{0.045}{0.58} = 0.078$. The *CR* value is less than 0.1. Therefore, the matrix of fuzzy judgments is coherent.

The weight vector W is as follows:

$$W = (0.5190, 0.3079, 0.1730)^{T}$$

The reading of the other levels as well as the calculation of the weight is established in the same way as the example. The hierarchical structure and the weights obtained are summarized in Figure 5.

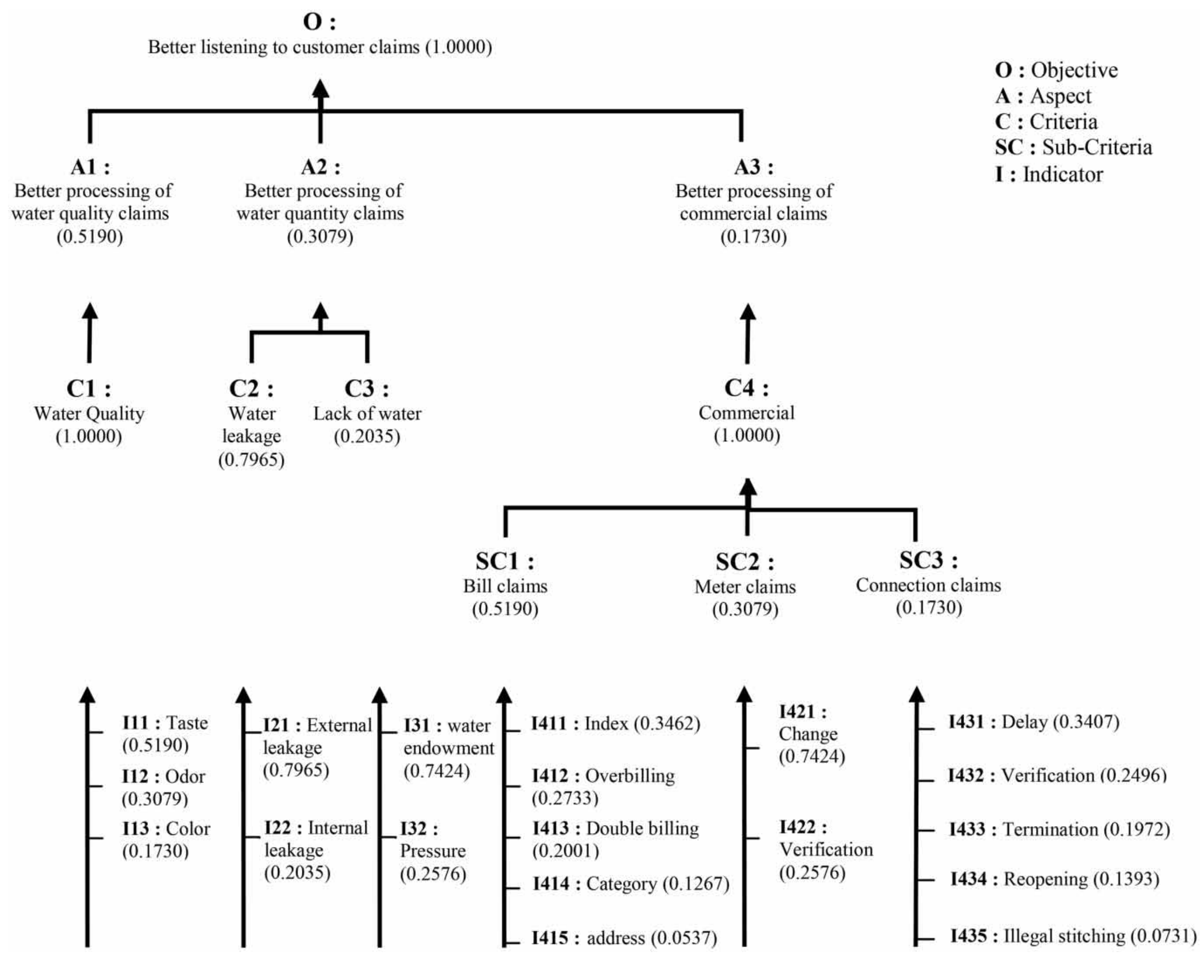


Fig. 5. Hierarchical structure of the objective 'Better listening to customer claim'.

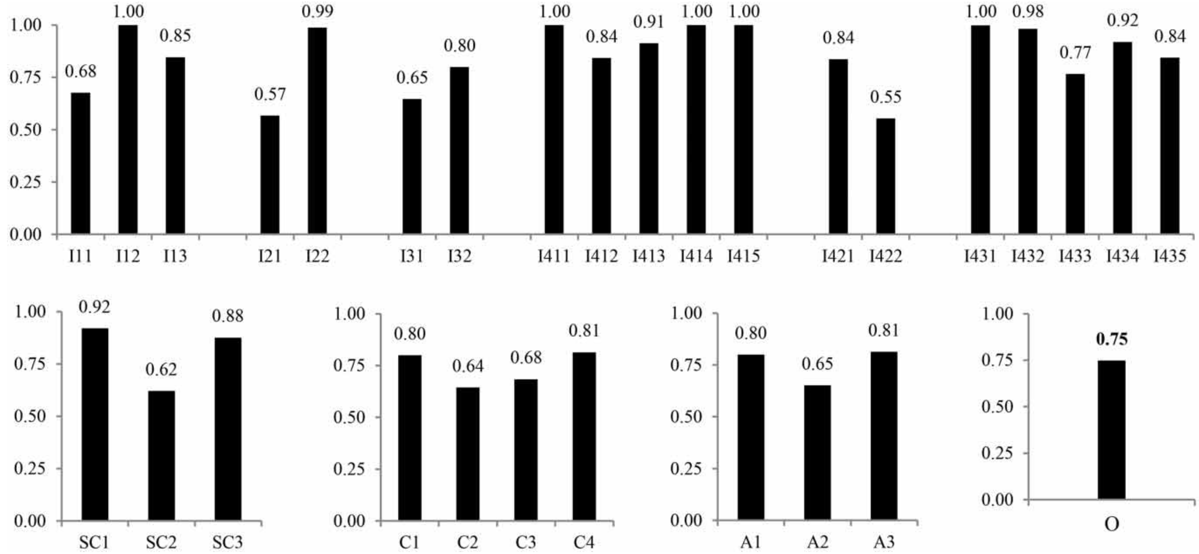


Fig. 6. Performance of indicators, sub-criteria, criteria, aspects, and objective for the year 2017.

The performance evaluation of the objective is obtained by first calculating the performance of processing the claims issued represented by indicators. After weighting with fuzzy-AHP method and aggregation using the WASPAS method, the performance of the sub-criteria and the criteria is calculated. In the same way, after weighting and aggregation, the performance of the three aspects and ultimately the performance of the studied objective is obtained. The obtained results are shown in Figure 6.

The performance of the objective 'Better listening to customer claims' is 0.75 in 2017. This performance gives managers a global overview of the effectiveness of claims' management, a result that is appreciable but incomplete. Indeed, the processing of all the very varied claims proves to be a very difficult task for the managers of the drinking water utility. The difficulties encountered are diverse. They range from the extent of the claims, to the lack of means, equipment, and funding needed to process all claims. Another much more detailed reading can be made by managers concerning the different levels of the hierarchical structure. Indeed, their analysis can be a very effective means of improving the performance of weak performance elements. In this case, the quantitative aspect records the weakest performance; a consequence of the weak performance of criteria C2 and C3. This shows that the major difficulties in the drinking water utility are of a quantitative nature. This situation is caused by the faulty state of the networks combined with a lack of water. These two elements require colossal investments that the water utility must accomplish in order to reduce claims.

3.3. Performance evolution

By carrying out the same work for the different years, 2014–2018, the synthesis of the obtained results concerning the evolution of the performance of the objective 'Better listening to customer claims' is summarized in Figure 7.

It can be seen that the performance is clearly progressing; in 2014 the performance is 69.23% and evolves to reach 79.03% in 2018. The analysis of the statistics over the five years shows the same

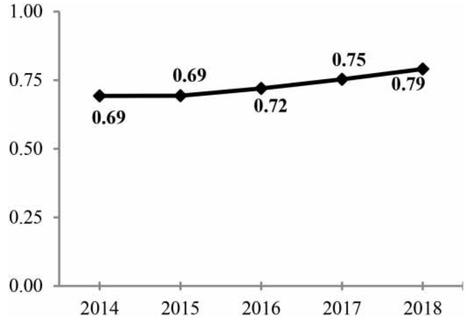


Fig. 7. Evolution of the performance of the objective during the period 2014–2018.

finding, namely, a weak performance in the quantitative aspect. The most important solutions are investment in the mobilization of new water resources by diversifying the resource and opting for seawater desalination and the construction of other dams and also, thinking about water saving, particularly the rehabilitation of drinking water networks, given the number of complaints recorded about leaks.

Conclusions

The customer area is of crucial importance as it is the showcase for the management of the drinking water utility. Its implementation, which has prompted the public authorities to implement a policy dedicated to customer listening, requires an evaluation of its performance. It is achieved by exploiting a structured methodology that takes into account several important considerations.

Beforehand, this methodology ensured the reliability of the information relating to claims. The managers' contribution was valuable in facilitating access to field data recorded at the level of the ADE centers. The use of these data has made it possible to better define the customer area by identifying the nature and extent of claims. In fact, the nature of the claims reflects the major requirements or important aspects that link the customer to the water utility. These requirements reproduce the itinerary of a customer who demands the right to be connected to the network, supplied with good quality water in sufficient quantity, and the duty to pay water bills for the equivalent of the service provided. The in-depth analysis of the field data enabled the identification of indicators that allow assessment of the level of achievement of each aspect. These indicators represent the different claims made by the customer which are of different natures.

Subsequently, this methodology made it possible to calculate the performance which required a simplification through the structuring of the problem in the form of a tree structure. At its head, the main objective is identified under the name 'Better listening to customer claims'. This objective is subdivided into three aspects: qualitative, quantitative, and commercial, which are defined by four criteria evaluated, in turn, by 19 indicators; all the elements of the structure take into account the nature of the claims registered, each of which brings added value. The choice of the structure is motivated by its correspondence to the chosen calculation methods, fuzzy-AHP for weighting and WASPAS for aggregation, thus offering greater precision in the evaluation of the performance of the studied objective. Therefore, the calculation of performance required the transformation of the data collected on performance scales to obtain the performance note for each indicator. In the same way, by going back up through weighting and aggregation, the performance note of the sub-criteria, criteria, aspects, and final objective will be arrived at. By opting for this methodology, the performance of the objective studied has evolved during the 2014–2018 period.

The developed methodology meets the expectations of the ADE managers and offer them several reading scales. The first one, which was holistic, made it possible to evaluate the results achieved through the implemented policy. They are appreciable and progression is observed in the handling of claims. The second one, more detailed, identified the elements of poor performance in the management of the customer area; therefore, it gives insight into the solutions to be undertaken to improve them. In fact, the processing of all claims of various kinds appears to be a very difficult task for managers, particularly those relating to the quantitative aspect. In this case, the improvement of the water utility requires funding to increase water production capacity and to rehabilitate networks to reduce water leakage.

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Data availability statement

All relevant data are included in the paper or its Supplementary Information.

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