Water Policies and Conflict Resolution of Public Participation Decision-Making Processes Using Prioritized Ordered Weighted Averaging (OWA) Operators

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Abstract

There is a growing interest in environmental policies about how to implement public participation engagement in the context of water resources management. This paper presents a robust methodology, based on ordered weighted averaging (OWA) operators, to conflict resolution decision-making problems under uncertain environments due to both information and stakeholders' preferences. The methodology allows integrating heterogeneous interests of the general public and stakeholders on account of their different degree of acceptance or preference and level of influence or power regarding the measures and policies to be adopted, and also of their level of involvement (i.e., information supply, consultation and active involvement). These considerations lead to different environmental and socio-economic outcomes, and levels of stakeholders' satisfaction. The methodology establishes a prioritization relationship over the stakeholders. The individual stakeholders' preferences are aggregated through their associated weights, which depend on the satisfaction of the higher priority decision maker. The methodology ranks the optimal management strategies to maximize the stakeholders' satisfaction. It has been successfully applied to a real case study, providing greater fairness, transparency, social equity and consensus among actors. Furthermore, it provides support to environmental policies, such as the EU Water Framework Directive(WFD), improving integrated water management while covering a wide range of objectives, management alternatives and stakeholders.

Keywords: OWA operators; stakeholders; decision-making; water resources management.

1. Introduction

The EU WFD establishes the achievement of a good qualitative and quantitative status of all water bodies by promoting the application of sound economic principles, methods and instruments; streamlining legislation; and stakeholders' active engagement in the implementation of the directive and development of watershed management plans (EC, 2000). There are a lot of works in the literature that have dealt with the implementation of the WFD (e.g., Peña-Haro et al., 2010; 2011; Molina et al., 2012; Llopis-Albert et al., 2014; Llopis-Albert and Palacios-Marqués, 2016).

The most appropriate measures and policies to achieve the environmental and socio-economic objectives entail balancing the interests of various groups, for which it is important that the process is open to the scrutiny of those who will be affected. In this way, PPP eases the enforceability of the water management plans since they provide more transparency in the establishment of objectives, the imposition of measures and policies, the reporting of standards. Furthermore, it leads to increased confidence in institutional actors, more consensus and acceptability among the actors, legitimacy of the watershed management plan; more benefit of the available information; and reinforcement of democratic practices (e.g., Llopis-Albert et al., 2015; 2016). However, there are also disadvantages when involving stakeholders. For instance, it requires considerable time, planning and economic resources. Note that the WFD requires that member states publish and make accessible for comments to stakeholders, a timetable and work programme of the watershed management plan. Eventually, if the final water management plan disregard the advice of several stakeholders, it can lead to distrust, and complaints procedures and the courts with consequent delay in the implementation of the plan.

Three levels of stakeholders' participation with different degrees of influence can be defined in a PPP, which include information supply (where the stakeholders are only informed); consultation (where their opinions are taken as input in the decision-making process); and active involvement (in which they develop alternatives, identify solutions and take responsibilities). In addition, stakeholders are a major source of uncertainty when defining water policies. The uncertainty encompasses the evaluation of how stakeholders may influence on the decision-making process, how they are affected by the actions to be taken, their relevance, motivation and capacity to participate in the decision-making process, and the fact that the available information about their preference is usually highly imprecise.

In this study, the actors involved in the PPP are divided into three main sets, which cover individuals, communities, social groups or organizations. These sets are the government (which include national, regional and local governments, and river basin authorities); the experts and opinion formers in water resource management (including advisors and academics from different fields such as hydraulics and environmental sciences, economics or law, and mass-media); and the users of water resources (i.e., water user associations for agricultural, industrial and urban use, associations from the tourism sector because its influence in the SE coast of Spain, and power generation companies).

They have different values, levels of knowledge, resources, interests, and perceptions of problems, solutions and strategies. Then there is a conflict of interest among the different stakeholders, which leads to an even more complex decision-making process and to achieve satisfactory outcomes (e.g., Jackson et al., 2012)

The factors that lead to the conflict of interest among stakeholders cover environmental objectives pursued, actual capacity of efficiently achieving the objectives, socio-economic development of the region, level of involvement and means of participation, and alternative policies and measures that should be performed.

We have defined priorities among the stakeholders. For the three group decision-making problem defined, the government has the largest weights, the users would be the second, and the experts have the smallest weights.

In order to analyze the adequate water policies and stakeholders' satisfaction in a PPP we have used the ordered weighted averaging aggregation (OWA) operator. Other approaches such as the fuzzy set/Qualitative Comparative Analysis (fsQCA) or structural equation modelling could also be used (Berbegal-Mirabent and Llopis-Albert, 2016: Xu et al., 2014).

OWA operators (Yager, 1988; Yager et al., 2011) and prioritized multi-criteria decision-making problem has been widely tackled in the literature (Yager, 2004; Amin and Sadeghi, 2010; Yan et al., 2011). OWA operator has been extended under a wide range of frameworks including probabilities (Merigó, 2010), distance measures (Merigó and Casanovas, 2011), linguistic information (Merigó et al., 2010; Merigó and Gil-Lafuente, 2013), moving averages (Merigó and Yager, 2013) and continuous operators (Zhou et al., 2016). Prioritized aggregation operators have been also studied in many situations (Chen and Xu, 2014; Chen et al., 2014a). Wei and Tang (2012) developed generalized prioritized aggregation operators. Chen et al. (2014b) developed a weakly prioritized measure for multi-criteria decision making and Yu et al. (2013) with preference relations. In fuzzy environments, Verma and Sharma (2016) designed prioritized operators with triangular fuzzy numbers, Ye (2014) considered trapezoidal intuitionistic fuzzy sets, Chen (2014) used interval-valued intuitionistic fuzzy sets, and Dong and Wan (2016) focused on triangular intuitionistic fuzzy numbers. Some other authors have used hesitant fuzzy sets in the aggregation process (Jin et al., 2016; Wei, 2012; Zhao et al., 2016). Additionally, other authors have considered other environments with interval numbers (Ran and Wei, 2015) and linguistic information (Zhao et al., 2014; Zhou et al., 2013).

However, this technique has been scarcely applied to water resources management and public participation decision-making processes. Sadiq and Tesfamariam (2007) developed water quality indices using probability density functions based on OWA operators. Sadiq et al. (2010) integrates indicators for performance assessment of small water utilities using OWA operators. Kentel and Aral (2007) presented a fuzzy multiobjective decision-making approach for groundwater resources management, where OWA operators allowed to determine individual satisfaction degrees of each management strategy with respect to multiple objectives. There are also applications in other environmental problems such as climate change. Rahmani and Zarghami (2013) developed a new approach to combine climate change projections by OWA operators.

In this work, the prioritized OWA operator is used to solve heterogeneous group decision- making problem in which there exists prioritization of stakeholders. The rest of the paper is structured as follows. Section 2 introduces the prioritized OWA operator for heterogeneous group decision-making problems. Section 3 presents a case study for water resource management in Spain. Section 4 concludes the paper.

2. Methodology

In many multi-criteria decision-making problems some of the stakeholders are regarded as prior to others, on account of their power and influence or because they mainly bear the measures to be undertaken. Stakeholder power analysis is used for helping decision-making problems with competing interests or when resources are limited so that stakeholder needs must be appropriately balanced. Then we need to construct the prioritization relations among the stakeholders, and subsequently obtain the overall scores of each alternative by means of the prioritized aggregation operators (Yager, 2008; 2009, Wang et al., 2014). This is carried out by assuming that all the stakeholders $D = \{D_1, D_2, \cdots, D_n\}$ can be divided into q categories $H_1, H_2, \ldots, H_n$; where $H_i = \{D_{i1}, D_{i2}, \cdots, D_{in_i}\}$, D_{ij} is the stakeholder in category H_i, $D = \bigcup_{i=1}^{q} H_i$ and $\sum_{i=1}^{q} n_i = n$. In addition, a prioritization among the categories exists, i.e., $H_1 > H_2 >$

$\cdots > H_q$. By defining the set of alternatives as $X = \{x_1, x_2, \cdots, x_m\}$ and assuming that for any alternative x in X and for each stakeholder, the value $D_{ij}(x) \in [0,1]$ expresses its satisfaction level or preference. The goal is to rank the alternatives in X, so that the priority hierarchy presents two cases. The strict priority order takes place when each priority level presents only one stakeholder (i.e., $n_k = 1$ for $k = 1,2,\dots,q$) while otherwise a weakly ordered prioritization is presented.

By using the prioritized scoring operator (Yager, 2008) in which $F: [0,1]^n \rightarrow [0,1]$ such that $F\left(\left(a_{11},\dots,a_{1n_1}\right),\dots,\left(a_{q1},\dots,a_{qn_q}\right)\right) = \sum_{i=1}^{q}\sum_{j=1}^{n_i}\omega_{ij}a_{ij}$ the value of $D(x)$ can be obtained for alternative x as:

$$D(x) = F\left(D_{ij}(x)\right) = \sum_{i=1}^{q}\left(\sum_{j=1}^{n_j}\omega_{ij}D_{ij}(x)\right) \quad (1)$$

The priority category H_i are aggregated by means of the OWA operator, which is akin to a weighted mean. The priority relationship is defined through the weights ω_{ij}, which are function of x and are associated with a particular ordered position of the arguments, contrary to the weighted means. However, the values of the variables are formerly ordered in a decreasing way.

The OWA operator presents important properties such as monotonicity, idempotency and boundary. Eventually, the OWA operator is used to obtain satisfaction degree of stakeholders for each priority level, which can be expressed as follows:

$$Sat_i = OWA\omega_i\left(D_{i1}(x), D_{i2}(x), \cdots, D_{in_i}(x)\right) = \sum_{k=1}^{n_j}\omega_{ik}b_{ik}(x) \quad (2)$$

in which ω_i is the OWA weighting vector associated with each priority category H_i and $b_{ik}(x)$ is the k^{th} largest of $D_{ij}(x)$. Each vector component ω_{ik} satisfies that $\omega_{ik} \in [0,1]$ and $\sum_{k=1}^{n_j}\omega_{ik} = 1$. These weights can be obtained by different methods, such as linguistic quantifiers, orness measure, dispersion measure, O'Hagan's maximum entropy measure, normal distribution based method, etc. (see, e.g., Yager, 1988; O'Hagan, 1988; Xu, 2005).

The priority relationship is modelled by taking into account that the lower priority will become important with the higher degree of higher priority level. In other words, the priority weights depends on the satisfaction of higher priority level. In this way, the priority induced importance weights (T_i) of each priority level H_i are defined as follows:

$$T_i = \prod_{k=1}^{i} Sat_{k-1} \tag{3}$$

where:

$$Sat_0 = 1;\ for\ H_1, T_1 = 1;\ for\ H_2,\ T_2 = T_1 Sat_1;\ for\ H_3,\ T_3 = T_1 T_2 Sat_2$$

The aggregated value for each alternative is obtained by means of the prioritized OWA (POWA) operator:

$$D(x) = \sum_{i=1}^{q} T_i Sat_i \tag{4}$$

Eventually, the overall score of each alternative can be obtained by:

$$D(x) = \sum_{i=1}^{q} u_i Sat_i \tag{5}$$

where:

$$u_j = \frac{T_i}{\sum_{j=1}^{q} T_j} \tag{6}$$

Note that the sum of all the level do not comply the normalization condition ($\sum_{i=1}^{q} T_i \neq 1$) and if $Sat_k = 0$, then $T_i = u_i = 0$ for all i>k.

Finally, this operator has some important properties, i.e., monotonicity, commutativity and boundary (e.g., Wang et al., 2014). Furthermore, note that many other aggregation operators could also be considered in the analysis (Merigó et al., 2015).

3. Application to a case study

This methodology is applied to the Jumilla-Villena aquifer (SE Spain), which supports the agricultural and economic development of the region. However, this has been carried out through time by the aquifer over-exploitation, with the subsequently environmental impacts, such as drying out of springs and wetlands, the disappearance and regime alteration of related rivers, presence of higher concentrations of substances identified as priority pollutants (e,g,, nitrates from the fertilizers applied to the irrigated crops) and seawater intrusion. The groundwater resources have been used to irrigate large crop areas and to supply water for industrial purposes and urban use. It is worth mentioning the increase in recent years of the groundwater demand in summer because of the tourism. The hidrologic unit has a surface of 338 km2, of which 108 km2 are outcrops, which is shared between the Segura and Júcar River Basin Authorities (CHS, 2016; CHJ, 2017). The economically exploitable reserves are estimated to be about 1400 hm3, while the accumulated water abstractions from the eighties is more than 1000 hm3, although the uncertainty in the hydrological parameters hinders the calculations (e.g, Llopis-Albert et al., 2015; Pulido-Velazquez et al., 2011; Llopis-Albert and Capilla, 2010; 2010a). The aquifer has undergone mean abstractions of around 40 hm3/year with a recharge estimated in 7 hm3/year, thus leading to a water balance disequilibrium of about 33 hm3/year in spite of the water efficient irrigation systems. Then a decrease in the piezometric levels of more than a hundred meters has been observed in some wells, although in recent years those drawdowns have been considerably reduced on account of the measures undertaken. Specifically, the aquifer was officially declared as over-exploited in 1987, which entails that well extractions and irrigated surface are limited and User's Communities must be set up as a control mechanism. In addition, the quantitative status of the aquifer is considered one of the most important issues in the Segura River Basin Management Plan for the period from 2015 to 2021 (CHS, 2016).

Hence, it is at risk of not meeting the good ecological and chemical status as stated by the EU WFD, which has caused severe political conflicts among the different stakeholders.

These conflicts entail a major issue for the successful achievement of any regulation or policy, even more under scarce water conditions and water transfers among different Water Agencies. In order to address this complex problem the WFD promotes the public decision-making with the goals of attaining the best management practices and enhancing transparency and confidence-building. There are different degrees of stakeholders' participation, which range from information supply, consultation and active involvement.

In this sense, following the guidelines established by WFD a public participation process was carried out by the Segura River Basin Authority for the hydrological planning cycle from 2015 to 2021 (CHS, 2016).

On the one hand, this study considers three categories of stakeholders with heterogeneous interests, which consider groups who in some way will be affected by the implementation of undertaken measures:

- The government (H_1), which include the national government (D_{11}), the regional and local governments (D_{12}), and the Segura and Júcar river basin authorities (D_{13}).

- The experts and opinion formers in water resource management (H_2), including advisors and academics from different fields such as hydraulics and environmental sciences, economics or law, and also from international organizations, e.g., the

Organization for Economic Co-operation and Development (OECD) or United Nations (UN) (D_{21}), mass-media (D_{22}), and non-governmental organization, NGO's (D_{23}).

- The users of water resources (H_3), which cover water user associations for agricultural, industrial and urban use (D_{31}), associations from the tourism sector on account of its influence in the south-eastern coastal areas of Spain (D_{32}), and power generation private firms such as hydroelectric or energy companies (D_{33}).

Table 1 shows the stakeholders' satisfaction degree or preference regarding each alternative. Due to the different capacity to influence on the measures to be undertaken the stakeholders' categories presents different weights. In this sense, the government (H_1) has the highest weights since the water resources in Spain presents a strong tradition of State interventionism. The experts and opinion formers (H_2) can provide technical advice or boost a certain position but their influence on the measures to be taken, and hence their weights, are lower than the other two categories.

Historically, the water user communities (H_3) in Spain are bodies governed by public law attached to the river basin authorities. They are self-governing institutions that can manage themselves to distribute the water efficiently, orderly and in an equitable way among its members and with the power to impose sanctions. Therefore, H_3 has weights lower than H_1 but higher than H_2. Therefore, the water resource management in Spain depends on a heterogeneous decision-making groups, where the categories are prioritized as follows $H_1 > H_3 > H_2$.

On the other hand, the stakeholders should decide on different alternatives raised to achieve a sustainable water management for the region based on political, socio-economic and ecological objectives while meeting the regulations of the WFD.

Then, there are 9 main groups of stakeholders, 3 from different level governments (D_{11}, D_{12}, D_{13}), 3 from experts and opinion formers (D_{21}, D_{22}, D_{23}), and 3 from water user communities (D_{31}, D_{32}, D_{33}). Eventually, each stakeholder provide its respective satisfaction level or preference to each alternative, i.e., the scores $D_{ij}(x)$ regarding to each alternative A_k (k=1,2,…,5).

The Segura Hydrologic Plan for the cycle 2015-2021 comprises a wide range of alternatives and possible measures to be taken for the sustainable management of the water body that can be discussed by the stakeholders. The Hydrological Plan is a mixing of those measures to achieve the environmental and socio-economic objectives, which includes reduction of over-exploitation, transfer of water resources from other river basins, use of desalination and sewage water plants, more government control measurements and regulations, etc. (CHS, 2016). In this study we consider five different alternatives, which differ in the priority that they give to the environmental and socio-economic objectives, and the emphasis in the possible measures to be taken. Since there are some alternatives giving priority to the environmental and ecological objectives, while other alternatives focuses on the socio-economic development of the region it seems clear that there is a conflict of interest among the stakeholders, which will show their degree of acceptance or preference to the different alternatives. The considered alternatives are listed below:

-Alternative 1 (A_1): this alternative gives more priority to the environmental and ecological objectives. It proposes to achieve a good quantitative and qualitative status of all water bodies for the horizon of 2027. The Segura river basin has been derogated the achievement of the good status, as determined by the WFD, and will not be achieve in the hydrological cycle 2015-2021. Specifically, the way towards the good status of all water bodies will be achieve by considering a reduction and more control of the over-exploitation and water storage of the water bodies by decreasing the surface of irrigated crops or not allowing new water demand for urban use as a consequence of the tourism growth in recent years. On the one hand, a large reduction would entail a reversal in the socio-economic development in the area with unaffordable losses for the farmers and tourism sector. On the other hand, the investment cost to achieve these objectives for the hydrological cycle was of almost 2.000 M€ for the watershed. For instance, the investment considers the construction of new infrastructures such as the planned connection to the infrastructure of Taibilla Canals Community (TCM) to supply water from the drinking water treatment plant of Sierra de la Espada to the municipalities of Yecla and Jumilla for urban use. This would allow in the future the replacement of groundwater resources, thus reducing the extractions from the aquifer. However, a significant investment in infrastructures during periods of economic crisis may be unaffordable (e.g., infrastructures for water transfers, drinking water and waste water plants, desalination plants, dams, network of water monitoring stations...).

The reduction of the over-exploitation is one of the important issues that the Segura River Basin Authority has posed for the hydrological cycle from 2015 to 2021, since it is greater than 200 hm3/year for the whole watershed. The reduction of abstractions in the Jumilla-Villena aquifer would improve the current water balance disequilibrium and ecological flows, avoid the decrease of groundwater levels and their corresponding subsidence problems, and partially allow in the long-term the recuperation of water dependent ecosystems such as springs and wetlands (i.e., due to the intensive exploitations during the last decades the springs of Ñorica and Chopo disappeared). This alternative also considers a low environmental impacts for future climate changes and land-use land-cover changes (including droughts, desertification, erosion, and availability of future water resources).

The Jumilla-Villena aquifer also presents an upward trend in observed concentrations of hazardous substances such as an increase in nitrate concentrations as a consequence of the fertilizer application in irrigated crops, and salt water as a result of the seawater intrusion. These problems are a major concerned in water resources management (e.g., Llopis-Albert and Pulido-Velazquez, 2014; 2015). The WFD establishes certain substances as hazardous and provides limits to their concentration on account of their substantial risk to the environment. This thresholds must not be exceeded for the achievement of the good chemical status. With the reduction of abstractions and the surface of irrigated crops defined by the alternative A_1 the chemical status would improve.

-Alternative 2 (A_2): this alternative tries to balance the environmental and ecological objectives with the socio-economic ones by using external water resources. However, all water transfers and the quantities transferred are controversial and present a high socio-economic cost, even more if they involve different river basins which may lead to a great rejection among the different regions. In fact, the current hydrological plan considers the use of external resources because otherwise it would imply disproportionate costs in socio-economic and environmental terms. The current plan poses some water transfers in order to satisfy the water demand in a sustainable way. The Tajo-Segura water transfer entails, since the early eighties, a mean of around 300 hm3/year; the Negratín-Almanzora of around 17 hm3/year; and the Júcar and Vinalopó (which is a recently approved water transfer) of around 6 hm3/year. Part of this water transfers are used in the Jumilla-Villena aquifer.

The Spain's National Water Plan sets the points of connections and water prices of the external resources and weighs up the cost of the construction of the new infrastructure required. In this sense, the Segura Water Agency performed simulations using different prices for the external resources. An analysis of payment capacity of the users of the area through elasticity of demand curves were carried out.

-Alternative 3 (A_3): this alternative is similar to alternative A_2 but instead of using such a large quantity of external water resources from other river basins it also relies on the use of desalination plants (the Jumilla-Villena aquifer is a coastal aquifer) and sewage treatment plants. This would allow when needed, the substitution of non-renewable groundwater resources, thus avoiding certain environmental problems (e.g., Llopis-Albert, 2016). However, the high cost of the construction and maintenance of those plants, and the cost of the energy needed, lead to a high price of the m3 of desalinated or reused water. Moreover, the desalinated water may present higher costs if compared to other water resources. These problems, together with the environmental impacts of desalinization plants can prevent or limit their use. The hydrological plan of the Segura river basin for the cycle 2015-2015 establishes a production of desalinated water between 150 and 200 hm3/year for the whole watershed and from a total of 13 desalination plants. Additionally, it poses a production of around 150 hm3/year from more than 200 sewage treatment plants in the watershed.

-Alternative 4 (A_4): this alternative gives more priority to the socio-economic objectives.

On the one hand, it includes the fulfillment of operating efficiency of the measures to be taken such as short realization time, low implementation costs (covering monetary, social and reputational costs, and human resources), and low costs in the construction, maintenance, and management of infrastructures. On the other hand, it entails the socio-economic development of the region (e.g., in terms of employment, social equity or gross domestic product) for the agriculture, industry and service sectors (e.g., tourism). This alternative tries to maximize water use and even increase future water demands for tourism purposes. In this sense, the reduction of the water demand considered in this alternative is much lower than that of the A_1.

-Alternative 5 (A_5): this alternative is similar to alternative A_1 but with a strong control on the part of the government, water agencies and user's communities in order to achieve the good status of all water bodies. A stringent water management control may lead to a strong opposition among water users, and to negative political repercussions to the government. A wide range of control mechanisms could be applied: control or reduction of water demand by economic instruments (e.g., reduction of irrigated areas by acquisition of water rights and its reordering, that would be selectively applied on crop areas with lower productivity); control or reduction of pollutants by economic instruments (e.g., water and fertilizer taxes, implementation of fertilizer standards, and water trading, i.e., buying and selling water access entitlements); increase of water control and sanctions by water agencies (e.g., illegal water abstractions, illegal dumping, over-fertilizers practices...); set up of user's communities as a control mechanism with the power to impose sanctions; control of water resources by application of satellite remote sensing; a strong intervention of the EU Common Agricultural Policy (CAP); more control for an efficient conjunctive use of surface water and groundwater (for the Jumilla-Villena aquifer this would be translated into groundwater substitution by surface water for agricultural purposes); water banking, which is the practice of foregoing water deliveries for a certain period of time, and to provide either the right to use the forgone water in the future, or saving it to use in exchange for a fee or delivery in kind); more intervention in the establishment of new protected and vulnerable areas and designation of artificial water bodies and heavily modified; control on the river basin operating system and the current and future water demand, promote land-use changes for adaptation to exploitation plans (e.g., change of crops or dry farming); reduction of water allotment in drought periods (e.g., in summer); and promote irrigation efficiency.

4. Results and discussion

The scores $D_{ij}(x)$ are presented in Table 1, which values are based on, meetings, interviews with stakeholders, surveys, expert judgment, mass-media information and reports regarding the PPP published by the Segura and Júcar river basins as a transparency and confidence-building measure (CHS, 2016).

Table 1. Satisfaction degree of each stakeholder regarding each alternative

	D_{11}	D_{12}	D_{13}	D_{21}	D_{22}	D_{23}	D_{31}	D_{32}	D_{33}
A_1	0.9	0.8	0.9	0.9	0.7	0.9	0.6	0.5	0.9
A_2	0.8	0.9	0.8	0.6	0.5	0.6	0.9	0.9	0.5
A_3	0.6	0.6	0.6	0.6	0.5	0.5	0.8	0.9	0.4
A_4	0.7	0.8	0.6	0.7	0.8	0.5	0.9	0.9	0.3
A_5	0.7	0.6	0.7	0.8	0.5	0.8	0.6	0.5	0.9

The weights associated to the OWA operator in Eq. (2) are determined using linguistic quantifiers (Q), such as “Most”, “At least half” and “Average” (Yager, 2008). The Q can be expressed as fuzzy set, where $Q(0)=0$, $Q(1)=1$, and $Q(x)>Q(y)$ for $x>y$. Eventually, the weights can be determined as follows:

$$\omega_j = Q\left(\frac{j}{n}\right) - Q\left(\frac{j-1}{n}\right), j = 1,2,\dots,n \quad (7)$$

where Q is defined as follows (Zadeh, 1983):

$$Q(r) = \begin{cases} 0, & if\ r < a \\ \dfrac{r-a}{b-a}, & if\ a \le r \le b \\ 1, & if\ r > b \end{cases}$$

Hence, the weight vector is $\omega_j = (0.066,0.666,0.268)^T$, with $j = 1,2,3$. Once the weights are obtained the degree of satisfaction for each priority level can be calculated by means of the OWA operator and using the linguistic quantifier "Most" in Eq. (7):

$$Sat_1(x_1) = OWA\omega_1\big(D_{11}(x_1), D_{12}(x_1), D_{13}(x_1)\big) = OWA\omega_1(0.9,0.8,0.9) = 0.8737$$

$$Sat_2(x_1) = OWA\omega_2(D_{21}(x_1), D_{22}(x_1), D_{23}(x_1)) = OWA\omega_2(0.9,0.7,0.9) = 0.8469$$

$$Sat_3(x_1) = OWA\omega_3(D_{31}(x_1), D_{32}(x_1), D_{33}(x_1)) = OWA\omega_3(0.6,0.5,0.9) = 0.5935$$

Subsequently, by using the Eq. (3) the priority weight for each priority level can be obtained:

$$T_1 = 1;\ T_2 = Sat_0 \cdot Sat_1 = 0.8737; T_3 = T_2 \cdot Sat_2 = 0.7400$$

Finally, the global prioritized aggregated value is obtained through Eq. (4):

$$D(x_1) = \sum_{i=1}^{3} T_i Sat_i = 1 \cdot 0.8737 + 0.8737 \cdot 0.8469 + 0.7400 \cdot 0.5935 = 2.0529$$

Similarly, for the other alternatives the prioritized aggregation values are:

$$D(x_2) = 1.6373;\ D(x_3) = 1.1177;\ D(x_4) = 1.4536;\ D(x_5) = 1.4465$$

Therefore, the ranking order for the five alternatives considered:

$$D(x_1) > D(x_2) > D(x_4) > D(x_5) > D(x_3)$$

These results show that the best alternative is A_1. That is, the stakeholders pay more attention to the environmental and ecological objectives than to the socio-economic ones. This is because stakeholders are concerned about the current quantitative and qualitative status of the water bodies in the river basin. They are aware that the achievement of the WFD standards cannot occurred in this hydrological cycle and must be derogated to 2027. However, they know that the measures have to be taken now. They prefer the alternative entailing an important reduction in the over-exploitations by a mixture of measures but without emphasizing one specific measure such as those raised in the other alternatives.

Results also show that the second best alternative is that relying on water transfers from other river basins. However, it should be taken into account that many of the stakeholders are from the Segura river basin and that it must be agreed upon the other regions.

Note that the third chosen alternative is that giving more priority to the socio-economic since some of the stakeholders are from the private sector. Finally, the alternative with more control and regulations is the worst rated by the actors.

The WFD establishes an official calendar regarding the main phases of public decision-making process and a period for observations and allegations. After all the mechanisms used for stakeholders' engagement (e.g., meetings, workshops, conferences, expert panels, web-based communication technologies, water associations, consultations in regulatory processes, surveys and polls, and river basin organizations) the Segura hydrological plan for the cycle 2015-2021 performed a lot of changes regarding the initial documents on account of the stakeholders' contributions. Furthermore, stakeholders' satisfaction surveys were carried out among the stakeholders showing encouraging results, although with the idea that public decision-making process could be improved (CHS, 2016). A methodology as that here presented can help in conflict resolution decision-making problems providing more consensus among the stakeholders regarding the measures to be taken.

5. Conclusions

Environmental planning and water policy decision-making processes are hindered by the existence of several alternatives that must be selected considering the points of view of stakeholders with conflicting interests and uncertainties on their preferences.

We have presented a methodology based on prioritized OWA operators that allows to achieve more consensus among stakeholders regarding the measures and regulations to be taken. The methodology has been successfully applied to a case study in the field of water resources. It can help public decision-making processes because both the methodology and its results are easily understandable by non-technicians and non-experts stakeholders, while providing a transparent and multidisciplinary framework for informing and optimizing water policies, thus contributing to the stakeholders' satisfaction and the implementation of the WFD.

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