water

MDPI

Article

Measuring the Sustainability of Water Plans in Inter-Regional Spanish River Basins

María M. Borrego-Marín † and Laura Riesgo *,†

Department of Economics, Pablo de Olavide University, Ctra. de Utrera, km. 1, 41013 Seville, Spain; mmbormar@upo.es
* Correspondence: laurariesgo@upo.es; Tel.: +34-954-349851
† The authors contributed equally to this work.

Academic Editors: Giacomo Zanni, Davide Viaggi and Meri Raggi
Received: 30 April 2016; Accepted: 5 August 2016; Published: 11 August 2016

Abstract: This paper analyses and compares the sustainability of the water plans in the Spanish River basins according to the objectives of the Water Framework Directive. Even though the concept of sustainability has been traditionally associated with the triple bottom line framework, composed of economic, environmental, and social dimensions, in this paper sustainability has been enlarged by including governance aspects. Two multicriteria decision analysis approaches are proposed to aggregate the sustainability dimensions. Results show that the environmental dimension plays the most important role in the whole sustainability (40%) of water basins, followed by both economic and social criteria (25%). By contrast, the dimension of governance is the least important for sustainability (11%). A classification of the Spanish basins according to their sustainability indicates that the water agency with the highest sustainability is Western Cantabrian, followed by Eastern Cantabrian and Tagus. By contrast, Minho-Sil, Jucar, and Douro are the least sustainable.

Keywords: sustainability; Water Framework Directive; integral water management; multicriteria decision analysis; water policy design

1. Introduction

A modern water management system must be not only effectively provide water security, but also be sustainable, combining economic progress with social development and the conservation of habitats and ecosystems. The Water Framework Directive (WFD)—Directive 2000/60/EC [1]—and the introduction of river basin districts may help to fulfil such objectives. The environmental objectives are defined in Article 4—the core article—of the WFD, aiming to achieve a sustainable water management system on the basis of a high level of protection of the aquatic environment. Achieving such sustainability requires some boundaries, as through the definition of river basin districts. These districts are hydrological units selected on the basis of the spatial catchment area of the river, and not depending on any administrative or political boundary.

Spain has a wide tradition in water management through agencies called basin water agencies (BWAs), which have been operative since 1920. BWAs play an important role in water planning, resource management and land use, protection of the public water domain, management of water use rights, water quality control, planning and execution of new water infrastructure, dam safety programs, etc.

The WFD sets out clear deadlines for each of the requirements as can be consulted in [2]. Within such milestones, water administration agencies from each member state have to report each issue to the European Commission on time, with 2015 being a relevant date in the WFD implementation. Thus, the first management plan (River Basin Management Plan 2009–2015) has been finalised and the second management plan (River Basin Management Plan 2015–2021) and the First Flood Risk Management Plan have just started.

Since the first River Basin Management Plan has finalised quite recently, it is of particular interest analysing the sustainability of Spanish BWAs in water management and their contribution to fulfil the WFD objectives. In this sense [3], it is recommended to strengthen the links between water planners and academics in order to improve future revisions of the River Basin Management Plans. More concretely, it is proposed that the assessment and the selection of methods were done jointly in order to design and implement new water policies in Spain. In addition, the role of BWAs is highlighted as potential coordinators of such evidence-based policy-making.

Considering this framework, the objective of this paper is to analyse and compare the sustainability of water plans in the Spanish river basins according to the objectives of the WFD. In addition, dimensions that may be enhanced to improve the basins' sustainability are analysed, being this analysis a starting point to improve water management sustainability in the following management plans.

After this brief introduction, Section 2 reviews some of the previous works on assessing sustainability by using multicriteria decision-making methods. In the Section 3 the case study is presented. Sections 4 and 5 include the methods used to assess the sustainability of water plans and results. Finally, Section 6 concludes the paper.

2. Literature Review

Sustainability has been used as a criterion to analyse water resource management quite often in the literature. In order to assess such sustainability, multicriteria decision analysis (MCDA) has been commonly used since the 1970s. It is possible to find a considerable number of applications related to water management on different river basins. Thus, Hajkowicz and Collins [4] reviewed 113 studies that used MCDA for analysing water resource management. They found that these methods are of relevance since the annual publication rate has been steadily growing since the late 1980s. The majority of applications are related to the fields of water policy, supply planning and the evaluation of major infrastructure.

Regarding the evaluation of different water management strategies, it is worth highlighting [5], in which a three-step process is developed to evaluate different water management strategies in a river basin in Brazil. The analytical hierarchy process (AHP) was used to help identifying the groups of interest, articulate their preferences and find the dominant preferences of the community within the river basin, as well as to get a consistent evaluation of management strategies. In addition, Martín-Ortega et al. [6] performed a multicriteria analysis of water management under the WFD. They selected some measures for a sustainable and socially accepted water management in the Guadalquivir river basin in order to test the applicability of the AHP in the new WFD context. A survey was carried out in the context of a future enlargement of a reservoir. Results suggest that the AHP is an adequate tool for the WFD purposes and a useful complement for the cost-effectiveness analysis.

There are other works that analyse different water management strategies to address concrete problems in some areas. In this line, Jaber and Mohsen [7] proposed a support system for decision evaluation and selection of nonconventional water resources in the river Jordan. They include desalination of saline and seawater, treated waste water, importation of water across boundaries, and water harvesting. Using AHP, they found that water desalination was ranked the highest, being the most promising resource, followed by water harvesting. Freiras and Magrini [8] presented a selection of sustainable water management strategies for a mining complex located in the southeast region of Brazil, which concentrates most of the country's population and the mining facilities, but a small portion of the water available in the territory. A stepwise process for incorporating environmental risks into the decision-making using a multicriteria approach and AHP was developed and applied in this case study. Da Cruz and Marques [9] used the MACBETH multicriteria model to determine sustainability level of urban water cycle services (UWCS). They show that it is possible to assess both global sustainability and performance of UWCS in each particular dimension of the sustainability, taking into account the values and judgments of the legitimate stakeholders. Recently, Marques et al. [10] discussed the concept of sustainable water services and suggested using MACBETH multicriteria method to assess it. They illustrated a real-world application of the method in urban water services (UWSs) in Portugal and used a simple additive aggregation model to calculate the sustainability score of each UWS. Finally, the work of [11] implemented MCDA in an irrigated area in Spain. They found six factors to define alternative strategies (policies) that could change the planning scenario of the irrigation system: irrigation system, water pricing, water allocation, crop distribution, fertiliser use and subsidies received. Five different MCDA techniques were used and results indicated that all techniques choose the same alternative strategy as the preferred one: sprinkler irrigation system, with no change in the existing water pricing and water allocation schemes, growing wheat and barley as the main crops with organic fertilisers and without any change in the subsidy policy.

3. Case Study

The main Spanish BWAs exceed a single region, being called as inter-regional water agencies (IRWAs). We can distinguish ten different IRWAs in Spain, that is, Western and Eastern Cantabrian (Cantábrico oriental y occidental), Minho-Sil (Miño-Sil), Douro (Duero), Tagus (Tajo), Guadiana, Guadalquivir, Segura, Jucar, and Ebro. In addition, there are minor basins comprised in one single region, and called intra-regional water agencies, such as Galician Coast, Andalusian Mediterranean Basin, Tinto, Odiel and Piedras, Guadalete and Barbate, inland basins of Catalonia, Balearic Islands, and Canary Islands. The location of BWAs is showed in Figure 1.

Figure 1. Location of inter-regional and intra-regional basins in Spain. Source: Adapted from [12].

This paper is focused on the analysis of the sustainability of integral water management in IRWAs, which account for 87% of the Spanish area and 64% of population. Among the IRWAs we can see high differences in the area and population covered. Tagus is the river basin that supplies water to the highest percentage of population, mainly because it includes one of the biggest Spanish cities, Madrid, with a metropolitan area population of around 6.5 million. Regarding the size of the IRWA, Ebro extends for nine regions, being the largest basin in Spain. By contrast, Eastern Cantabrian is the lowest basin and covers the lowest ratio of population.

The main characteristics of the inter-regional water basins under study are summarized in Table 1.

Table 1. Main characteristics of the Spanish inter-regional water basins.

River Basin	Area (km^2)	Area over Spain (%) *	Population (No. of Inhabitants)	Population over Spain (%) **	Number of Regions Involved in Spain
Western Cantabrian	19,002	3.8	1,656,626	3.6	5
Eastern Cantabrian	6405	1.3	1,297,494	2.8	3
Minho-Sil	17,619	3.5	825,851	1.8	3
Douro	78,859	15.6	2,222,532	4.8	8
Ebro	85,569	16.9	3,226,921	6.9	9
Tagus	55,781	11.1	7,273,871	15.6	5
Jucar	42,851	8.5	5,178,000	11.1	4
Guadiana	55,527	11.0	1,443,707	3.1	3
Guadalquivir	57,527	11.4	4,480,321	9.6	4
Segura	20,234	4.0	1,884,220	4.3	4

Notes: * This percentage shows the area that each river basin represents in the total area of Spain; ** This percentage shows the population in each basin over the total population in Spain. Source: River Basin Management Plans 2015–2021 [13–22].

4. Methods

Within the framework of the MCDA, this paper assesses the sustainability of inter-regional water agencies (IRWAs). Sustainability is assessed by considering the traditional economic, environmental, and social dimensions (Triple Bottom Line [23]), but also governance. Each of the sustainability dimensions has been analysed using a number of indicators that will be presented below in detail. In a second step, the relative importance of indicators and dimensions/criteria is assessed through the analytical hierarchy process (AHP). Later, the IRWAs are classified in a ranking in terms of their sustainability according to the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (see Figure 2). In summary, MCDA allows us to aggregate the performance of each attribute in each dimension, and afterwards to get a sustainability measure on the basis of the aggregation of each dimension.

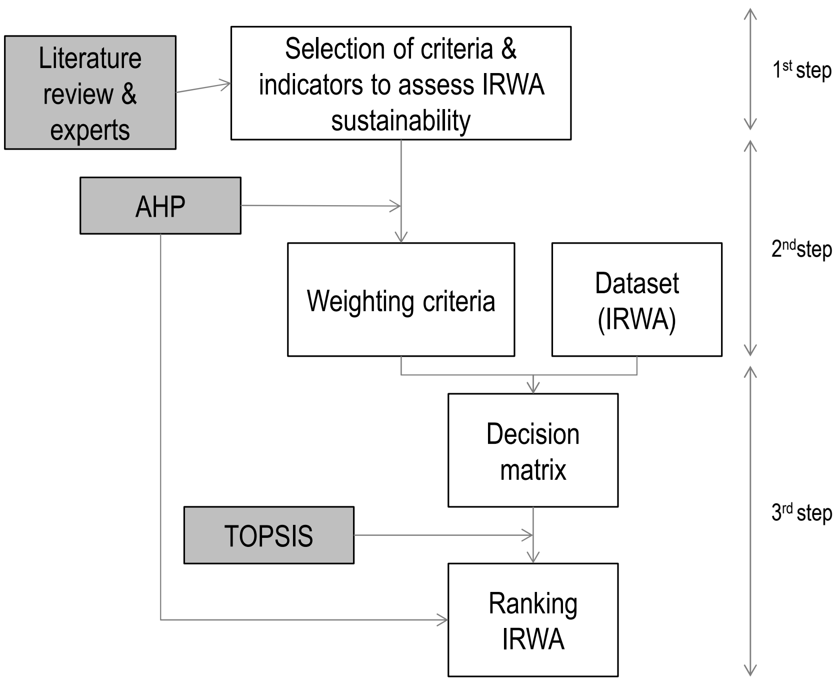

Figure 2. Outline of the methodological approach.

Table 2 shows the dimensions/criteria and indicators selected to assess IRWAs' sustainability.

Table 2. Dimensions and indicators to assess the sustainability of BWA.

Dimension/Criterion	Indicators
Economic	Ratio of cost recovery for water services.
	Water productivity, measured as the ratio between the gross values added of economic sectors (GVA) and the volume of water supplied to each sector.
	Budget limits, measured as the maximum expenditure in investments.
Environmental	Water stress, measured as the ratio of the volume of water consumed and existing water resources in the basin.
	Number of measures aimed at achieving environmental objectives.
	Efficiency: losses in distribution infrastructures.
	Volume of reused water in the total amount of water supplied.
Social	Additional population served over the resident population in the basin.
	Number of measures aimed at satisfying demands.
	Employment relative to the volume of water supplied in the basin.
Governance	Number of measures to improve governance.
	Number of administrations involved in the management, implementation and/or financing measures.
	Number of initiatives to encourage active participation of the public.

The selection of indicators in each dimension has been based on both a literature review [24–26] and the expertise of a panel of experts.

The *economic* dimension is measured through three indicators:

1. Ratio of cost recovery for water services. The concept of cost recovery appears in the WFD (Article 9) in the sense that member states shall take into account such principles, including environmental and resource costs, having regard for the economic analysis, and in accordance to the polluter-pays principle. Member states shall report in the river basin management plans the steps towards implementing the recovery of the costs of water services. Taking into account the WFD, the ratio of cost recovery is calculated as the ratio between revenues and costs for water services, including financial, environmental, and resource costs. An estimation of the cost recovery ratio of financial costs related to water services can be found in [27]. Environmental costs are related to the externalities that occur mainly in water extraction and discharge processes when affecting other users or ecosystems. Resource costs refer to the value of water scarcity. More information about environmental and resource cost in the context of the European WFD can be found in [28]. The higher the ratio of cost recovery, the higher the economic sustainability of the IRWA.
2. Water productivity, measured as the ratio between the gross value added (GVA) of economic sectors and the volume of water supplied to each sector. More information about the estimation of water productivity values can be found in [29]. The higher the water productivity the higher the economic sustainability of the BWA.
3. Budget limits, measured as the maximum expenditure in water investments. Due to the economic crisis in Spain, the IRWAs have limited their budget for investments. This may have an impact on the measures needed to achieve the objectives of the WFD. The lower the budget limits, the higher the economic sustainability of the IRWA.

The *environmental* dimension is assessed on the basis of four indicators:

1. Water stress, measured as the ratio of the volume of water consumed and existing water resources in the basin. Water stress is an increasingly important phenomenon that causes deterioration of

fresh water resources in terms of quantity (overexploited aquifers, dry rivers, and polluted lakes) and quality (eutrophication, organic matter pollution, and saline intrusion). It happens when water demand is greater than the available amount during a certain time or when it is restricted by its low quality for a time period. The lower the water stress, the higher the environmental sustainability of the IRWA.

2. Number of measures aimed at achieving environmental objectives. The main environmental objective established in the WFD is to achieve good status of water bodies. To do this, the IRWAs establish measures to prevent or mitigate the punctual and diffuse pollution and to involve hydrological and environmental restoration of the basin. The higher the number of measures aimed at achieving environmental objectives, the higher the environmental sustainability of the IRWA.
3. Efficiency measured as losses in distribution infrastructures. Once captured, the water must be transported to the point of purification, to then be stored in tanks from which the distribution infrastructures are supplied to the points of domestic, agricultural, or industrial supply, in which once used it is evacuated. The main technical problem of water distribution infrastructures is the volume of losses due to deterioration. The lower the losses in distribution infrastructures, the higher the environmental sustainability of the IRWA.
4. Recycled water volume in the total amount of water supplied. Reusing wastewater is an increasing practice in arid or semiarid countries, where water resources are scarce. The uses that can be given to recycled wastewater are many and varied: watering (crops, gardens, greenbelts, golf camps, etc.), industrial reuse (cooling, boiler feed), non-potable urban uses (greenery, fire extinction, sanitary, air conditioning, washing cars, cleaning streets, etc.), and others (aquaculture, livestock cleaning, snowmelt, construction, dust removal, etc.). The higher the recycled water volume, the higher the environmental sustainability of the IRWA.

The *social* dimension is measured using three indicators:

1. Additional population served over the resident population in the basin. In addition to the local population in the basin, the population may increase during certain seasonal periods for different reasons: work, holidays, etc. This indicator measures the capacity of the basin to satisfy this additional water demand. The higher the additional population served, the higher the social sustainability of the IRWA.
2. Number of measures aimed at satisfying demands. Economic sectors require water (and other resources) to develop their economic activities. The IRWA provides a series of measures to be able to respond to this demand. The objectives of these measures are to increase the availability of resources through regulation and management infrastructures, encourage recycling, and increase water use efficiency. The higher the number of measures aimed at satisfying demands, the higher the social sustainability of the IRWA.
3. Employment relative to the volume of water supplied in the basin. This indicator refers to employment on activities that require water resources for their economic development. The higher the employment ratio, the higher the social sustainability of the IRWA.

Finally, the *governance* dimension is assessed using three indicators:

1. Number of measures to improve governance. Governance allows addressing the problems of resource and territory management through an integrated and systematic way. Clark and Semmahasak [30] examine the introduction of adaptive governance to water management in Thailand. The analysis shows the significant role that the new approach may play in resolving underlying differences between stakeholders. The higher the number of measures to improve governance, the higher the governance sustainability of the IRWA.
2. Number of administrations involved in management, implementation and/or financing of measures. Besides the IRWAs, other administrations and institutions are also involved in the

development, implementation, and financing of programs of measures. The higher the number of administrations, the higher the governance sustainability of the IRWA.

3. Number of initiatives to encourage active participation of the public. These initiatives encourage the transparency and participation of stakeholders in both the decision-making and the planning processes. Hedelin [31] analyses two criteria based on the concepts of participation and integration. She notes that these concepts work as well-established dimensions of both sustainable development and management. The higher the number of initiatives, the higher the governance sustainability of the IRWA.

The values of these indicators for each IRWA have been assessed using the information included in the IRWA management plans [13–22], and can be found in the Supplementary Materials (Table S1).

Considering the indicators mentioned above, two multicriteria decision-making methods were used to assess the sustainability of IRWAs. More concretely, AHP was used to get the importance of each dimension and each indicator in the sustainability of the IRWA, and afterwards TOPSIS allowed us to rank the IRWAs according to their sustainability.

The AHP method was created by [32] as a structured but flexible technique for making decisions in a multicriteria context. This method is based on dealing with complex decision problems using a hierarchical structure. Figure 3 shows the three-level structure considered for our case study.

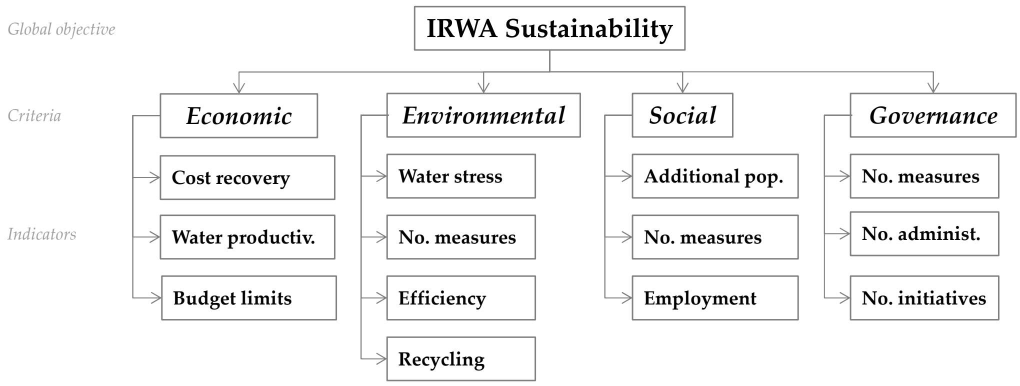

Figure 3. AHP structure.

In this hierarchical structure, the relative importance or weights (w_k) of each criterion or subcriterion hanging on each node are obtained from pairwise comparisons between them. In order to perform these pairwise comparisons, a 1–9 scale is used, as proposed by [33]. Table 3 shows the relative scores and their interpretation.

Table 3. Table of relative scores.

Value of a_{jk}	Scale Meaning
1	j and k are equally important
3	j is slightly more important than k
5	j is more important than k
7	j is strongly more important than k
9	j is absolutely more important than k
2, 4, 6, 8	Middle values of the above
reciprocal	$a_{jk} = 1/a_{kj}$

Scores of these comparisons are used to build the Saaty matrices ($A = a_{jk}$), which are employed to determine the vector of priorities or weights (w_1, ...w_k, ...w_n). Although different procedures to estimate these weights have been proposed, for this case we selected the simplest one: the geometric mean method [34].

The AHP decision technique was originally designed for individual decision-makers, but was promptly extended for group decisions [34], such as our case study. Thus, in order to determine the weights attached to each criterion we have to consider the judgments of a group of people (p), each with his/her own pairwise comparison matrix ($A_p = a_{jkp}$) and its related weights (w_{kp}). This individual information is suitably treated in order to obtain a synthesis of aggregated weights (w_k).

For this purpose, Saaty et al. [35,36] suggest that group decision-making should be done by aggregating individual priorities using the geometric mean:

$$w_k = \sqrt[m]{\prod_{p=1}^{p=m} w_{kp}} \quad (1)$$

For indicators weights, a panel of 25 experts in water management sustainability was consulted. The members of this panel have been selected on the basis of their experience in water management, their scientific and technical contribution to the analysis of water sustainability and their involvement in the development and implementation of river basin plans. In addition, experts have been also selected in order to cover different technical profiles, such as university lecturers, researchers in agricultural research centres, civil servants in charge of water policy implementation, environmental journalists, hydrogeologists, agronomists, economists, environmental organisations, and farmers.

Before aggregating priority scores, the consistency of respondents' pairwise choices was tested by means of the consistency ratio (CR) based on the eigenvalue method [37]. In this paper we consider only CR lower than 0.1 [38]. Taking into account this CR, the percentage of consistent experts was 72%.

Once the weights of each dimension had been calculated, by considering the experts' evaluations, another MCDA technique was applied in order to rank IRWAs according to their sustainability. To do that, TOPSIS was used. The principle behind the method is that the optimal alternative should have the shortest distance from the positive ideal solution and the furthest distance from the negative ideal solution. The positive and negative ideal solutions are artificial alternatives which are hypothesised by the decision-maker, based on the ideal solution for all criteria and the worst solution which possesses the most inferior decision variables. Assuming that every indicator has an increasing or decreasing scale, TOPSIS calculates the results by comparing Euclidean distances between the actual and the hypothesised alternatives.

Generally, the TOPSIS approach consists of seven steps, as it is summarized below [39,40].

Step 1. Constructing the decision matrix D on the basis of the value of each indicator (F_i) by IRWA (A_i), where f_{ij} is the performance of the IRWA A_i with respect to the indicator F_j.

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} F_1 & F_2 & \cdots & F_j & \cdots & F_n \end{array} \\ \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1j} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2j} & \cdots & f_{2n} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ f_{i1} & f_{i2} & \cdots & f_{ij} & \cdots & f_{in} \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mj} & \cdots & f_{mn} \end{bmatrix} \end{array} \quad (2)$$

Step 2. Normalizing the initial decision matrix to eliminate the effects of complex relations. The normalized value v_{ij} is calculated as:

$$v_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} \quad (3)$$

Step 3. Calculating the weighted normalized decision matrix R by using the weights w_j obtained through the APH for each indicator. The weighted normalized value f_{ij} is calculated as:

$$r_{ij} = v_{ij} \cdot w_j \quad (4)$$

Step 4. Determining the positive and negative ideal reference points:

$$T^+ = \{r_1^+, r_2^+, \ldots, r_n^+\} = \{(\max_i r_{ij} \,|\, j \in J'), (\min_i r_{ij} \,|\, j \in J'')\} \quad (5)$$

$$T^- = \{r_1^-, r_2^-, \ldots, r_n^-\} = \{(\min_i r_{ij} \,|\, j \in J'), (\max_i r_{ij} \,|\, j \in J'')\} \quad (6)$$

where J' and J'' are linked to the indicators with positive polarity (more is better) and the indicators with negative polarity (less is better), respectively.

Step 5. Calculating the distances to the positive and negative ideal reference points using the Euclidean distance. The separation of each IRWA from the positive-ideal solution (S_i^+) and the separation of each IRWA from the negative-ideal solution (S_i^-) is given by the expressions:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (r_{ij} - r_j^+)^2} \quad (7)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (r_{ij} - r_j^-)^2} \quad (8)$$

Step 6. Calculating the relative closeness to the ideal solution for each IRWA (C_i):

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}, \; i = 1, \ldots, m \quad (9)$$

where C_i is an index with values ranging between 0 and 1, where 0 corresponds to the worst possible performance of the IRWA and 1 to the best.

Step 7. ranking the IRWA, according to the C_i values.

5. Results

Table 4 shows the results of the application of the AHP method. First, we can see the weights for the sustainability dimensions according to the preferences of the group of experts. The environmental dimension is playing the most important role in the whole sustainability (40%), followed by both the economic and social criteria (25%). The governance dimension is the least important for sustainability (11%) according to the panel of experts.

Table 4. Normalised weights for dimensions/criteria and indicators.

Dimensions		Indicators	
Economic	0.246	Ratio of cost recovery	0.471
		Water productivity	0.313
		Budget limits	0.216
Environmental	0.402	Water stress	0.380
		Number of measures of environmental objectives	0.358
		Efficiency: losses in distribution infrastructures	0.133
		Reused water	0.128
Social	0.246	Additional population served	0.236
		Number of measures aimed at satisfying demands	0.394
		Employment	0.370
Governance	0.106	Number of measures to improve governance	0.434
		Number of administrations	0.247
		Number of initiatives	0.319

Considering these weights, the overall sustainability level of each IRWA can be assessed through TOPSIS. Table 5 shows the ranking of the Spanish IRWAs according to their sustainability in the water plans. The river basin with the highest sustainability is Western Cantabrian, followed by Eastern Cantabrian and Tagus. By contrast, Minho-Sil, Jucar, and Douro are the least sustainable basins. Regarding the Segura Basin, our results coincides with [41], classifying this basin as intermediate sustainable. Senent-Aparicio et al. [41] applied a watershed sustainability index (WSI), assuming that the sustainability of the basin depends on its hydrology environment, life, and policies in water resources. The greatest strengths of the basin were related to political indicators, while the biggest weaknesses were the hydrological indicators on quantity mainly due to the situation of water scarcity. Although not all the dimensions are comparable between studies, water scarcity or water stress appears to be one of the main weaknesses of Segura sustainability in both analyses.

Table 5. Global sustainability of inter-regional water agencies (IRWAs).

IRWA	Sustainability (C_i)	Ranking
Western Cantabrian	0.602	1
Eastern Cantabrian	0.530	2
Tagus	0.513	3
Ebro	0.482	4
Guadalquivir	0.410	5
Segura	0.397	6
Guadiana	0.383	7
Minho-Sil	0.376	8
Jucar	0.353	9
Douro	0.277	10

When analysing separately the dimensions of the sustainability (i.e., economic, environmental, social, and governance dimensions) for each IRWA, we obtained the results in Tables 6–9.

Table 6. Economic sustainability of IWBA.

IRWA	Economic Sustainability	Ranking
Eastern Cantabrian	0.677	1
Western Cantabrian	0.460	2
Tagus	0.441	3
Jucar	0.376	4
Ebro	0.360	5
Guadiana	0.319	6
Guadalquivir	0.311	7
Minho-Sil	0.311	8
Douro	0.308	9
Segura	0.148	10

Table 7. Environmental sustainability of IWBA.

IRWA	Environmental Sustainability	Ranking
Minho-Sil	0.610	1
Tagus	0.604	2
Western Cantabrian	0.593	3
Douro	0.585	4
Guadalquivir	0.575	5
Eastern Cantabrian	0.562	6
Guadiana	0.525	7
Ebro	0.431	8
Segura	0.385	9
Jucar	0.271	10

Table 8. Social sustainability of IRWA.

IRWA	Social Sustainability	Ranking
Eastern Cantabrian	0.713	1
Western Cantabrian	0.521	2
Tagus	0.452	3
Segura	0.439	4
Minho-Sil	0.343	5
Ebro	0.265	6
Guadalquivir	0.234	7
Douro	0.197	8
Jucar	0.138	9
Guadiana	0.016	10

Table 9. Governance sustainability of IRWA.

IRWA	Sustainability in Governance	Ranking
Ebro	0.561	1
Segura	0.511	2
Minho-Sil	0.399	3
Tagus	0.335	4
Jucar	0.315	5
Guadiana	0.237	6
Eastern Cantabrian	0.224	7
Douro	0.137	8
Guadalquivir	0.116	9
Western Cantabrian	0.068	10

The basin with the greatest economic sustainability is the Eastern Cantabrian river basin, followed by the Western Cantabrian basins. In this case, Douro and Minho-Sil are still in the last places of the ranking, and Segura shows the least economic sustainability.

Regarding the environmental sustainability, the dimension with the largest importance in river basin sustainability (Table 7), we can see that Minho-Sil is the basin with the greatest environmental sustainability, followed by Tagus.

Table 8 shows the classification of basins derived from the social dimension of sustainability. In this case, Eastern Cantabrian is in the first position, followed by Western Cantabrian and Tagus. The lasts are Jucar and Guadiana, showing the last one a significant distance with the others.

Finally, analysing the dimension of governance, which has the lower weight in sustainability, we can see that Ebro is the most sustainable basin, followed by Segura and Minho-Sil. By contrast, Guadalquivir and Western Cantabrian show the lowest sustainability in governance.

Different sustainability scores can be explained mainly by lower water stress (environmental dimension) and higher water productivity (economic dimension) of northern water basins. Due to the location of these basins, rainfall is more constant and consequently water stress is lower than in other basins of the country. In addition, we can see that water productivity is also higher in northern basins due to the weight of industrial activities. By contrast, IRWAs such as Jucar or Douro show the lowest sustainability due to the lower scores on economic, social, and governance dimensions for Douro, and environmental and social dimensions for Jucar. In Douro, low water productivity and water efficiency on distribution results in lower global sustainability. For Jucar, water stress due to the location of the basin and a low number of environmental and social measures make the basin the least sustainable.

Global and partial sustainability results have been showed to the panel of experts for their feedback. The experts agreed that the methodology is appropriate to measure the sustainability of IRWAs, and that the identification of the weaknesses of each IRWA may contribute to improve its sustainability in the future.

6. Concluding Remarks

This paper contributes to analysis of the dimensions that may be enhanced to improve basins' sustainability in order to fulfil the objectives and requirements set by the WFD on basin management, and consequently may be a starting point to improve water management sustainability in the following planning cycles.

The river basins of Minho-Sil, Jucar, and Douro are the least sustainable in the integral water plans. Such results on sustainability can be improved following different strategies depending on the river basin analysed. Douro, the river with the lowest sustainability, may improve in most of the dimensions (i.e., economic, social, and governance), whereas it is well positioned on the environmental criterion. In the case of the Jucar basin, it may focus on environmental and social aspects in order to improve its sustainability. Since environment is the dimension with the highest importance in global sustainability, Jucar may decrease the water stress or raise the number of measures aimed at achieving environmental objectives, since these two indicators show the highest contribution to environmental sustainability. Finally, Minho-Sil may raise mainly its economic and social dimensions. It has a good position on environmental and governance aspects, but it needs to improve mainly on the economic dimension.

Not only basins positioned in the last places may improve their sustainability, but the rest as well, since the maximum score is 0.677. The Western Cantabrian river basin is in the first position on sustainability of river basins but with the lowest score in governance. It may make progress in at least this dimension in order to improve. The same strategy should be followed by Eastern Cantabrian. Tagus is the most stable river basin in all the dimensions of the sustainability, but there is still room for improvement, especially on governance of stakeholders in decision-making.

Future research on this topic might analyse what would happen with sustainability in each water use provided in the Article 9.1 of WFD: agricultural, domestic, and industrial. In this case it would be very interesting to analyse how results may change when industrial and agricultural uses are differentiated to measure water productivity. Potential follow-up studies might also evaluate the sustainability of the different water services as provided in Article 2.38 of WFD, such as abstraction, storage and distribution of water, and collection and treatment of used water. River basin planning may include more information on these issues in order to allow us to refine the analysis of the sustainability.

Supplementary Materials: The following are available online at www.mdpi.com/2073-4441/8/8/342/s1, Table S1: Indicators value per inter-regional water agency.

Acknowledgments: This research acknowledges the financial support from the Spanish Ministry of Economics and Competitiveness (MINECO) and the European Regional Development Fund (ERDF) through the research project MERCAGUA (AGL2013-48080-C2-1-R). These funding institutions had no involvement in the conduction of the research or the preparation of the article.

Author Contributions: The authors contributed equally to this work.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. European Union. *Directive 2000/60/EC*; European Union: Brussels, Belgium, 2000.
2. European Union. WFD: Timetable for Implemenation. Available online: http://ec.europa.eu/environment/water/water-framework/info/timetable_en.htm (accessed on 15 December 2015).
3. Gómez-Limón, J.A.; Martin-Ortega, J. The economic analysis in the implementation of the Water Framework Directive in Spain. *Int. J. River Basin Manag.* **2013**, *11*, 301–310. [CrossRef]
4. Hajkowicz, S.; Collins, K. A review of multiple criteria analysis for water resource planning and management. *Water Resour. Manag.* **2007**, *21*, 1553–1566. [CrossRef]
5. Srdjevic, B.; Medeiros, Y.; Srdjevic, Z.; Schaer, M. Evaluating management strategies. In *Paraguacu River Integrated Assessment and Decision Support*, Proceedings of the 1st Biennial Meeting of the iEMSS, Lugano, Switzerland, 24–27 June 2002.

6. Martín-Ortega, J.; Giannocaro, G.; Berbel, J. Environmental and resource cost under water scarcity conditions: An estimation in the context of the European Water Framework Directive. *Water Resour. Manag.* **2007**, *25*, 1615–1633. [CrossRef]
7. Jaber, J.O.; Mohsen, M. Evaluation of non-conventional water resources supply in Jordan. *Desalination* **2002**, *136*, 83–92. [CrossRef]
8. Freiras, A.H.A.; Magrini, A. Multi-criteria decision-making to support sustainable water management in a mining complex in Brazil. *J. Clean. Prod.* **2013**, *47*, 118–128. [CrossRef]
9. Da Cruz, N.F.; Marques, R. A multi-criteria model to determine the sustainability level of water services. *Water Asset Manag. Int.* **2016**, *9*, 16–20.
10. Marques, R.C.; da Cruz, N.F.; Pires, J. Measuring the sustainability of urban water services. *Environ. Sci. Policy* **2015**, *54*, 142–151. [CrossRef]
11. Srinivasa-Raju, K.; Duckstein, L.; Arondel, C. Multicriterion analysis of sustainable water resources planning: A case study in Spain. *Water Resour. Manag.* **2000**, *14*, 435–456. [CrossRef]
12. Demarcaciones Hidrográficas de España. Available online: http://3.bp.blogspot.com/-aKDna0mbvMg/UDsl9S6_iMI/AAAAAAAAASs/h1-tNoN-0sE/s640/espa%C3%B1a+demarcaciones+hidrog.jpg (accessed on 9 August 2016).
13. Western Cantabrian Basin Management Plan, 2015–2021. Available online: http://www.chcantabrico.es/index.php/es/actuaciones/planificacionhidrologica/nuevo-periodo-de-planificacion/plan-hidrologico-de-la-demarcacion-hidrografica-del-cantabrico-occidental-2 (accessed on 15 December 2015).
14. Eastern Cantabrian Basin Management Plan, 2015–2021. Available online: http://www.chcantabrico.es/index.php/es/actuaciones/planificacionhidrologica/nuevo-periodo-de-planificacion/parte-espanola-de-la-demarcacion-hidrografica-del-cantabrico-oriental-2 (accessed on 15 December 2015).
15. Minho-Sil Basin Management Plan, 2015–2021. Available online: http://www.chminosil.es/es/chms/planificacionhidrologica/plan-hidrologico-2015-2021 (accessed on 15 December 2015).
16. Douro Basin Management Plan, 2015–2021. Available online: http://www.chduero.es/Inicio/Planificación/Planhidrológico20152021/PropuestaPlanHidrológico20152021/tabid/652/Default.aspx (accessed on 15 December 2015).
17. Ebro Basin Management Plan, 2015–2021. Available online: http://www.chebro.es/contenido.visualizar.do?idContenido=34057&idMenu=4281 (accessed on 15 December 2015).
18. Tagus Basin Management Plan, 2015–2021. Available online: http://www.chtajo.es/Informacion%20Ciudadano/PlanificacionHidrologica/Planif_2015-2021/Paginas/default.aspx (accessed on 15 December 2015).
19. Jucar Basin Management Plan, 2015–2021. Available online: http://www.chj.es/es-es/ciudadano/participacion_publica/Paginas/PHC-2015-2021-Plan-Hidrologico-cuenca.aspx (accessed on 15 December 2015).
20. Guadiana Basin Management Plan, 2015–2021. Available online: http://www.chguadiana.es/?chguadiana=7eso11kibgupae6orr93ft5eq0&url=planificaci%F3n+proceso+de+elaboraci%F3n+de+nuevos+planes+plan+hidrol%F3gico+2015+-+2021&corp=chguadiana&lang=es&mode=view (accessed on 15 December 2015).
21. Guadalquivir Basin Management Plan, 2015–2021. Available online: http://www.chguadalquivir.es/opencms/portalchg/planHidrologicoDemarcacion/demarcacionGuadalquivir/segundoCicloPlanificacion/ (accessed on 15 December 2015).
22. Segura Basin Management Plan, 2015–2021. Available online: https://www.chsegura.es/chs/planificacionydma/planificacion15-21/ (accessed on 15 December 2015).
23. AWWA Research Foundation and CSIRO Land and Water. *Tripple Bottom Line Reporting of Sustainable Water Utility Performance*; AWWA Research Foundation and CSIRO Land and Water: Canberra, Australia, 2007.
24. United Nations Commission for Sustainable Development. *Indicator of Sustainable Development. Guidelines and Methodologies*; United Nations Commission for Sustainable Development: New York, NY, USA, 2001.
25. Kluge, T. Integrated water resources management (IWRM) as a key for sustainable development. In *The Economics of Global Environmental Change: International Cooperation for Sustainability (New Horizons in Environmental Economics)*; Cogoy, M., Steininger, K.W., Eds.; Edward Elgar: Cheltenham, UK; Northampton, MA, USA, 2007; pp. 134–154.
26. American Society of Civil Engineers. *Sustainability Criteria for Water Resource Systems*; ASCE Task Committee on Sustainability Criteria and the Working Group of UNESCO/IHP IV Project M-4.3; American Society of Civil Engineers: Reston, VA, USA, 1998.

27. Borrego-Marín, M.M.; Gutiérrez-Martín, C.; Berbel, J. Estimation of cost recovery ratio for water services based on the System of Environmental-Economic Accounting for water. *Water Resour. Manag.* **2016**, *30*, 767–783. [CrossRef]
28. Borrego-Marín, M.M.; Gutiérrez-Martín, C.; Berbel, J. Water productivity under drought conditions estimated using SEEA-Water. *Water* **2016**, *8*, 138. [CrossRef]
29. Martín-Ortega, J.; Berbel, J.; Mesa, P. Multicriteria analysis of water management under the Water Framework Directive. *Agric. Econ. Nat. Resour.* **2008**, *8*, 105–126.
30. Clark, J.R.A.; Semmahasak, C. Evaluating Adaptive Governance Approaches to Sustainable Water Management in North-West Thailand. *Environ. Manag.* **2013**, *51*, 882–896. [CrossRef] [PubMed]
31. Hedelin, B. Criteria for the Assessment of Sustainable Water Management. *Environ. Manag.* **2007**, *39*, 151–163. [CrossRef] [PubMed]
32. Saaty, T.L. *The Analytic Hierachy Process*; McGraw-Hill: New York, NY, USA, 1980.
33. Aguarón, J.; Moreno-Jiménez, J.M. Stability intervals in the analytic hierarchy process. *Eur. J. Oper. Res.* **2000**, *125*, 114–133. [CrossRef]
34. Easley, R.W.; Madden, C.S.; Dunn, M.G. Conducting marketing science: The role of replication in the research process. *J. Bus. Res.* **2000**, *48*, 83–92. [CrossRef]
35. Forman, E.; Peniwati, K. Aggregating individual judgments and priorities with the Analytic Hierarchy Process. *Eur. J. Oper. Res.* **1998**, *108*, 165–169. [CrossRef]
36. Whitmarsh, D.; Palmieri, M.G. Social acceptability of marine aquaculture: The use of survey based methods for eliciting public and stakeholder preferences. *Mar. Policy* **2009**, *33*, 452–457. [CrossRef]
37. Saaty, T.L.; Vargas, L.G. *Models, Methods, Concepts and Applications of the Analytic Hierarchy Process*; Kluwer: Boston, MA, USA, 2000.
38. Bozoki, S.; Rapcsak, T. On Saaty's and Koczkodaj's inconsistencies of pairwise comparison matrices. *J. Glob. Optim.* **2008**, *42*, 157–175. [CrossRef]
39. Gallego-Ayala, J. Selecting irrigation water pricing alternative using a multi-methodological approach. *Math. Comput. Mod.* **2012**, *55*, 861–883. [CrossRef]
40. Behzadian, M.; Otaghsara, S.K.; Yazdani, M.; Ignatius, J. A state-of-the-art survey of TOPSIS applications. *Expert Syst. Appl.* **2012**, *39*, 13051–13069. [CrossRef]
41. Senent-Aparicio, J.; Pérez-Sánchez, J.; Bielsa-Artero, A.M. Assessment of Sustainability in Semiarid Mediterranean Basins: Case Study of the Segura Basin, Spain. *Water Technol. Sci.* **2016**, *7*, 67–84.