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A Case Study of Group Decision Method for Environmental Foresight and Water Resources Planning Using a Fuzzy Approach

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Abstract Group decision-making (i.e., multi-expert) is an important subject in planning water resources. The inherent complexity and uncertainty of real world urge many experts to be involved in decision-making processes. This paper presents an application of the linguistic-label aggregation method in a real-life case study. The case was taken from a foresight exercise in Colombia (South America) concerning environmental and water resources planning in a river basin. The group decision-making problem is solved using a four-step approach based on (i) the evaluation of experts' opinions, (ii) the aggregation of opinions for each alternative, (iii) fuzzy ranking, and (iv) final assessment. Two main issues that are new in our work is that we consider temporal linguistic labels and a fuzzy ranking procedure that is able to include the mean, the standard deviation, the fuzzy membership function and the frequency of experts' opinions for each alternative. The approach is developed and implemented on a computational tool. Results show an efficient decision-making process, that is, the tool demonstrated to deal with shortest time frames and to increase the efficiency of the planning resources, mainly because allows the decision manager to focus on the

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establishment of criteria. The latter also leads to objectivity and eases the identification and discussion of elements of consensus in decisions that otherwise may be embedded in individuals' interests.

Keywords Environment foresight · Group decision-making · Multi-criteria · Fuzzy opinion · Case study

1 Introduction

As Weinhardt and Seifert (2010) state, negotiations are present in our daily life for better or worse. They can carry out difficulties and conflicts; however, they represent a unique opportunity to express individual and collective desires. Also, these authors point out that negotiators can have similar or opposite preferences and interests and the substantial solution becomes challenging when there is a need to promote the consensus. In real world, the inherent complexity of management, manufacturing, and information systems urge the participation of many experts in decision-making processes. The uncertain constraints and vague knowledge of experts may imply that decision makers provide fuzzy opinions. Ben-Arieh and Chen (2006) propose the use of fuzzy linguistic labels to ascertain expert's judgments. In the literature, similar references can be found (Zadeh 1983; Yager 1984, 2004; Kacprzyk 1986; Degani and Bortolan 1988; Delgado et al. 1992; Liu et al. 1994; Carlsson and Fuller 2000a,b; Herrera and Martínez 2001; Wang and Chu 2004; Xu 2006).

Some researchers give great attention to group decision-making under linguistic preference relations. For instance, the works of Herrera et al. (1995, 1996a,b, 1997, 1998) are devoted to the development of selection processes with group decision-making. In their model, preferences of the individuals are modeled with linguistic-labels. Herrera and Herrera-Viedma (2000a,b) utilized choice functions and mechanisms to analyze the problem of finding a solution in a set of alternatives when a linguistic preference relation represents a collective preference. The decision process is based on the concepts of fuzzy majority, fuzzy linguistic quantifiers, Linguistic Ordered Weighted Averaging (LOWA) operators, non-dominance, and dominance, by introducing consensus models for group decision-making guided by consistency and consensus measures. The measures allow analyzing, controlling and monitoring the consensus reaching process, describing the current consensus and current consistency stage and using homogeneous and non-homogeneous groups. Delgado et al. (1998) introduced a fusion operator for numerical and linguistic information that combines linguistic values with numerical ones. Xu (2004a, 2005) gives some operational laws of linguistic variables, and develops a method based on linguistic geometric averaging operator and linguistic hybrid geometric averaging operator, for group decision making with linguistic preference relations. Xu (2004b, 2006) defines the concepts of additional and multiplicative linguistic preference relations, and develops an approach to aggregating linguistic information based on additional and multiplicative linguistic preference relations with complete and incomplete information. The key of this procedure is to provide a way to estimate the missing judgment of experts. Herrera et al. (2005) developed an aggregation process for dealing with non-homogeneous information.

This aggregation process is based on the unification of numerical, interval and linguistic values. These authors use different approaches to solve the decision-making approach through fuzzy sets theory.

All of the above attempts focus on the linguistic preference relations, in which all the elements (judgments) must be given. However, the complexity and uncertainty of real world decision problem may lead to situations where a decision maker is unable to provide all the judgments due to time pressure, or because he/she lacks knowledge or expertise with respect to the problem domain, the decision maker may develop an incomplete linguistic preference relation in which some of the elements are missing. On the other hand, one of the problems of group decision making in fuzzy domains is to aggregate experts' opinions, expressed using linguistic labels, into a group opinion. This aggregation allows the group to select the most "preferred" alternative from a finite set of candidates (Ben-Arieh and Chen 2006). The aggregation of individual judgments into a group opinion requires a measured level of consensus. Ben-Arieh and Chen (2006) proposed a procedure for handling an autocratic group decision-making process under linguistic assessments by introducing a linguistic-label aggregation operation based on Fuzzy Linguistic Ordered Weighted Averaging (FLOWA) operators. These authors developed the mathematical background for the analysis of their procedure and also presented a simple numerical example but no real-life application has been yet presented.

The objective of this paper is to present a real-life case study of the application of linguistic-label aggregation based on fuzzy opinion modeling. The case is taken from a real-life application in Colombia (South America) concerning environmental foresight and water resources planning for a river basin. Despite its importance in long-term economic and ecological sustainability, little has been presented in the literature about the application of formal (i.e. mathematical-based) decision-making models for efficient environmental management and water resources planning in developing countries. Some works in other contexts are due to Boclin and de Mello (2005), Hepting (2007), Liu and Lai (2009) and Peche and Rodríguez (2009).

As previously mentioned, the aim of this paper is to show that fuzzy opinion model can be effectively used for environmental planning in the case of water resources in Colombia. The group decision-making problem is solved adapting the approach presented by Ben-Arieh and Chen (2006), which, to the best of our knowledge, is the unique approach up to date in literature that considers fuzziness in group decision-making process. Hence, we decided to exploit this feature of the approach in our study. First, the opinion from each expert is unified. The second step consists on aggregating the uttered opinions to a final measure of consensus in regards to each alternative. This measure is based on the fuzzy linguist-label concept. One of our contributions is that we modified the original fuzzy ranking procedure to be able to include both the fuzzy membership function and the frequency of experts' opinions. The third step of the approach consists of ranking and selecting the preferred alternatives based on this order. Finally, using this ranking, the decision maker assesses the decision. Another significant difference between our work and that of Ben-Arieh and Chen (2006) is that we are considering temporal labels.

This paper is organized as follows. Section 2 presents some preliminary concepts, as well as the case under study in this paper. Section 3 is devoted to present the involved processes and the structure of the modeling approach. Section 4 presents an overview of the results of the computational implementation. The paper ends in Sect. 5 by presenting some concluding remarks.

2 Preliminaries and Description of the Case Study

Zhang and Lu (2003) presented a modeling framework for group decision-making. The concepts presented in this section are based on the work of these authors. We first recall the basics of this framework and then present the case under study for this research.

2.1 Concepts and Modeling Framework

According to Alavi and Keen (1989), a "decision group is the term of a small, self-regulating, self-contained task-oriented work group that typically focuses on organizationally assigned decision-making tasks". Individuals perform decision-making together only partially; therefore, the overlapping of goals in management should be coordinated to ensure individuals sharing the same goals. Additionally, a group decision results from interpersonal communication among the members. For example, in business, group decision-making has to confront various conditions. As presented by Karacapilidis and Gordon (1995) many negotiators are required to perform group decision-making procedures. As we mentioned, conflicts of interest are inevitable, however, achieving consensus and compromise is required.

The group decision-making framework proposed by Zhang and Lu (2003), which is implemented in our research (see Fig. 1), incorporates the following properties:

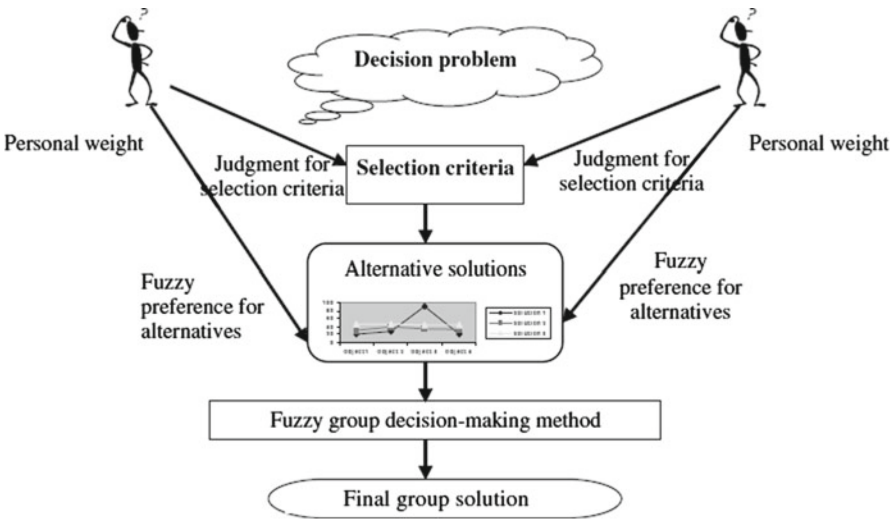

Fig. 1 Integrated group decision-making process. Taken from Zhang and Lu (2003)

> Decision makers may have different weights, decision-makers can express fuzzy preferences for alternative solutions, and decision-makers can give different judgments on solution selection criteria (Zhang and Lu 2003, p. 503)

In their framework a set of optimal alternative solutions is generated (i.e. for a multi-objective decision problem). A suitable model generates the set of solutions with the help of multiple decision makers. A group of selected criteria is to be used when assessing and ranking the alternatives. To each decision maker is assigned a weighting factor. A final group decision can be reached after aggregating decision makers' preferences on alternative solutions under conditions (i.e. weights and criteria).

2.2 Case Study Presentation and Motivation of the Study

We present in this paper a case dealt by "Quinaxi" (Colombian environmental consultants) in 2004 in the "Caldas" region along the "La Miel" river basin (see Fig. 2). Agricultural, cattle breeding and industrial activities, among others, are to be found that make the surrounding population to be almost self-sufficient. Upstream "The Florencia", as a protected forest, is rich in biodiversity and due to the high level of precipitations (exceeding 7,000 mm per annum), it also serves as a reservoir that is a source of water for the nearby population. The target pursued by government bodies was to elicit the dialogue and democratic practices in order to ensure the conservation of water resources. The method used to attempt the elicitation of dialogue was by holding a number of workshops. These workshops were oriented towards providing inhabitants foresight and were led by experts. These experts -responsible decision makers and stakeholders- had been invited to submit opinions on scenarios of sustainable social and environmental water conservation. The purpose of gaining these

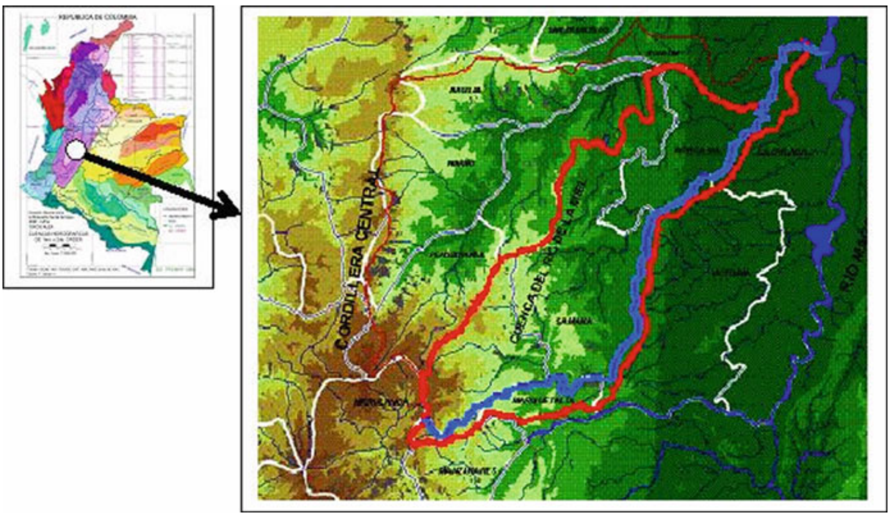

Fig. 2 Case study location in Colombia

opinions is to draft a mid and long term action plan between civil society and public administration.

The reason for this initiative derived from the unique and conflicting characteristics of the region in natural treasures but high poverty and soil degradation. Family income depends on an extensive use of land whose quality is poor due to the heavy precipitation. Additionally, economic activity is hampered by armed insurgent forces who dominate the personal development of the roughly 50,000 inhabitants. The challenge for conducting foresight activity was to attract all persons interested in this matter. This call resulted in 120 people participating in 16 working committees during the foresight exercise that evaluated all upcoming opinions, information, facts and conflicts in order to reach an acceptable and recognized consensus. All these opinions are taken into account in the analysis.

3 Modeling and Solution Approach

The approach to this case is based on the applicability of Intelligent Systems (IS). IS are well-known set of tools for reasoning and computation in order to tackle complex challenges faced by human beings. It comprises the creation and application of mathematical models and Information Technology (IT) tools. Based on IS, an entire framework is set up for decision making and support systems of water planning. Fuzzy Logic is harnessed with features and properties that allow to access quests about different ways of human reasoning and how they can be solved (Heske and Heske 1999; Boclin and de Mello 2005). A new branch of Fuzzy Logic named Fuzzy Opinion has proved to be useful supporting consensus among experts in order to suggest a solution that satisfies the opinions of all concerned (Chen and Chen 2005). It is used to solve the decision-making problem for the case study as an efficient approach to computational group decision-making on water management, more specifically of river basins.

3.1 Processes Involved

An important aim of this research is to investigate the environmental management cycle of water resources (see Fig. 3) in order to understand the interactions between its components and interdependences necessary for a community coordination and participation in each stage. As presented in Fig. 3, the cycle consists, as a whole, of the following stages: (1) Fact finding and foresight, (2) Design and Programming, (3) Implementation, and (4) Follow-up and Appraisal. The foresight process is usually implemented as a methodology for the planning and plotting of projects involving several experts, responsible decision makers and stakeholders (Landeta 2006).

It is to note that the analysis involved in our case study responds exclusively to the first step of the cycle (namely fact finding and foresight in Fig. 3). In our analysis of results, however, we roughly gave an understanding of the other aspects. For example, it is necessary to take into consideration that the environmental management cycle has as many stakeholders as the decisions would be required during the period thereof. Our case study just connected some of those stakeholders: a consultant, some government bodies, environmental experts and natives of the area. In contrast, if our analysis had

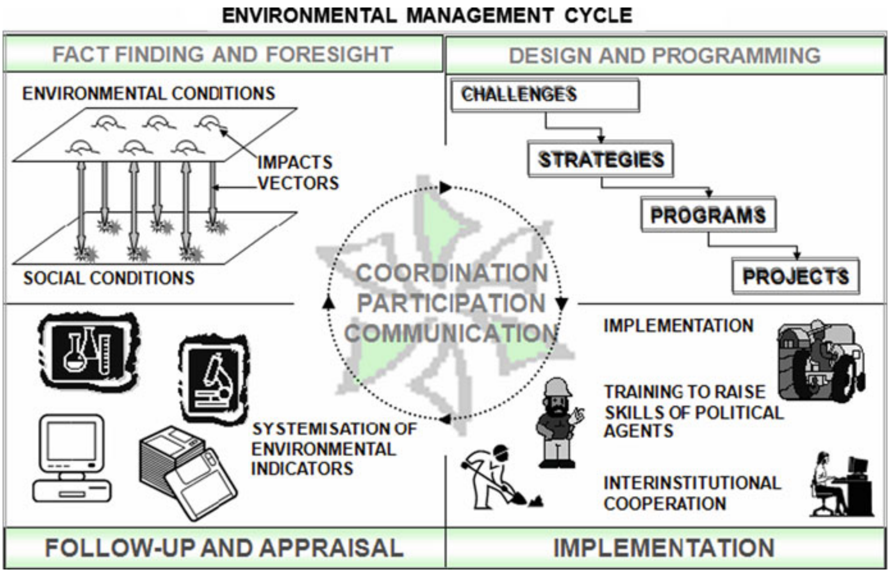

Fig. 3 Environmental management cycle

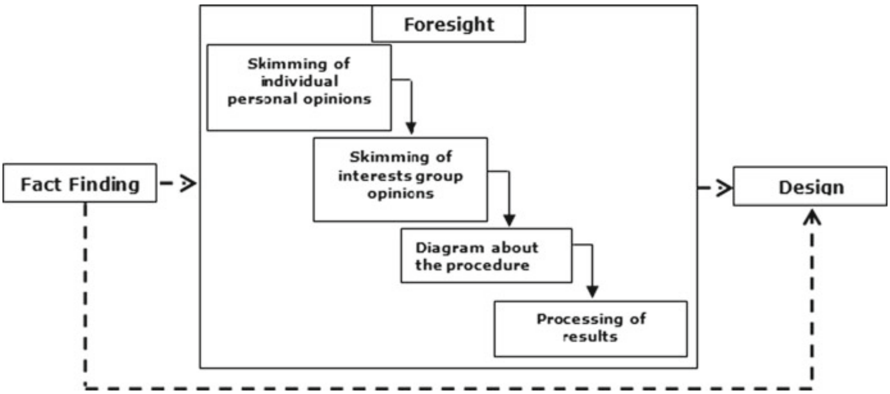

Fig. 4 Steps for the foresight process

required the implementation's step, an interventor would be definitively necessary to overcome our results.

Drilling further down, as shown in Fig. 4, intermediate steps are drawn up depending on the target of the foresight. These are: (1) Drawing up of individual personal opinions, (2) Drawing up of interests' group opinions, (3) Diagram about the procedure for selecting representative opinions, and (4) Processing of results. The dotted line in the figure shows how the foresight process is not always part of decision makers' actions. Since the anticipation of the action is an instrumental attitude, an independent and envisaged decision may have general acceptance or not. We implemented a collaborative approach using the original foresight exercise due to the importance of achieving consensus in managerial processes and also to support anticipated and sound decisions. In the next subsection, we will discuss how with the use of Fuzzy Opinion we obtained a certain grade of computational consensus based on the original foresight exercise.

3.2 Structure of the Group Decision-Making Model

The drawn up of the model depends on input information (i.e. the opinions of the stakeholders who take part in the foresight exercise). It collates new results whenever new input data are received. In other words, when the number of input opinions does not vary then the model fits into the deterministic category. Nevertheless, this classification is a tentative approach since it depends on opinions voiced by the people participating in the decision-making process and it is prone to unexpected contradictions and biased results. Additionally, steady inputs and accurate opinions depend on the changing composition of the group. Among other assumptions, this deterministic approach can transform into a probabilistic one if we take into account factors such as an absence, negativism and positivism, among others.

For the case under study, a deterministic decision-making process is not employed, but a possibility-based approach (i.e. fuzzy opinion-based). The group decision-making problem is solved adapting the approach presented by Ben-Arieh and Chen (2006). First, the submitted opinion of each expert/stakeholder is unified. The second step consists on aggregating the opinions of all participants in order to access each alternative. This step is based on fuzzy linguist labels and is used as an ordering method of alternatives. The third step of the approach consists on ranking the fuzzy sets and selecting the desirable alternatives (scenarios) based on the obtained order. One of our contributions is that the original fuzzy ranking criteria are extended in order to consider both the fuzzy membership function and the frequency of opinions. Finally, the decision is setup based on the ranking results. A consensus can be achieved in the previous step, but also autocratic decisions can be made in the last step. For the purpose of this research, we terminate the decision-making procedure at the raking stage, since we intended to model the original foresight exercise to validate our computational model. It is to note that a significant difference between our work and that of Ben-Arieh and Chen (2006) is that we are considering both temporal labels and additional steps in the alternatives' ranking process (see Sect. 3.2.3). Steps of this approach are presented next in detail. Figure 5 displays the conceptual model which involves a direct problem. Note that specific experimental input data, parameters and transition of state(s) are known in order to obtain a single solution or result per alternative. This output would be practicable for the decision-making authority either to act, forecast events, and/or adapt policies.

3.2.1 Submission of Opinions

The characteristics of the experimental data are based on the compilation of the opinions drawn by the consultants in the case study (see Table 1). Concerning this information, 12 tables had been designed, each of them regarding a limited aspect of foresight target. The elements of the foresight analysis are presented next:

Table 1 Example of experimental data: experts' opinions

Population dynamics, employment and standard of living (PDESL)

Due to their relevance, figures and causes for population growth, migration and distribution have to be taken into account as vital factors for the impact of human setlement in the territory, particularly for the protected and endangered natural ecosystems. Likewise socioeconomic issues have to be analyzed considering aspects together with employment and standard of livinng

	Escenarios				Desirable	
	Trend	Pessimistic	Optimistic	Modified	2010	2015
1	The curren dynamics continue steadily and the conjectures made by population are fulfilled concerning the quantity and distribution of setlement in the river basm. Displacements increase towards urban areas and also the subsequent food scarcity, poverty, unemployment, low level of eduction and healthcare, housing and energy supply	A growing urban population will be registered in the most densely populated areas of the country due to impairment of public security together with the envisaging of large scale projects which boost further displacement and increase for housing demand, energy, supply, and negative environment impacts	The river basin suffers low environmental impact compared with other Andean regions. Thanks to the planned, organized development of land use by the incumbent environmental authorities, the randon population growth and the setlements in endangered or protected areas are kepi under control	The current dynamics continue steadily and the conjectures made by population are fulfilled concerning the quantity and distribution of setlement in the river basin. Displacements increase towards urban areas and also the subsequent food scarcity, poverty, unemployment, low level of eduction and healthcare, housing and energy supply. Additionally, there is no increase in prices for locally grown produce	The current dynamics continue steadily and the conjectures made by population are fulfilled concerning the quantity and distribution of setlement in the river basin. Displacements increase towards urban areas and also the subsequent food scarcity, poverty, unemployment, low level of eduction and healthcare, housing and energy supply	A growing urban population will be registered in the most densely populated areas of the country due to impairment of public security together with the envisaging of large scale projects which boost further displacement and increase for housing demand, energy, supply, and negative environment impacts

TR1	2010	2010	2010	2010	2015	2015	2015	2015	○	○	○	○	○	○	○	○	Trend	Pessimistic
TSR1	○	2010	2010+	2010+	2010	○	2010	2010+	2015	2015	2015	2015	○	○	○	○		
TSR2	2010+	2010	○	○	2010+	○	2010	○	2015	2015	2015	10 *y* 15	○	○	○	○		
TSR3	2010+	10 *y* 15	2010	*x*	2010+	○	○	*x*	2015	○	2015	*x*	○	○	○	○		

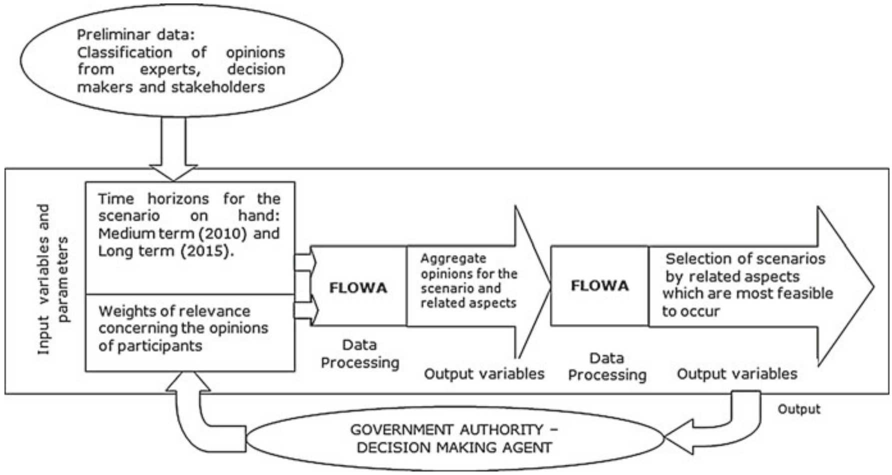

Fig. 5 Structure of the group decision-making model

- Alternatives in this study are scenarios, named as suggested by Barbieri and Medina (2000) as follows:
  1. Trend: this scenario describes the prolongation of the current situation
  2. Pessimistic: this scenario describes negative effects or consequences when it is foreseen things that do not change or slowly worsen
  3. Optimistic: this scenario describes the positive effects or consequences when it is foreseen things that change or slowly improve
  4. Modified: this scenario describes a selected combination of the previous scenarios.
  5. The most desirable: This scenario describes the result of the assessment of the four scenarios and represents the compromise with the greatest consensus base about the most feasible aspects.
- The targets of the foresight are topics of future impact related to the condition of the river basin.
- The information in Table 1 results from the workshops attended by state (TR) and county representatives (TSR). Figures indicate the occurrence (number of ballots) of a certain scenario after a certain period of time. According to the case study, the time frames are: 2010 (index 1), between 2010 and 2015 (index 2), and 2015 (index 3). The number of ballots corresponds to 16 working committees representing 120 participants labeled as TR1, TSR1, TSR2 and TSR3.
- The parameters of the model are weights that influence the opinions provided by stakeholders groups. From the initial non-computing based procedure we obtained the assumptions used for weighting the opinions for TR and TSR opinions (see Sect. 4.1). Additionally, we formulated these assumptions as numerical factors and validated them with Quinaxi's consultants as the initial parameters of the model. One important aspect covered by the data resulting from the consultancy was how the initial aggregation procedure was based heavily on opinions conceived by the state administration (i.e. due to the lack of assistance or information). However,

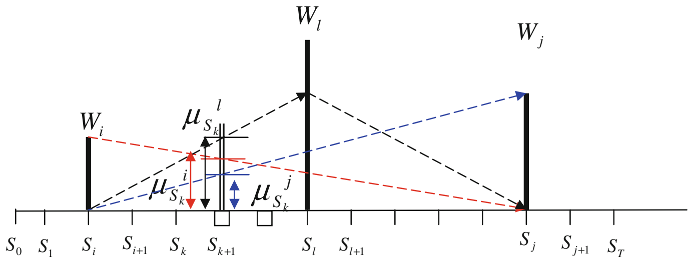

Fig. 6 Concept of FLOWA proposed by Ben-Arieh and Chen (2006, p. 560)

it was also a challenge to attempt a computational model able to duplicate the limitations of the foresight exercise.

3.2.2 Aggregation of Opinions

In order to compute the transition of state(s) shown in Fig. 5, four rules of the Fuzzy Linguistic-Label Ordered Weighted Average Operator (FLOWA) are used. Although they originate from mathematics operator (Yager 2004), this has been used for the solution of the dilemma for general agreement in the decision making process (Herrera et al. 1998). This research attempts to handle the consensus like an arbitration problem. Since no unanimous compromise was reached among experts/stakeholders, the mathematical operator plays the adequate role of a referee. The aggregation method based on FLOWA was proposed by Ben-Arieh and Chen (2006) and is formally described next. Figure 6 shows the basic concept of FLOWA.

The Fuzzy Linguistic Ordered Weighted Average Operator (FLOWA) of Ben-Arieh and Chen (2006) is an extension of the Linguistic Ordered Weighted Average (LOWA) operator presented by Herrera et al. (1996b). The following is the mathematical formulation presented by Ben-Arieh and Chen (2006, pp. 560–561)

Let m linguistic labels $X = \{s_1, s_2, \ldots, s_j\}(i < l < j)$ be a set of labels to be aggregated, where s_i is the smallest label in X and s_j is the largest one and $X \subseteq S$, where S is the set of ordered linguistic labels. A detailed description of the linguistic labels' common properties is available, for example, in (Herrera et al. 1996b) and (Herrera and Herrera-Viedma 1997). The FLOWA operator F is defined as:

$$F\{s_i \ldots s_l \ldots s_j\} = \{(s_k, \mu_{s_k})|s_k \in S\} \tag{1}$$

where μ_{s_k} is the fuzzy membership assigned to the kth linguistic label s_k after aggregating the weights on label set $X = \{s_1, s_2, \ldots, s_j\}$. It is defined as:

$$\mu_{s_k} = \sum_{l=0}^{T} \mu_{s_k}^{l} \tag{2}$$

Where $\mu_{s_k}^{l}$ is the membership function of the kth linguistic label s_k, $s_k \in S$ generated from the weighted label s_l, $s_l \in X$. The $\mu_{s_k}^{l}$ is defined as follows:

Case 1: $l = i$. Aggregation for the extremely low indicator or less relevant ranking opinion, usually a lower ranking is applied in order to describe linguistic labels like: low, non-existing and lacking.

$$\mu_{s_k}^{l} = \frac{2(j-k)}{(j-i)(j-i+1)} w_l \tag{3}$$

Case 2: $l = j$. Aggregation for the extremely high indicator or highly relevant ranking opinion, usually a higher ranking is applied in order to describe linguistic labels like: high, existing and abundant

$$\mu_{s_k}^{l} = \frac{2(k-i)}{(j-i)(j-i+1)} w_l \tag{4}$$

Case 3: $i < l < j$. Aggregation for the intermediate or opinions of average ranking, usually intermediate rankings are applied in order to describe linguistic labels like: medium, increasing and scarce

$$\mu_{s_k}^{l} = \begin{cases} \frac{2(k-i)}{(j-i)(l-i)} w_l & i < k \leq l \\ \frac{2(j-k)}{(j-i)(j-l)} w_l & l \leq k < j \end{cases} \tag{5}$$

Case 4: $l < i$ or $l > j$. The aggregation would leave the frame of subset X which means that provided opinions should be concerned as within a set that encompasses them. Otherwise they are in a possible supplementary set but not expressed. This is mathematically expressed by the following equation:

$$\mu_{s_k}^{l} = 0 \tag{6}$$

The weighted vector $W = [w_i ... w_l ... w_j](i < l < j)$ associated with the linguistic labels represents the experts' weight.

We used the weight of importance for each expert/stakeholder opinion from the Quinaxi's consultants exercise carried out in 2004. They were who processed the non-computing-based information for the case study. Then, we defined those weights as factors for their subjective nature. Thus, w_l represents the weight of the expert who chooses l as the linguistic representation of his/her preference. It is to note that $w_l \in [0, 1]$ and that $\sum_l w_l = 1$.

3.2.3 Ranking Alternatives

The objective of this step is to find several desirable alternatives (scenarios) accomplished by ranking the four alternatives based on the aggregated results. Several methods can be used in ranking both fuzzy sets and groups of linguistic labels. As proposed in the literature by Chen and Hwang (1992), Hwang and Lin (1987), Chang and Lee (1994), Lee and Li (1988) and Lee-Kwang and Lee (1999). The approach we use is

Table 2 Ranking rules considered in this paper

Relation of means	Relation of spreads	Relations of membership functions	Relation of opinions frequencies	Ranking order
$\overline{x}(A) > \overline{x}(B)$	–	–	–	$A > B$
$\overline{x}(A) = \overline{x}(B)$	$\sigma(A) < \sigma(B)$	–	–	$A > B$
$\overline{x}(A) = \overline{x}(B)$	$\sigma(A) = \sigma(B)$	$\mu(A) > \mu(B)$	–	$A > B$
$\overline{x}(A) = \overline{x}(B)$	$\sigma(A) = \sigma(B)$	$\mu(A) = \mu(B)$	$X(A) > X(B)$	$A > B$

based on the mean value of a fuzzy set and its standard deviation, which are, respectively computed as Lee and Li (1988) propose:

$$\overline{x}_u(A) = \frac{\int_{S(A)} x\mu_A(x)dx}{\int_{S(A)} \mu_A(x)dx} \tag{7}$$

$$\sigma_u(A) = \left[\frac{\int_{S(A)} x^2\mu_A(x)dx}{\int_{S(A)} \mu_A(x)dx} - [\overline{x}_u(A)]^2 \right] \tag{8}$$

where $S(A)$ is the support of fuzzy set A.

Assuming that the mean values and spreads are computed for two fuzzy sets A and B, the rules for ranking are shown in Table 2.

4 Computational Results

This section presents a summary of results obtained after programming and running the solution approach. In order to have a decision-making tool that may remain easily available for under a wide employed computational environment, the FLOWA algorithm was programmed using MS Excel® Macros under Visual Basic for Applications® programming language. Following subsection describe the criteria for model application and an overview of results obtained.

4.1 Criteria Applied to the Model

The following four criteria used during the systematic aggregation of the afforded opinions have been gleaned from the Quinaxi's workshops. As we affirmed previously, weights were not randomly established by the author due to the attempt of representing the reality of the case at hand and as an expert validation procedure of the model.

Criteria applied to the model is summarized as follows:

1. Political criteria: Submitted opinions regarding state representatives have preference over county ones.

2. Absence criteria: The result is influenced by real represented opinions. The general agreement would be affected but even though accepted under less number of opinions.
3. Frequency criteria: The more frequent an opinion, the more biased the desirable alternative (scenario)
4. Criteria for selection of opinions: The results of the model have to be accessed, regardless the number of voiced opinions. Exemptions applied with less than 3 opinions.

4.2 Weighting's Procedure

Following the method proposed by Ben-Arieh and Chen (2006), the computation of all experts' weighted opinions has to be 1

$$\sum_{l} w_l = 1$$

Then, having two differentiated groups of maximum 4-TR working committees and 12-TSR working committees, we have a proportion of 3 times less TR participants than TSR ones. Next table shows the standard matrix of weights (factors) that exhibit the rule of proportionality for all possible opinions:

Consequently, we incorporated the decision criteria step by step as follows:

1. Incorporation of the political criteria: we had several interviews with the consultants with the aim of discussing the non-computational data processing assumptions. Finally, we came up with two validated values that represent the quantitative loss of any opinion due to it is state or county opinion.
2. Incorporation of the absence criteria: As a consequence of losing opinions because of participants' absence, the matrix of weights is redistributed using the political criteria. Here is an example. Suppose, the first row in matrix w_i represent state opinions whilst the others are raised by the county opinions. The weighting loss was calculated according to 4-TSR opinions, which represents $4 \times 0.0575 \times 0.426 = 0.0122475$ value is to be redistributed into the 8-TSR left opinions.

As it is noted, the frequency of opinions affects the final outcome of the model as a consequence of the above step. Thus, FLOWA works with these matrixes as the standard weighted vector $W_s = [w_i ... w_l ... w_j]$ and reassigned weighted vector $W_r = [w_i ... w_l ... w_j]$ $(i < l < j)$. This differentiation facilitates our validation procedure.

Because of the recently development of the FLOWA, there are few codes available. Barrera and Escobar (2003) suggest a tailored computational solution, however, we did not find it applicable in our case due to the harder effort required for redesigning the algorithm, so we developed the computational tool based on our condition. In Fig. 7 we present a screen shot of the computational interface.

Consequently, the algorithm processes the information as follows:

1. WL-weights matrixes are displayed and reassignment of the weights of importance for uttered opinions

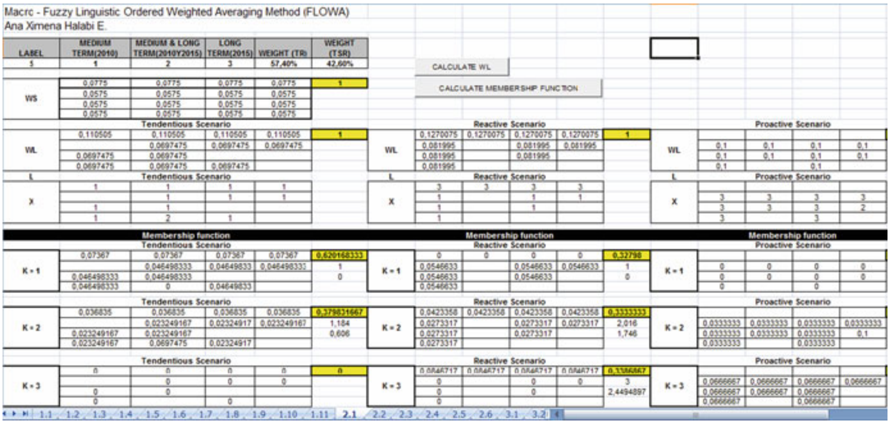

Fig. 7 Computational interface of the FLOWA application

Table 3 Rule of proportionality for the afforded opinions

w_l				
0.0775	0.0775	0.0775	0.0775	1
0.0575	0.0575	0.0575	0.0575	
0.0575	0.0575	0.0575	0.0575	
0.0575	0.0575	0.0575	0.0575	

Table 4 Thumbed rule for the political criteria

w_l Loss op. state (%)	w_l Loss op. county (%)
57.40	42.60

Table 5 Redistributed matrix using absence criteria

	Trend scenario		
w_l			
0.110505	0.110505	0.110505	0.110505
	0.0697475	0.0697475	0.0697475
0.0697475	0.0697475		
0.0697475	0.0697475	0.0697475	

2. Calculation of the membership function (μ) for all plotted scenarios
3. Calculation of the first moment (mean) and the standard deviation of the membership function regarding the indexes of the opinions (1 = 2010, 2 = between 2010 and 2015, and 3 = 2015). This is followed by some calculations the algorithm conducts in order to obtain the mean and the standard deviations of the aggregate membership functions.

In conclusion, the resulting functions of the algorithm lead to rating each alternative (scenario) in order to stipulate the highest feasibility of occurrence for the desirable ones.

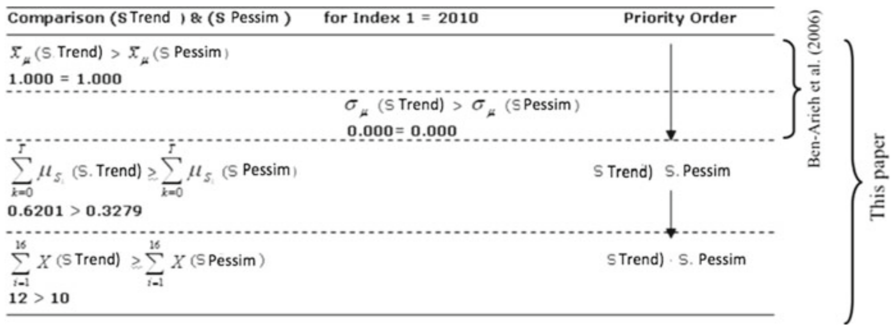

Fig. 8 Application example of this paper's modified ranking rule

4.3 Model's Results

In this part, we display the results for one of the aspects of the modeling foresight and exhibit the analysis carried out. The selected target is "Population Dynamics, Employment and Standard of Living" (PDESL). Taking into account that the analysis is akin to the other targets, the simplified analysis on PDESL is valid for rest of the processed information. Additionally, as the PDESL explains one of most relevant foresight targets, we allow an analysis that contributes to explain the roots and upshots for the impoverishment of the inhabitants in the La Miel River Basin to the government entities.

As a first step, uttered opinions are taken to process the aggregate membership functions, i.e. the level of trust within the group towards the feasibility of a desirable alternative (scenario) given a time frame and the weights of importance for each opinion. Table 6 shows the output table with the weights put out by the model regarding each scenario: Trend, Pessimistic, and Optimistic. From the following three tables (Table 7) the mean values and standard deviations of the aggregate membership functions can be obtained. Also the model classifies the each opinions with the index $1 = 2010$, $2 =$ between 2010 and 2015, and $3 = 2015$.

Making use of the ranking and selection method suggested by Ben-Arieh and Chen (2006), a comparison of aggregated membership functions is obtained (see Fig. 8). Note we processed as an example the same mean and standard deviation for the Trend and Pessimistic scenarios, so we embodied limitations in the selection of a desirable alternative (scenario) using the method of Ben-Arieh and Chen (2006). Therefore, we adapted the selection method in order to allow a new comparison of scenarios. See the results also indicate a greater aggregated membership function and a higher number of representative opinions. As a consequence, the Trend scenario is to be assumed as the most likely to occur in $1 = 2010$). At this step on, it is to note that the contribution of our work to the procedure of Ben-Arieh and Chen (2006) is twofold. On one hand, our approach requires the use of temporal linguistic labels. On the other hand, the ranking of alternatives is based on two additional criteria. As these authors, we need a ranking based on the mean and standard deviation of each alternative. In our approach, we additionally consider the comparison between the membership function and the

Table 6 Example of weight calculation for the model

Frequency	Trend scenario				Pessimistic scenario				Optimistic scenario		
Target 2. Population dynamics, employment and standard of living (PDESL) section 1. Population density											
Redistribution of weights per scenario	0.0697475	0.110505	(Absence)	Total	0.081995	0.1270075	(Absence)	Total	0.1	(Absence)	Total
Submitted opinions for 1 = 2010	7	4		11	6			6			
Submitted opinions for 2 = between 2010 and 2015	1			1					1		1
Submitted opinions for 3 = 2015						4		4	8	1	9
(Absence)											
Overall total	8	4		12	6	4		10	9	1	10

Table 7 Example of results obtained using the model

Scenario	Aggregate membership function	Number of opinions	Mean	Dev.
Related aspect 2. Population, dynamics, employment and standard of living (PDESL) section 1. Population density				
Aggregate opinion index 1 = 2010				
Trend	0.620168333	12	1.000	0.000
Pessimistic	0.32798	10	1.000	0.000
Optimistic	0.000	10	0.000	0.000
Modified	0.000	0	0.000	0.000
Aggregate opinion index 2 = between 2010 and 2015				
Trend	0.379831667	12	1.184	0.606
Pessimistic	0.333333333	10	2.016	1.746
Optimistic	0.400	10	2.750	2.236
Modified	0.000	0	0.000	0.000
Aggregate opinion index 3 = 2015				
Trend	0.000	12	0.000	0.000
Pessimistic	0.338686667	10	3.000	2.449
Optimistic	0.600	10	3.000	2.449
Modified	0.000	0	0.000	0.000

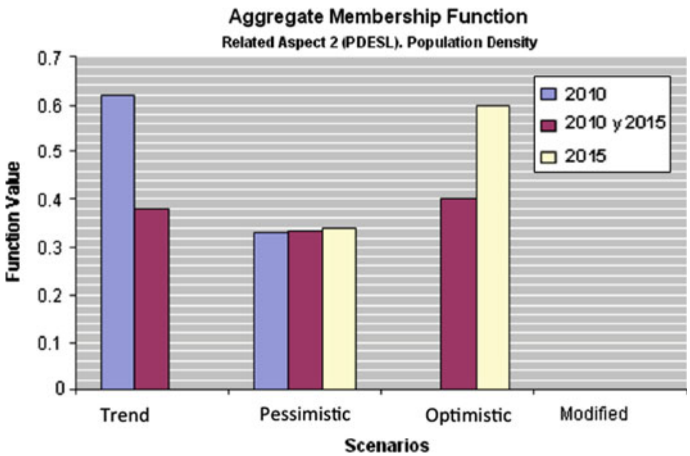

Fig. 9 Comparison of aggregate membership function

frequency of opinions. This can be observed in Fig. 8. Analyzing more in depth the ranking procedure, Fig. 9 displays a bar chart to describe the comparison of alternatives (scenarios) based on the aggregate membership function. We show how using modeled opinions, the Trend scenario is feasible to occur in 2010 and the Optimistic scenario in 2015. Then, a general agreement can be processed for each of the targets in the foresight exercise.

4.4 Model's Validation

We present a validation method in which the assumptions about the weights and criteria applied to the model are considered by relating the outcomes of the non-computer processing with the FLOWA aggregation method. Using a comparison of scenarios and the expert's validation procedure (i.e. Quinaxi), the results indicate reasonable solutions when replicating the initial study. A total of 288 possible combinations of alternatives (scenarios) for 72 foresight targets is the whole size of our sample. Excluding cases with less than 3 opinions, just 15 instances resulted not satisfactory combined (i.e. 5% of the model's outputs. (see Table 8). These results are adequate to say that the computer-based processing is reliable.

5 Conclusions

This paper presented the application of the linguistic-label aggregation method (FLOWA) in a real-life case study. The case was taken from a foresight exercise in Colombia concerning environmental and water resources planning in a river basin.

The group decision-making problem was solved using a four-step approach based on (i) the evaluation of experts' opinions, (ii) the aggregation of opinions for each alternative, (iii) fuzzy ranking, and (iv) final assessment. Two main issues that were new in our work is that we considered temporal linguistic labels and a fuzzy ranking procedure that is able to include the mean, the standard deviation, the fuzzy membership function and the frequency of experts' opinions for each alternative.

The approach was implemented on a computational tool for efficient decision-making, that is, the tool demonstrated to deal with shortest time frames and to increase the efficiency of the planning resources, mainly because allows the decision manager to focus on the establishment of criteria. The latter also leads to objectivity and eases the identification and discussion of elements of consensus in decisions that otherwise may be embedded in individuals' interests.

Attention must be drawn to the fact that results show an impact for each foresight target suggesting that the working committees where more likely to foresee a pessimistic scenario in the short-term (Trend scenario in the year 2010—note this study was conducted in 2004). Whilst an Optimistic scenario for 2015. All of which may indicate either a desirable situation or poor knowledge of some aspects proposed by the foresight exercise.

Absence and the consequent redistribution of weights negatively affect the aggregated consensus, mainly because the majority of simulated scenarios -with absence features- produces very low membership functions. Hence, unbiased input data (opinions) and transparent criteria will turn this model into a proper tool for decision-making with a substantial impact on the local communities.

As we have presented, our contribution is on the evaluation of experts' opinions. The aggregation of opinions for each alternative, the fuzzy ranking, and final assessment consider a decision making autocratic process due to the reality of the case studied. Although, other groups of decisions will be under revision in further implementations, such as pure consensus situations, operative and tactical collective decisions, among

Table 8 Model's validation results

Related aspect	Section	Measures							
		Dec.1 index FLOW A	Dec.2 index FLOW A	Dec.1 Sce. FLOW A	Dec.2 Sce. FLOW A	Dec.1 index Non-comp	Dec.2 index Non-comp	Dec.1 Sce. Non-comp	Dec.2 Sce. Non-comp
1. Land planning	1	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	2	1 = 2010	3 = 2015	Tend	Proac	2010	2015	Tend	Reac
	3	2 = 10 & 15		Proac		2010	2015	Proac	Reac
	4	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	5	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	6	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	7	1 = 2010	3 = 2015	Tend	Mod	2010	2015	Tend	Mod
	8	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Tend	Proac
	9	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	10	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	11	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
2. Population dynamics, employment and standard of living	1	1 = 2010	3 = 2015	Tend	Proac	2010	2015	Tend	Reac
	2	1 = 2010	3 = 2015	Tend	Proac	2010	2015	Tend	Reac
	3	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	4	1 = 2010	3 = 2015	Tend	Proac	2010	2015	Tend	Reac
	5	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	6	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
3. Rural environmental impacts	1	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	2	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	3	2 = 10&15		Reac		2 = 10&15		Reac	
	4		2 = 10&15		Proac	2010	2015	Reac	Proac
	5	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
	6		2 = 10&15		Reac	2010	2015	Tend	Reac
	7	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	8	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	9	2 = 10&15		Reac		2010	2015	Reac	Proac
	10	2 = 10&15		Reac		2010	2015	Reac	
	11	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac

Table 8 continued

Related aspect	Section	Measures							
		Dec.1 index FLOW A	Dec.2 index FLOW A	Dec.1 Sce. FLOW A	Dec.2 Sce. FLOW A	Dec.1 index Non-comp	Dec.2 index Non-comp	Dec.1 Sce. Non-comp	Dec.2 Sce. Non-comp
4. Urban environmental impacts	1	1 = 2010	3 = 2015	Tend	Proac	2010	2015	Tend	Reac
	2	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
	3	1 = 2010	3 = 2015	Tend	Proac	2 = 10&15		Reac	
	4	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	5		2 = 10&15		Reac	2010	2015	Tend	Reac
	6	2 = 10&15	3 = 2015	Reac	Proac	2010	2015	Tend	Proac
5. Hydroelectric generation	1		2 = 10&15		Reac	2010	2015	Tend	Reac
	2	2 = 10&15		Tend		2 = 10&15		Tend	
	3	2 = 10&15		Tend		2 = 10&15		Tend	
	4		2 = 10&15		Proac		2 = 10&15		Proac
	5	1 = 2010	2 = 10&15	Tend	Proac	2010	2015	lend	Reac
6. Conservation and sustainable management of biodiversity	1	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	2	2 = 10&15	3 = 2015	Proac	Mod	2010	2015	Proac	Mod
	3	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	4		2 = 10&15		Reac	2010	2015	Tend	Reac
	5	1 = 2010	3 = 2015	Tend	Mod	2010	2015	Tend	Mod
	6	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	7	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
7. Implementation of technical ecofriendly processes and green markets	1		2 = 10&15		Reac	2010	2015	Tend	Reac
	2	2 = 10&15		Tend		2 = 10&15		Tend	
	3	1 = 2010	3 = 2015	Tend	Proac	2010	2015	Reac	Proac
	4	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	5		2 = 10&15		Reac	2010	2015	Tend	Reac
	6		2 = 10&15		Reac	2010	2015	Tend	Reac
	7	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Tend	Reac

Table 8 continued

Related aspect	Section	Measures							
		Dec.1 index FLOW A	Dec.2 index FLOW A	Dec.1 Sce. FLOW A	Dec.2 Sce. FLOW A	Dec.1 index Non-comp	Dec.2 index Non-comp	Dec.1 Sce. Non-comp	Dec.2 Sce. Non-comp
8. Institutional capacity	1	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	2	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	3	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
	4	2 = 10&15		Reac		2010	2015	Reac	Proac
	5	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	6	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
9. Interangency coordination and participation	1	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	2	1 = 2010	3 = 2015	Reac	Proac	2 = 10&I5		Reac	
	3	2 = 10&15		Reac		2 = 10&15		Reac	
	4	1 = 2010	3 = 2015	Reac	Proac	2 = 10&15		Reac	
	5	1 = 2010	3 = 2015	Reac	Proac	2 = 10&15		Mod	
10. Financial resources	1	1-2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	2	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	3	2 = 10&15		Reac		2 = 10&15		Reac	
	4	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
11. Law and public order	1	1 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
	2	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	3	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	4	1 = 2010	3 = 2015	Tend	Reac	2010	2015	Tend	Reac
12. Cultural factors and environmental education	1		2 = 10&15		Reac	2010	2015	Tend	Reac
	2	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	3	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac
	4	1 = 2010	3 = 2015	Reac	Proac	2010	2015	Reac	Proac

Table 8 continued

Related aspect	Section	Measures							
		Dec.1 μ_{sk}^{l}	Dec.2 μ_{sk}^{l}	Dec.1 # of Op	Dec.2 # of Op	Dec.1 Mean	Dec.2 Mean	Dec.1 Dev	Dec.2 Dev
1. Land planning	1	0.625	0.667	14	13	1.000	3.000	0.000	2.449
	2	0.667	0.667	5	10	1.000	1.000	3.000	2.449
	3	0.377		13		2.103		1.770	
	4	0.434	0.579	12	7	1.000	3.000	0.000	2.449
	5	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	6	0.527	0.612	12	10	1.000	3.000	0.000	2.449
	7	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	8	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	9	0.448	0.483	10	9	1.000	3.000	0.000	2.449
	10	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	11	0.667	0.519	9	11	1.000	3.000	0.000	2.449
2. Population dynamics, employment and standard of living	1	0.620	0.600	12	10	1.000	3.000	0.000	2.449
	2	0.667	0.600	12	10	1.000	3.000	0.000	2.449
	3	0.468	0.579	15	13	1.000	3.000	0.000	2.449
	4	0.667	0.667	7	8	1.000	3.000	0.000	2.449
	5	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	6	0.574	0.667	12	10	1.000	3.000	0.000	2.449
3. Rural environmental impacts	1	0.417	0.667	14	7	1.000	3.000	0.000	2.449
	2	0.448	0.448	15	6	2.044	3.000	1.658	2 449
	3	0.778		3		2.143		1.604	
	4		0.404		8		3.000		2.449
	5	0.554	0.444	8	9	1.000	3.000	0.000	2.449
	6		0.604		9		2.125		1.644
	7	0.587	0.667	15	13	1.000	3.000	0.000	2.449
	8	0.667	0.605	8	9	1.000	3.000	0.000	2.449
	9	0.778		3		1.857		1.309	

Table 8 continued

Related aspect	Section	Measures							
		Dec.1 μ^l_{sk}	Dec.2 μ^l_{sk}	Dec.1 # of Op	Dec.2 # of Op	Dec.1 Mean	Dec.2 Mean	Dec.1 Dev	Dec.2 Dev
1. Land planning	1	0.625	0.667	14	13	1.000	3.000	0.000	2.449
	2	0.667	0.667	5	10	1.000	1.000	3.000	2.449
	3	0.377		13		2.103		1.770	
	4	0.434	0.579	12	7	1.000	3.000	0.000	2.449
	5	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	6	0.527	0.612	12	10	1.000	3.000	0.000	2.449
	7	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	8	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	9	0.448	0.483	10	9	1.000	3.000	0.000	2.449
	10	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	11	0.667	0.519	9	11	1.000	3.000	0.000	2.449
2. Population dynamics, employment and standard of living	1	0.620	0.600	12	10	1.000	3.000	0.000	2.449
	2	0.667	0.600	12	10	1.000	3.000	0.000	2.449
	3	0.468	0.579	15	13	1.000	3.000	0.000	2.449
	4	0.667	0.667	7	8	1.000	3.000	0.000	2.449
	5	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	6	0.574	0.667	12	10	1.000	3.000	0.000	2.449
3. Rural environmental impacts	1	0.417	0.667	14	7	1.000	3.000	0.000	2.449
	2	0.448	0.448	15	6	2.044	3.000	1.658	2 449
	3	0.778		3		2.143		1.604	
	4		0.404		8		3.000		2.449
	5	0.554	0.444	8	9	1.000	3.000	0.000	2.449
	6		0.604		9		2.125		1.644
	7	0.587	0.667	15	13	1.000	3.000	0.000	2.449
	8	0.667	0.605	8	9	1.000	3.000	0.000	2.449
	9	0.778		3		1.857		1.309	
	10	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	11	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a

Table 8 continued

Related aspect	Section	Measures							
		Dec.1 μ^l_{sk}	Dec.2 μ^l_{sk}	Dec.1 # of Op	Dec.2 # of Op	Dec.1 Mean	Dec.2 Mean	Dec.1 Dev	Dec.2 Dev
4. Urban environmental impacts	1	0.590	0.590	7	7	1.000	3.000	0.000	2.449
	2	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	3	0.530	0.530	9	9	1.000	3.000	0.000	2.449
	4	0.548	0.504	8	11	1.000	3.000	0.000	2.449
	5		0.437		12		1.908		1.539
	6	0.448	0.607	11	8	1.709	3.000	1.321	2.449
5. Hydroelectric generation	1		0.454		7		2.096		1.700
	2	0.787		8		1.865		1.315	
	3	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	4		0.662		9		2.255		1.738
	5	0.667	0.737	3	5	1.000	2.178	0.000	1.647
6. Conservation and sustainable management of biodiversity	1	0.579	0.667	13	10	1.000	3.000	0.000	2.449
	2	0.333	0.667	13	5	2.051	3.000	1.775	2.449
	3	0.620	0.481	12	12	1.000	3.000	0.000	2.449
	4		0.380		12		2.204		1.852
	5	0.667	0.667	5	4	1.000	3.000	0.000	2.449
	6	0.617	0.667	11	11	1,000	3.000	0.000	2.449
	7	0.667	0.667	4	4	1.000	3.000	0.000	2.449
7. Implementation of technical ecofriendly processes and green markets	1		0.410		13		1.972		1.624
	2	0.559				1.606		1.101	
	3	0.601	0.667	7	8	1.000	3.000	0.000	2.449
	4	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	5		0.672		6		1.878		1.370
	6		0.448		11		1.965		1.585
	7	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a

Table 8 continued

Related aspect	Section	Measures							
		Dec.1 μ^l_{sk}	Dec.2 μ^l_{sk}	Dec.1 # of Op	Dec.2 # of Op	Dec.1 Mean	Dec.2 Mean	Dec.1 Dev	Dec.2 Dev
8. Institutional capacity	1	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	2	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	3	0.500		4		1.500		1.000	
	4	0.500	0.667	4	3	1.000	3.000	0.000	2.449
	5	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	6	0.527	0.482	10	12	1.000	3.000	0.000	2.449
9. Interangency coordination and participation	1	0.625	0.667	14	13	1.000	3.000	0.000	2.449
	2	0.500		4		1.500		1.000	
	3	0.454	0.614	12	10	1.000	3.000	0.000	2.449
	4	0.500	0.667	8	7	1.000	3.000	0.000	2.449
	5	0.667	0.667	4	4	1.000	3.000	0.000	2.449
10. Financial resources	1	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	2	1.000		4		2.000		1.414	
	3	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	4	0.667	0.667	4	4	1.000	3.000	0.000	2.449
11. Law and public order	1	0.667	0.667	4	4	1.000	3.000	0.000	2.449
	2	0.500	0.667	4	4	1.000	3.000	0.000	2.449
	3	0.500	0.667	4	3	1.000	3.000	0.000	2.449
	4	0.500	0.667	4	3	1.000	3.000	0.000	2.449
12. Cultural factors and environmental education	1		0.421		13		2.168		1.786
	2	0.583	0.667	14	13	1.000	3.000	0.000	2.449
	3	0.579	0.617	13	11	1.000	3.000	0.000	2.449
	4	0.503	0.596	10	8	1.000	3.000	0.000	2.449

others. It should be stressed that a fuzzy model allowed us to reproduce a wide array of opinions in an agreement just because it is capable of processing human standards (criteria). In this study this meant several hours of interviews with the decision-maker (consultant) before stipulating the weighting of opinions. This also suggests to the stakeholder and key players the need of being conscious about the political influence of collective decision processes.

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