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Hydrology and Earth System Sciences
Discussions

Interactive comment on "A decision analysis framework for stakeholder involvement and learning in groundwater management" *by* T. P. Karjalainen et al.

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Herewith below are our responses to the reviewers' comments.

Responses to the comments of Reviewer 1:

Comment 1): "The presentation of the results should be more balanced, highlighting both the strengths and weaknesses of the proposed approach. There are many statements in these two sections that are subjective, "personnal", observations. On page 8763, for instance, the authors claim that "the approach was considered the most suitable..." but we do not know anything about the alternative approaches. The

only approach described in section three and implemented in section four deals with MAVT/DIA. It is very unclear why the authors' conclude that MAVT/DIA is superior to other methods that are available to promote stakeholders' involvement and learning. Another example on the same page: "most of the respondents considered personnal learning to have occured". But this could have happened with the other methods! To what extent this is specific to the proposed approach? The authors should provide comparative evidences to support such statements."

Response to comment 1): We agree that we should have discussed more about the strengths and weaknesses of the proposed approach. This is done in the revised version of the manuscript referring other experiences using MCDA with DIA and a other decision analytical approaches. There are still surprisingly few comparative studies of the pros and cons of different ways to involve different parties and realize stakeholder processes with MCDA. In a recent paper, Marttunen et al (2013) compared pros and cons of different MCDA approaches (from expert-driven to DAI approach) and we have used especially this article to describe the strengths and weaknesses of the proposed approach.

However, in the current version of the manuscript we are not stressing that only MAVT/DIA approach can foster learning and promote stakeholder involvement. The sentence (on page 8763: "The approach was considered the most suitable that referee. . ."), that referee notes, refers to how respondents of the feedback survey evaluated the applied MCDA approach: what benefits of the approach they highlighted in their survey responses (fig. 8: suitability of the decision analytical approach for meeting the following objectives). This is the evaluation of the approach by the stakeholders. Also (on the same page) the sentence "most of the respondents considered personal learning to have occurred" refers to the stakeholders own evaluation (fig. 8. "my understanding of the alternatives and their effects increased with interviews") and our assessment of these stakeholder responses only refers to this. We are not highlighting that these results could be obtained only by using this specific MAVT/DIA approach.

What we'd like to stress is that we have measured the learning aspect and reflected it, which is a rare case in the literature despite the ongoing discussion and research on learning in natural and water resource management. Our intention in this paper is to analyse "whether there is any improved understanding of the groundwater issue in the Rokua area among the participants after the MCDA process, and if there is, how the applied approach enhanced the conditions for learning."

The following text is added in the revised manuscript:

"The strengths and potential problems of DAI/MCDA approach are discussed by Marttunen et al 2013. Most of the strengths identified are related to a high level of interaction which means that key stakeholders are actively involved in the various phases of the process and that weight elicitation and analysis of the results are interactive and computer-aided. One of the main strengths listed in their analysis is enhanced learning among stakeholders as well as the well documented result of building trust and creating commitment to the planning case. In addition, DAI/MCDA approach has been shown to improve trust in the method and results. These strengths are due to DAI approach's interactive style in workshops and interviews: immediate feedback is enabled and possible misunderstandings, mistakes and biases can be detected more carefully than the compared approaches with less interaction. The approach also enables more careful answers from interviewees due to the presence of the analyst. However, this means also that the decision analyst can unintentionally influence interviewees' answers and s/he should be aware of that. The close interaction with stakeholders also means that the approach requires time and commitment from stakeholders and it is quite a laborious procedure. In some cases such an intensive interaction can be hard to implement and trade-offs have to be made between the amount of resources and effectiveness of MCDA.'

References related to comment 1): Marttunen M, Mustajoki, J, Dufva M, Karjalainen TP 2013. How to design and realize participation of stakeholders in MCDA processes? A framework for selecting an appropriate approach. EURO J Decis Process. DOI

10.1007/s40070-013-0016-3.

Comment 2): I was wondering to what extent was MAVT suitable for this exercise? More specifically, were the compensation and mutual independence assumptions discussed with the stakeholders? What were their reactions and their understanding of the consequences of these two assumptions?

Response to comment 2:

This is a very good comment, many thanks. The selection of the MAVT is mainly because of the relatively intuitive procedure that presents lesser berries to stakeholders to understand groundwater management issues (see also e.g. Hostmann et al 2005). The capacity of stakeholders to understand the procedure of the method was one of the main reasons for the application of this more straightforward and interactive approach. MAVT provided an illustrative way to systematically compare and to analyze alternatives and to describe the differences in participants' opinions. One of our main goals for the MCDA process in the Rokua was to explore and describe differences in the stakeholders' values and preferences and the reasons behind them in order to form basis for learning, deliberation and future collaboration. The compensation and mutual independence assumptions were not discussed with the stakeholders, and in practice, it may be better to ignore them in order to allow a simpler and more transparent decision support to be implemented and by a wider range of users.

In the decision analysis literature, there is hardly any discussion of whether people have really understood the method applied and its assumptions – in many cases such problems have remained unnoticed (Hämäläinen 2004). However, in the DAI approach, a special attention is paid to the clarity of the process, the choice of tools, and capacity-building for the participants (Marttunen 2011). Before the interviews, a meeting is usually arranged wherein the approach is explained and its use was demonstrated. The workbook also includes a brief description of the main calculation principles of the MCDA model. Furthermore, early in the interviews there is a short introduction

to the method, and the respondent had an opportunity to ask questions. Before the computer-aided phase, the analyst asks whether the participant felt in possession of sufficient understanding of the process and the tool.

We have clarified the motivation for using MAVT for this study by adding the following sentences: "The capacity of stakeholders to understand the procedure of the method was one of the main reasons for the application interactive approach. MAVT provided an illustrative way to systematically compare and to analyze alternatives and to describe the differences in participants' opinions. One of our main goals for the MCDA process in the Rokua was to explore and describe differences in the stakeholders' values and preferences and the reasons behind them in order to form basis for learning, deliberation and future collaboration. "

Hostmann, M., Bernauer, T., Mosler, H.J., Reichert, P., Truffer, B. 2005b. Multi-attribute value theory as a framework for conflict resolution in river rehabilitation. Journal of Multiple Criteria Decision Analysis 13 (2–3): 91–102. Hämäläinen, R.P. 2004. Reversing the perspective on the applications of decision analysis. Decision Analysis 1 (1): 26–31.

Marttunen M (2011) Interactive multi-criteria decision analysis in the collaborative management of watercourses. Aalto University publication series: Doctoral Dissertations 75/2011, Helsinki

Comment 3): There is a fairly large body of scientific literature on the usefulness of MCA techniques for public investment projects (see e.g. Mladineo, EJOR 1992). The authors should discuss the specificities associated with water/natural resources management and check whether their conclusions are consistent similar experiences in the broader context of public investments.

Response to comment 3): We agree with the reviewer that there is a large body of scientific literature on the usefulness of MCDA techniques for public projects. In the manuscript, we now provide references to many studies concerning the applications

of MCDA techniques to natural resources management and the usefulness of them in facilitating stakeholder involvement and conflict resolution. In the revised manuscript, we cited several more studies that are most relevant to the issues addressed in our present study.

The following text is added in the revised manuscript: 'Multi-criteria decision analysis (MCDA) methods are increasingly being used to facilitate stakeholder involvement in decision support for natural resources management (Hostmann et al., 2005; Kiker et al., 2005; Prato et al., 2007; Weng et al., 2010; Coelho et al., 2012; Reichert et al., 2013, Karjalainen et al 2013; Marttunen et al 2013). The common purpose of MCDA methods has been to evaluate and choose among alternatives based on multiple criteria using systematic analysis that overcomes the limitations of unstructured individual or group decision making. However, in many planning processes the ranking of the alternatives may be less important than other process outputs, such as identification of knowledge gaps, improved and shared understanding of the situation or explication of the diversity of different views. According to our experience with MCDA/DAI approach in the Rokua case (as well as Marttunen et al 2013, Karjalainen et al 2013 in other cases), in a highly interactive MCDA process the stakeholders involvement lead to a better understanding of the groundwater issue, different viewpoints and key uncertainties. While the process may not lead to a specific action plan, it can provide a basis for better cooperation.'

References related to comment 3)

Coelho AN & J.W. Labadie & D.I G. Fontane 2012. Multicriteria Decision Support System for Regionalization of Integrated Water Resources Management. Water Resour Manage 26: 5, 1325-1346.

Hostmann, M., Bernauer, T., Mosler, H.J., Reichert, P., Truffer, B. 2005b. Multi-attribute value theory as a framework for conflict resolution in river rehabilitation. Journal of Multiple Criteria Decision Analysis 13 (2–3): 91–102.

Karjalainen TP, Marttunen M, Sarkki S, Rytkönen A-M (2013). Integrating ecosystem services into environmental impact assessment: an analytic-deliberative approach. Environmental Impact Assessment Review 40 (April 2013), 54-64.

Kiker GA,Todd S. Bridges, A. Varghese,‘ T.P. Seager,§and Igor Linkovj. 2005. Application of Multicriteria Decision Analysis in Environmental Decision Making. Integrated Environmental Assessment and Management. 1: 2, 95–108.

Marttunen M, Mustajoki, J, Dufva M, Karjalainen TP 2013. How to design and realize participation of stakeholders in MCDA processes? A framework for selecting an appropriate approach. EURO J Decis Process. DOI 10.1007/s40070-013-0016-3.

Prato, T; Herath, G 2007. Multiple-criteria decision analysis for integrated catchment management. Ecological Economics 63: 2-3, 627-632.

Reichert P, Nele Schuwirth, Simone Langhans, 2013. Constructing, evaluating and visualizing value and utility functions for decision support. Environmental Modelling & Software. 46 (August 2013), 283–291.

Weng, SQ , Huang, GH, Li, YP, 2010. An integrated scenario-based multi-criteria decision support system for water resources management and planning - A case study in the Haihe River Basin. Expert Systems with Applications 37:12, 8242-8254 .

General comment: This paper addresses an important issue in water resources management. Major modifications are needed before this paper can be accepted for publication. The introduction, analysis and conclusions must be rewritten in order to better stress the contribution of this manuscript and to have a more balanced presentation of the results.

Response:

The introduction, analysis and conclusion are now revised.

Response to comments of Reviewer #2:

INITIAL COMMENTS

This article is one of the best practical examples of the use of decision analysis to inform natural resource management decisions that I have seen. Particularly striking is that despite the acrimony among stakeholders, the decision analysis process showed stakeholders that they all actually agree on the best solution. I will plan to use this article as an example in a graduate-level class on environmental decision analysis that I teach.

We want to thank you for the very positive assessment of our work.

The only possible improvement I could recommend is to compare the results to those of similar decision analysis applications published in relevant decision analysis journals. Also, if the authors plan to update this analysis in the future, once some of the uncertainties regarding attributes are resolved, they may wish to elicit utility functions for each attribute from stakeholder interviews, since these functions may not be linear as the authors currently assume.

As also mentioned in the responses to the 1st reviewer, we now provide references to many studies concerning the applications of MCDA techniques to natural resources management. The issue of the linear utility functions is discussed below.

EXPANDED COMMENTS

1. Form of the Multi-Attribute Utility Model

Comment a. The authors develop an MAU model that is a linear function of seven attributes (change in water level, chemical state of lakes, etc.). However, they should have formally checked that the linear model is appropriate for describing the preferences of these stakeholders. In order for such a linear model to provide a mathematically valid representation of preferences, the attributes must satisfy the additive independence condition, described in a number of classic decision analysis texts (for example, Keeney and Raiffa, 1976, von Winterfeldt and Edwards 1986, and Clemen

and Reilly 2001).(2–4) The authors should use the techniques described in these texts to establish whether or not the seven attributes are additively independent. If they are not, then a different form of utility function (for example, perhaps including interaction terms) may be needed.

Comment b. The authors assume each single attribute utility function is linear. Such a linear assumption assumes the participants are risk neutral and may not be appropriate. The authors should elicit individual utility functions for each attribute, in order to test whether the linear assumption is valid. An alternative would be to test the robustness of the resulting rankings of the three decision alternatives under various commonly encountered nonlinear functional forms.

Response:

In this study, a linear additive value function model has been applied for the weighted aggregation of the partial (single) attribute values, which is the simplest and most used aggregation model in MAVT (Belton and Steward 2002; Hostmann et al., 2005). As the reviewer rightly points out, in order to have a linear aggregation of values the properties of separability and addititivy must hold, which requires mutual preferential independence between the attributes (in order to allow for Compensation) (as stated in Keeney and Raiffa, 1976, von Winterfeldt and Edwards 1986 and others). In this specific case, we consider that the trade-off condition holds into each pair of the 6 selected attributes: the 2 attributes related to the groundwater status (quantitative, chemical), and for the case of the 4 attributes related to economic values (second home, tourist, forestry, peat production losses). For that reason, we consider that the linear additive value function is a valid approach and we have not tested other functional form. This response is included and formulated in the text.

The SWING method was chosen for eliciting the weights for the criteria in order to ensure that the participants account for the decision context by identifying the most important attribute first, and then the relative importance of the other attributes was

compared to it. The single (partial) attribute value functions were obtained using relative values within a 0–1 value scale For each criterion, the lowest attribute value among our alternative set was mapped to 0 and the highest value to 1, while the other attribute values were mapped linearly to this scale as in Belton and Stewart, 2002).

Comment c. Ideally, the authors would have developed quantitative measures to describe the four attributes that currently are characterized with categorical scores. These four at tributes are (1) chemical state of lakes, (2) chemical/ecological state of springs, (3) income loss for peat production, and (4) attractiveness for tourists. For example, it should have been possible to estimate specific peat-related income losses for each decision alternative in Euros, instead of using the categories -, 0, +, and ++. Similarly, attractiveness for tourists could have been estimated as changes in tourism revenue. Appropriate chemical or ecological indicators could have been determined for the other two attributes, as well.

Response:

As stated in the manuscript, the hydrological studies of Rokua esker were still ongoing. For the MCDA questionnaire only the preliminary results were used. Especially the exact ecological and chemical impacts were uncertain as data were still gathered and analyzed. Therefore, the categories of -, 0, + and ++ aimed to reflect this level of uncertainty. Concerning the tourism attractiveness, the nature of Rokua esker as a whole, the sand dunes and hills, protected forests, and the kettle lakes formed a unique combination that is important for the tourism. As the groundwater dependent ecosystems are only one piece of the esker nature, the exact impact of GDEs on tourism revenue was hard to separate. For this reason the selected categories were used. On peat production, the method and the price of the peat area restoration needed for stopping the groundwater seepage compared to normal restoration procedures after peat production are unknown. Because of this, the exact monetary impact on the peat production was left with uncertainty and the selected category was used.

2. Pre-Post Evaluation Figure 8 shows the results of a questionnaire administered to participants after the decision analysis process. Missing from this is any indication of whether the participant's preferred alternative changed as a result of participating in the decision analysis workshops. If possible, the authors should develop a very brief survey that could be administered to the 19 participants asking whether engagement in the decision analysis process changed their preferred alternative. The questionnaire should be carefully designed to minimize recall bias.

Response:

Since this decision analysis process was based on 'value-focused thinking' (Keeney 1992), the alternatives were formulated during the process and they were based on the stakeholder's objectives elicited in the workshops. In short, there were no pre-process alternatives. The preferences and viewpoints of the stakeholders may not have changed much, but because there is more understanding of the reasoning behind different views and overall problems of groundwater management, deliberation and co-operation is now easier. As our intention in this paper is to analyse "whether there is any improved understanding of the groundwater issue in the Rokua area among the participants after the MCDA process, and if there is, how the applied approach enhanced the conditions for learning", we can say based on the results of a questionnaire that some learning occurred among stakeholders.

Keeney R. Value-focused thinking. A path to creative decisionmaking. Cambridge, MA: Harvard University Press; 1992.

3. Comparison of Results with Larger Literature One of the most striking results from this work is that although the stakeholders represented divergent interests with different priorities, the MAU model for each of these participants identified Alternative C as the preferred choice, as shown in Figure 6. The authors should comment on whether this result could be an artifact of functional form flaws in the MAU model (for example, failing to consider nonlinearity in individual attribute utilities and/or interactions among

attributes). Also, the authors should comment on how this particular finding (the MAU process leading all 19 stakeholders to the same preferred alternatives) is common or rare in the decision analysis application literature.

Response:

This case study identified three alternatives together with stakeholders (Table 2). These are: Business-as usual, GW-area expansion and Active restoration. The stakeholders are generally aware of the current problems, which are closely associated with the Business-as usual situation. This is especially so after the second workshop when the problems were presented with the scientific findings to the stakeholders. The low preference to this alternative is therefore expected. Between the GW-area expansion and Active restoration, the results show clear preference among stakeholders to the latter. The attribute values shown in Table 2 can give some explanations. The GW-area expansion (alternative B) involves a wide range of losses of the recreation values of second homes (0 to -230,000 ERO, Table 2), while benefits associated with other criteria are either insignificant or uncertain (0/+). The alternative C, Active restoration, shows more benefit gains/less losses compared with alternative B for all the criteria, except for profitable forestry. As this criterion mostly affects forest owners in the next 30 years, the stakeholders may discount its effect to some extent, even for the forest owners as there is no certainty that they will remain in the sector during this time span. Given this situation, a high consensus on the alternative C among the stakeholders is reasonable.

We would like to note that the literature on decision analysis shows diverse results regarding the level of consensus on the preference of alternatives among stakeholders. Some found high consensus among stakeholders on certain alternatives (e.g., Hostmann et al., 2005a, b; Stefanopoulos et al., 2013), and others showed wide conflicts (e.g., Calizaya et al. 2010; Bryan et al., 2010). The level of consensus or diversity is highly depended on individual cases.

We realized the problem concerning the text 'linearity of attribute values' in the original manuscript. In fact, we did not make linearity assumption in eliciting the attribute values, but obtained them directly from the stakeholders who were asked to give the values on the scale between 0 and 1. There is not effect of a linearity assumption in the results. In the revised manuscript, this paragraph is rewritten and the confusion is clarified.

References:

Stefanopoulos, K., Yang, H., Gemitzi, A. Tsagarakis, K.P., 2013. Application of multi-attribute value theory for engaging stakeholders in groundwater protection in the Vosvozis catchment in Greece. Science of the Total Environment. In press.

Calizaya, A; Meixner, O; Bengtsson, L; Berndtsson, R, 2010. Multi-criteria Decision Analysis (MCDA) for Integrated Water Resources Management (IWRM) in the Lake Poopo Basin, Bolivia. WATER RESOURCES MANAGEMENT Volume:24 Issue:10 Pages:2267-2289 DOI:10.1007/s11269-009-9551-x

Bryan, BA; Grandgirard, A; Ward, JR. 2010. Quantifying and Exploring Strategic Regional Priorities for Managing Natural Capital and Ecosystem Services Given Multiple Stakeholder Perspectives. ECOSYSTEMS. Volume:13 Issue:4 Pages:539-555 DOI:10.1007/s10021-010-9339-0 .

Hostmann M, Borsuk M, Reichert P, Truffer B. Stakeholder values in decision support for river rehabilitation. Arch Hydrobiol Suppl 2005;155:491–505. Hostmann, M., Bernauer, T., Mosler, H.J., Reichert, P., Truffer, B. 2005b. Multi-attribute value theory as a framework for conflict resolution in river rehabilitation. Journal of Multiple Criteria Decision Analysis 13 (2–3): 91–102.

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