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In this paper a tractable methodology is presented to improve environmental sustainability by incorporating stakeholders' intensities of preferences into the decision making process. The environmental decision making will be controversial when there is a complex issue at hand. The difficulty comes up as stakeholders cannot see how their preferences are taken into account in the policy making process. To reduce this controversy, we propose a qualitative method to elicit stakeholders' intensities of preferences towards a set of environmental services. Subsequently, the elicited intensities of preferences are aggregated by a mathematical approach on each single criterion. Finally, a multi-criteria approach is applied to use the aggregated values across all criteria to provide the analyst with a rank order of existing alternative plans. In this way, the stakeholders are able to verify that their opinion is taken into account, even if it is contrary to the majority voice. The natural resources manager will benefit from an increased insight into the prevalent opinion on each of the criteria through the supplied social intensities of preferences, enabling a more easily communicated justification of the final decision, and an augmented tractability of the decision making process.

Keywords: Sustainability, stakeholder's preferences, tractable decision making, social support, qualitative valuation

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1. Introduction

The aim of this paper is to introduce a methodology to incorporate stakeholders' intensities of preferences into the environmental decision making to enable the natural resources manger to formulate an acceptable decision. Any complex environment with a diversity of economic, ecological and social services will be a centre of attraction for different social groups. To allow ecological economists to develop value indicators for decision making, they need to identify the services provided by the ecosystem and to determine the value that each of these services provide to the interested social groups. But in order to do so, they must understand and acknowledge the inherent complexities of economic, ecological and social systems. Because of these complexities, environmental valuation practitioners have introduced different valuation methodologies to elicit people's preferences. Environmental valuation approaches such as Contingent Valuation Method (CVM) or Deliberative Monetary Valuation (DMV) (Spash, 2007), simply use a common scale (e.g. monetary) to make direct trade-offs between environmental criteria and market products to estimate individual or social Willingness to Pay (WTP) respectively. However, economic efficiency is only one of a diversity of the indicators that can guide decision making. These methods have therefore received considerable criticisms coming from economic (Hausman, 1993; Diamond and Hausman, 1994; Knetsch, 1994; Vatn, 2004), political (Cookson, 2000; Smith, 2003; Tompkins, 2003) and psychological fields (Kahneman et al., 1999; Vatn, 2004).

Valuation methodologies mostly provide inputs for decision making approaches such as Cost-Benefit Analysis (CBA), Group Decision Support System (GDSS) or Multi-Criteria Decision Aid (MCDA) to establish a social decision among different courses of action (Stirling, 1997; Varma et al., 2000; Stagl, 2003; Munda, 2004; Springael and De Keyser, 2004; Stagl, 2005; Howarth and Wilson, 2006; Spash, 2007). In presence of multiple Decision Makers (DMs), natural resources managers always have difficulties to convince people how their preferences have been taken into account in the decision making process (Matsatsinis et al., 2005). In the recent years, some new methodologies such as Multi-Criteria Mapping (MCM) (Stirling, 1997), Deliberative Multi-Criteria Evaluation (DMCE) (Proctor and Drechsler, 2003) and other combined valuation methods have been introduced to improve the preference elicitation steps as well as the tractability of the decision making process (Stirling, 1997; Stagl, 2003; Stirling and Mayer, 2004; Munda, 2006). Although these new methods have enabled the manger to consider multiple dimensions of a problem, they introduce some new difficulties to stakeholders. For example, in DMCE, DMs need to reach a consensus on the problem at hand. However, when the issue is very controversial and a diversity of social groups is involved, neither a consensus is an easy target to achieve nor it is representative of the groups' opinions. Furthermore, most of these methods need to convert stakeholders' ordinal preferences to cardinal values to be able to proceed with the aggregation step, which is mostly confusing and problematic for stakeholders (Godo and Torra, 2000; Vatn, 2004; Zendehdel et al., in press).

To eliminate the criticisms, we propose a methodology that firmly roots in respect for the three central properties of environmental decision making: environmental and social complexity, incommensurability between environmental criteria (no trade-off between different criteria) and plurality of environmental values. The methodology partly consists of an exploratory discussion among different groups of stakeholders, who will be identified based on a stakeholder analysis, to broaden their view on the problem at hand. This can be achieved by allowing each stakeholder group to formulate their interests in the area, which will lead to the identification of the multitude of environmental criteria under discussion and environmental plan(s). The second step in the methodology is individualistic. In this step, stakeholders first attach a qualitative indicator from a list of indicators as a weight to each criterion. Then, impacts of plans on each criterion, Alternative Impacts (AIs), will be used to elicit stakeholders' preferences on each single criterion by asking them to rank the AIs on each selected criterion. In the next step, pairwise comparisons of the AIs on the constructed rank order allow the stakeholders to express their intensity of preference for each pair of AIs.

By having stakeholders' intensities of preferences and criteria weights (stakeholders' inputs), one needs to apply a tractable process to establish a group decision that meets social support. Doing so, we propose to use a mathematical approach OSDL (Ordinal Stochastic Dominance Learner) (Lievens, and De Baets, in press; Lievens, et al. in press), to provide social intensities of preferences to be used as an input into an outranking method (ARGUS). ARGUS stands for Achieving Respect for Grades by Using ordinal

Scales only, and it is capable to handle quantitative and qualitative information in the same way (De Keyser and Peeters, 1994). Therefore, the social intensities of preferences and social weights will simultaneously be processed by ARGUS to provide a rank order of the alternative plans (De Keyser and Peeters, 1994; Springael and De Keyser, 2004). Due to the use of the social intensities of preferences and social weights, the number of intensities and weights that need to simultaneously processed, is reduced. In this regard, the natural resources manager and DMs will then benefit from an increased tractability in the decision making process.

2. A multi-criteria deliberative approach to elicit stakeholders' intensities of preferences on multiple environmental criteria

The methodology starts with Stakeholder Analysis (SA) to identify the different social groups which benefit from environmental services in the area. Subsequently, group discussions will be conducted among representatives of the social groups to define environmental problems and to establish a list of environmental criteria and applicable alternative plans to support the criteria. Next, the lists of environmental criteria and alternative plans are given to a group of experts to construct an Impact Matrix (IM). Table 1 provides us with an IM, which is a part from an IM related to a rangeland decision making study (Lar rangeland) (Zendehdel et al., in press). In the IM one can find the criteria but the names of proposed plans are removed from the table, which its reason will be explained later in this section.

Once this matrix is obtained and AIs are determined, the question is how stakeholders can use these AIs to express their preferences in a straightforward manner. As psychologists have indicated, human cognitive capacity is quite limited and people cannot take a large number of alternatives into account at the same time to come up with a right choice (Miller, 1955; De Keyser and Peeters, 1994; Cookson, 2000; Saaty and Ozdemir, 2003). To eliminate this problem, environmental criteria are considered once at a time and the stakeholders are asked to rank and then make parwise comparisons between AIs on each single criterion. Therefore, stakeholders compare the usefulness of alternative plans on each single criterion by providing a rank order of the plans without the need to take other criteria into account. However, in presence of conflicts among social groups (which is mostly the case) one cannot use directly alternative plans to elicit stakeholders' intensities of preferences (De Keyser and Peeters, 1994). In other words, using alternative plans to elicit stakeholders' preferences where there are conflicts among the stakeholders, will influence their preferences and motivate them to act politically and express biased preferences. In this regard, the name of each plan is eliminated from the IM and AIs are used to elicit stakeholders' preferences and their intensities. The following section provides more information on the elicitation of stakeholders' intensities of preferences.

Table 1. Impact matrix of different alternative plans on environmental criteria

Plan	Climate regulation **a**	Soil conservation **b**	Plant diversity **c**	Wildlife diversity **d**	Security of habitat **e**	Cultural attributes **F**	Social education **g***	Recreation **h***
1	strong increase in support a_1	5 tonnes per hectare per year b_2	moderate increase in support c_3	strong increase in support d_1	strong increase in support e_1	fully compatible f_1	6 g_2	4 h_3
2	small increase in support a_2	7 tonnes per hectare per year b_4	small increase in support c_4	no increase in support d_4	no increase in support e_4	slightly compatible f_2	3 g_4	5 h_2
3	no increase in support a_2	4 tonnes per hectare per year b_1	strong increase in support c_2	small increase in support d_3	moderate increase in support e_2	moderately compatible f_2	5 g_3	3 h_4
4	moderate increase in support a_1	6 tonnes per hectare per year b_3	very strong increase in support c_1	moderate increase in support d_2	small increase in support e_3	incompatible f_3	7 g_1	8 h_1

* The scores range from 0 to 10, where a score of 10 corresponds to availability of the service up to the maximal theoretically realisable capacity and a score of 0 corresponds to unavailability of the service

3. Elicitation of criteria weight and stakeholders' intensities of preferences

3.1 Construction of an impact matrix

Table 1 presents us with an IM. To simplify the impacts in the IM , we present the criteria with **a** to **h** respectively, and denote the specific AIs for each criterion with subscripts 1, 2, … up to the number of distinct AIs proposed by the 4 hypothetical plans. We have opted to use a natural ordering to assigns subscripts to AIs, i.e., the AI denoted with subscript 1 is the ecologically most desirable impact proposed. For example, all other things remaining equal, taking measures to promote wildlife diversity is ecologically more desirable than doing the opposite. Hence, the AI of *strong support* for the Wildlife Diversity criterion ($\mathbf{d}$) would be denoted d_1, as it is the largest increase in support proposed by one or more of the four plans, in this case by the first of the four plans. Obviously, it is not always the case that the first plan proposed the environmentally optimal choice, as can be easily verified in Table 1. Consequently, for the criterion $\mathbf{d}$ the AIs d_1, d_2, d_3 and d_4 stand for *strong increase*, *moderate increase*, *small increase* and *no increase in support* respectively. For the Recreation criterion ($\mathbf{h}$), the values of h_1, h_2, h_3 and h_4 stand for *score 8*, *5*, *4* to *3* respectively (denoting on a 0 to 10 scale to what extent the recreational facilities of Lar rangeland will be exploited).

3.2 Weighting the environmental criteria

Based on people's experience to use qualitative labels to attach weights to different objectives (Cook and Seiford, 1984; Liljas and Lindgren, 2001; Vatn, 2004), qualitative indicators are used to order environmental criteria. The qualitative labels are: *Unimportant (Uim) – Little important (Lim) – Moderately important (Mim) – Very important (Vim) – Extremely important (Eim)*. The stakeholders should use these labels to express how important each of the criteria is, according to their own view. The weights should be attached prior to the elicitation of the intensities of preferences.

To elicit stakeholders' intensities of preferences, two steps are needed: the stakeholders indicate their preferences by making a rank order of AIs, after which they express the intensities of their preferences by using a qualitative scale.

3.3 Elicitation of stakeholders' preferences

An individual's preferences can be represented by an ordinal utility function (ordinal rank order) without necessitating the existence of a common scale and making trade-offs between environmental criteria (Cook and Kress, 1985; Liljas and Lindgren, 2001; Cook, 2006). Each stakeholder can rank the AIs for each criterion in a different way, they neither need to agree with each other nor with the environmentally optimal ordering. To come up with an ordinal utility function, respondents are individually will be asked to provide a rank order of AIs on each single criterion. In the Choice Experiment (CE), researchers use alternative plans and their attributes to elicit respondents' preferences (Garrod and Kenneth, 1999), but in our methodology the AIs (and not the alternative plans) are used to establish the stakeholders' ordinal utility function. In this regard, respondents should first rank these AIs for each criterion according to their personal preference, without the possibility of easily doing so on the basis of political motivations. Tables 2 and 3 show rank orders of AIs for the Wildlife Diversity and the Recreation criteria, as well as the frequency of each rank order for 31 stakeholders related to the Lar rangeland study (Zendehdel et al., in press). As can be seen in Table 2, it is possible to have a majority view among the rank orders or the rank orders do not show any majority. For example, a 50% majority exists among the rank orders of AIs for the Wildlife Diversity criterion (18 stakeholders out of the 31 chose $d_1>d_2>d_3>d_4$ as their rank order), while there is no such majority among the rank orders for the Recreation criterion.

3.4 Elicitation of stakeholders' intensities of preferences

The main difficulty faced by researchers in environmental valuation is eliciting respondents' intensities of preferences in a way that respects the three properties of incommensurability, complexity of environmental criteria and plurality of environmental values. As explained previously, the stakeholders provided us with a rank order (ordinal utility function) of AIs on each single criterion in the last step of the methodology. However, an ordinal utility function is weak as it does not give any information about stakeholders' intensities of preferences (Spash, 2007). This weakness can be circumvented by asking respondents to express their intensities among each pair of AIs (Springael and De Keyser, 2004). The scale of these intensities can be quantitative as well as qualitative. But as people use a qualitative format to express their intensities of preferences between two alternatives in every day life, using a later scale is preferred to the former.

Table 2- Rank orders of AIs for the Wildlife diversity criterion (***d***)

Number of respondents	Rank order
18	$d_1>d_2>d_3>d_4$
3	$d_3>d_4>d_2>d_1$
3	$d_4>d_3>d_2>d_1$
2	$d_2>d_1>d_3>d_4$
1	$d_2>d_3>d_1>d_4$
1	$d_2>d_4>d_3>d_1$
1	$d_3>d_2>d_4>d_1$
1	$d_4>d_2>d_3>d_1$
1	$d_2>d_3>d_4>d_1$
d_1: Strong increase **d_2: Moderate**	**d_3: Small increase** **d_4: No increase**

Table 3- Rank orders of AIs for the Recreation criterion (***h***)

Number of respondents	Rank order
11	$h_2>h_3>h_4>h_1$
9	$h_1>h_2>h_3>h_4$
8	$h_2>h_4>h_3>h_1$
2	$h_2>h_1>h_3>h_4$
1	$h_3>h_4>h_2>h_1$
h_1: Score 8 **h_2: Score 5**	**h_3: Score 4** **h_4: Score 3**

To prevent using quantitative valuations, we propose a purely qualitative approach. To do this, stakeholders are asked to make pairwise comparisons between AIs and express their intensity of preference on a 5 point qualitative scale: *very small preference (vsm)* - *small preference (sm)* - *moderate preference (mo)* - *strong preference (st)* - *very strong preference (vst*). To facilitate a respondent to be consistent on their intensities of preferences during the pairwise comparisons, a preference matrix is constructed based on each stakeholder's rank order of AIs (De Keyser, and Peetres 2004). Table 4 shows such a preference matrix and its properties for the Recreation criterion (**h**).

Table 4- General structure of a preference matrix for the Recreation criterion (h)

Criterion **h**	h_1	h_4	h_3	h_2
h_1	Indifferent			
h_4		Indifferent		
h_3			Indifferent	
h_2				Indifferent

The table shows $h_2>h_3>h_4>h_1$ (abbreviated as $h_2h_3h_4h_1$) as an example of a rank order in which AIs for the Recreation criterion (**h**) have been established from worst to best (left to right and top to bottom). Each cell in the lower left triangle should be filled in by one of the values from the qualitative indicators. The stakeholders should follow a simple consistency rule to express their intensities of preferences: the intensity of preference should neither decrease from top to bottom nor from right to left in the preference matrix (Table 4). This means that if a respondent expressed a strong intensity of preference for one of the top left cells, such as the preference of h_4 over h_1, (h_4h_1) then he cannot indicate a weaker intensity of preference in one of the cells that lie immediately below, such as for the preference of h_3 over h_1 (h_3h_1) or for that of h_2 over h_1 (h_2h_1) as the rank order is $h_2h_3h_4h_1$ (Table 4). The pairwise comparisons should be done for each single criterion and the respondents do not need to make trade-offs between different criteria. This helps stakeholders to focus on just one criterion and express their intensities of preferences based on that specific criterion without having to take into account other criteria (Springael and De Keyser, 2004).

An example of a completed preference matrix is provided in Table 5 for the Recreation criterion (**h**). It shows the intensities of preferences of a respondent whose rank order is $h_2h_3h_4h_{1.}$ The respondent filled in the lower triangle with the qualitative intensities (shown in bold). As one can see the expressed intensities have a consistent structure (monotonicity) and follow the mentioned rule. The significance of the upper part of the triangle (containing negative values) will be explained in Section 5. Based on the elicited intensities of preferences for each criterion for all respondents, we want to calculate the social intensities of preferences. This will be done through the steps we discuss next.

Table 5- Completed preference matrix for the Recreation criterion (h)

Criterion ***h***	h_1	h_4	h_3	h_2
h_1	Indifferent	$-mo$	$-st$	$-vst$
h_4	$+mo$	Indifferent	$-st$	$-st$
h_3	$+st$	$+st$	Indifferent	$-vst$
h_2	$+vst$	$+vst$	$+vst$	Indifferent

4. Construction of social intensities of preferences and social weight on each single criterion

4.1 Establishing a social rank order among individual rank orders

To determine social intensities of preferences, first a social rank order is needed among the stakeholders' rank orders of AIs on each single criterion. A social rank order can be reached according to different ranking rules. In absence of strategic considerations, one can identify the most preferred alternative among different pairwise comparisons based on the Condorcet criterion. The preferred alternative among a set of alternatives is the one that receives a majority of votes over the other alternatives (Condorcet winner) (Craven, 1992; Nurmi, 1999). For the Wildlife Diversity criterion (**d**), a majority rank order ($d_1d_2d_3d_4$) is shown to exist among the rank orders. However, we have no such majority for the Recreation criterion (**h**). In this case we determine the Condorcet winner as the social rank order $h_2h_3h_4h_1$. In case of a Condorcet cycle, we propose to resolve the paradox in a way that results in a minimal number of protest voices among stakeholders. Therefore, we recommend to use Condorcet's maximal agreement method, also known as Kemeny's approach (Mas-Colell et al., 1995; Nurmi, 1999).

4.2 Establishing social intensities of preferences based on the social rank order

After establishing a social rank order of AIs on each single criterion, the second step is to construct the social intensities of preferences based on the social rank order. This can be done based on the median value among the intensities of preferences while taking the social rank order and stochastic monotonicity into account. In the case of respondents indicating different preferences, not everyone will fully agree with the social rank order. As one can see in Tables 3 and 4, the rank orders can differ from one individual to the next. For those whose rank order is different from the social rank order, we are unable to directly use the intensities of preferences to obtain a social value based on each pair of the social rank order. To be able to use every respondent's intensities of preferences, we opted to mirror the intensities of preferences for all individuals (Table 5, upper triangle). This step enables us to have all possible pairwise comparisons (12 pairs based on 4 AIs).
For such a multitude of opinions and a single social rank order, the problem is thus to compute a monotone structure on the basis of a collection of such partially non-monotone structures of AIs. Instead of the regular monotonicity constraint, which is simply not applicable to distributions, the distributions of intensities for the preferences in the social rank order are bound by the stochastic monotonicity constraint. The concept of stochastic monotonicity is of great importance, as it is a required property if one aims to regard the social rank order as one that accurately reflects the group consensus (Cao-Van and De

Baets, 2004; Lievens and De Baets, in press; Lievens et al., in press). Stochastic monotonicity is defined on cumulative distributions. One distribution is said to dominate another one, if, seen as functions, it lies below this second one. Two distributions are stochastically monotone w.r.t. each other if the one that should contain the higher values, dominates the one that should contain the lower values. If this is not the case, the distributions are not stochastically monotone w.r.t. each other. In this way, stochastically non-monotone distributions on the intensities of preference do not only signify that the group is not in consensus on the rank order of the AIs, but can even lead to inconsistent social intensities of preference. Presence of stochastic monotonicity between distributions of AIs can be guaranteed by applying OSDL.

The Ordinal Stochastic Dominance Learner (OSDL) framework (Lievens et al., in press) consists of a main theorem that helps building monotone distribution-based classifiers. One of these classifiers is OSDL, which is only one of several variants of an algorithm to solve the supervised ranking problem. As we are dealing with distributions of intensities for each pairwise comparison of AIs, the explicit distribution-based approach makes this framework very well suited to our particular problem. We give here only a limited introduction to the framework, more information can be found in (Lievens et al., in press). The input to the algorithm will be the (possibly stochastically non-monotone) set of distributions, and the output will be a stochastically monotone set of distributions. We propose to regard these monotone distributions as a necessary reflection of the group consensus on the relative order of the preferences (i.e. which preference is implied by the other one) or the social rank order.

4.3 Providing social weights of criteria

As the stakeholders used linguistic labels to attach weights to the criteria, one can choose the median among the attached weights as a social weight for that criterion. It is also possible to take the median from those whose rank order is identical to the Social Rank Order of Alternative Impact (SROAI) on the given criterion. It might be reasonable to take into account only the weight of those stakeholders agreeing with the social rank order, as taking into account the weight of those stakeholders that do not agree with the social rank order, could result in protests: a decision they did not support, could receive a greater weight because of their input. On the other hand, it is very well possible that only few stakeholders or none of the stakeholders chose the SROAI, in which case the median of those agreeing with the rank order can hardly be considered to be representative for the entire group of stakeholders. For this reason we recommend using the first approach to establish social weight.

5. Using ARGUS to determine the group decision based on social intensities of preferences and weights of criteria

After providing social intensities of preferences and weights of criteria, one should choose a compatible MCDA with respect to the structure of data to be used to establish a group decision. Among different MCDA the outranking methods have some advantages to others (Kangas et al., 2001; Proctor and Drechsler, 2003; Cook, 2006; Munda, 2006). Outranking methods are able to deal with uncertain, qualitative and quantitative preferences of DMs (Proctor and Drechsler, 2003; Springael and De Keyser, 2004). We opt to use ARGUS in our methodology, as it is an outranking method that can handle qualitative and quantitative preferences without requiring the decision criteria to be commensurable (De Keyser and Peeters, 1994; Springael and De Keyser, 2004). The method uses concordance and discordance indices to determine a credibility matrix to establish a pre-order relation of alternatives. As ARGUS processes criteria without supposing commensurability, it does not necessarily output a rank order, i.e., some alternatives may become indifferent, while others remain incomparable (De Keyser and Peeters, 1994). A stakeholder needs only to enter, for each criterion, his/her weight and intensities of preferences. In our method, we will let ARGUS determine the group decision by entering the social weights and social intensities of preferences.

ARGUS combines intensities of preferences with weight of the corresponding criterion to provide an indicator with a specific rank number and a positive or negative sign depending on the direction of preference (De Keyser and Peeters, 1994; Springael and De Keyser, 2004). The indicators constitute a totally ordered set, and indicators with lower rank numbers are the result of stronger intensities of preferences and/or higher weight than those with higher rank numbers. Each combination of intensities of preferences and weight corresponds to a specific indicator, though multiple combinations can yield the same one. Based on these negative and positive symbols for all criteria, one can establish a relation of outranking, indifference or incomparability between two alternative plans.

6. Conclusion

Environmental sustainability requires sustainable decision making, which in turn requires the incorporation of the stakeholders' preferences into the decision making process. This process increases the acceptability of the final decision (Pearce, 1993; Pykäläinen et al., 1999; Proctor and Drechsler, 2003). Decision aiding methodologies need to be judged w.r.t. their consistency and transparency, key factors in meeting social support towards the group decision. In this regard, it is reasonable to pay special care to correctly process stakeholders' intensities of preferences, as they are related to the strength of their conviction to support or oppose a plan. In our methodology, stakeholders' intensities will be maintained in every step of the decision making process, so as to determine the group decision in a consistent way.

Because even the best understood methodology will no longer be tractable if the number of inputs is too large, we opt to input social intensities of preferences and social weights into ARGUS, rather than each individual stakeholder's intensities of preferences and weights of criteria. Even though the calculation of the social intensities of preferences amounts to an increase in complexity of the application of the MCDA, we feel the methodology as a whole becomes more understandable and tractable as a result. The provision of social intensities of preferences and social weights helps both stakeholders and natural resources mangers to see the diversity of opinions, as well as the overall social choice for each single criterion. Moreover, it is clear that the methodology does not take into account solely the majority's view, as more contested criteria will by construction receive lower social intensities of preferences through the use of OSDL. We focus on the intensities of preferences as the reasons why one plan will meet with less opposition and more support than another one. This is in contrast with GDSS approaches which mostly focus too much on the stakeholders' preferences and not enough on the corresponding intensities (Matsatsinis et al., 2005). Stakeholders will understand that decreased intensities of preference will lead to lower rank numbers in ARGUS, causing the corresponding criteria to play a smaller role in the determination of the final decision.

Minority groups will consequently be able to see and understand how their voices were taken into account in the social rank orders when performing the conflict resolution. All stakeholders will therefore more readily accept the group decision, which in turn improves the environmental sustainability. This is due in part to the fact that we opt to resolve conflicting preferences and corresponding intensities as soon as possible, rather than waiting until the very end, by resolving conflicting rank orders of alternatives. The SROAIs will also prove invaluable if ARGUS should output not a total rank order, but rather indicate some incomparability among plans. On the basis of the SROAIs and associated intensities, a natural resources manager can more easily understand how exactly the incomparability arises. More importantly, through the SROAIs, social intensities and social weights, the natural resources manger can determine the expected opposition or support to the choice of one incomparable plan over another.

References

Cao-Van, K. & De Baets, B. (2004) An instance-based algorithm for learning rankings. Proceedings of the Thirteenth Dutch-Belgian conference of machine learning. Brussels, Belgium.

Cook, W. D. (2006) Distance-based and ad hoc consensus models in ordinal preference ranking. European Journal of Operational Research, 172**,** 369-385.

Cook, W. D. & Kress, M. (1985) Ordinal ranking with intensity of preference. Management Science, 31**,** 26-33.

Cook, W. D. & Seiford, L. M. (1984) An ordinal ranking model for the highway corridor selection problem. Computers, Environment and Urban Systems, 9**,** 271-276.

Cookson, R. (2000) Incorporating psycho-social considerations into health valuation: An experimental study. Journal of Health Economics, 19**,** 369-401.

Craven, J. (1992) Social Choice: A Framework for Collective Decision and Individual Judgments, Cambridge, Cambridge University Press.

De Keyser, W. S. M. & Peeters, P. H. M. (1994) ARGUS - A new multiple criteria method based on the general idea of outranking. Belgium, Vrije Universiteit Brussel.

Diamond, P. A. & Hausman, J. A. (1994) Contingent valuation: Is some number better than no number? Journal of Economic Perspectives, 8**,** 45-65.

Garrod, G. & Kenneth, G. W. (1999) Economic Valuation of the Environment. Methods and Case Studies, Cheltenham, Edward Elgar Publishing.

Godo, L. & Torra, V. (2000) On aggregation operators for ordinal qualitative information. IEEE Transactions on Fuzzy Systems, 8**,** 143-154.

Hausman, J. E. (1993) Contingent Valuation: A Critical Appraisal, Amsterdam, Elsevier.

Howarth, R. & Wilson, M. (2006) A theoretical approach to deliberative valuation: Aggregation by mutual consent. Land Economics, 82**,** 1-16.

Kahneman, D., Ritov, I. & Schkade, D. (1999) Economic Preferences or Attitude Expressions?: An Analysis of Dollar Responses to Public Issues. Journal of Risk and Uncertainty, 19**,** 203-235.

Kangas, A., Kangas, J. & Pykäläinen, J. (2001) Outranking methods as tools in strategic natural resources planning. Silva Fennica, 35**,** 215–227.

Knetsch, J. L. (1994) Environmental valuation: Some problems of wrong questions and misleading answers. Journal of Environmental Values, 3**,** 351-368.

Lievens, S. & De Baets, B. (in press) Supervised ranking in the WEKA environment. Information Sciences.

Lievens, S., De Baets, B. & Cao-Van, K. (in press) A probabilistic framework for the design of instance-based supervised ranking algorithms in an ordinal setting. Annals of Operations Research. doi: 10.1007/s10479-008-0326-1.

Liljas, B. & Lindgren, B. (2001) On individual preferences and aggregation in economic evaluation in healthcare. Pharmacoeconomics, 19**,** 323-336.

Matsatsinis, N. F., Grigoroudis, E. & Samaras, A. (2005) Aggregation and disaggregation of preferences for collective decision-making. Group Decision and Negotiation, 14**,** 217-232.

Munda, G. (2004) Social multi-criteria evaluation: Methodological foundations and operational consequences. European Journal of Operational Research, 158**,** 662-677.

Munda, G. (2006) Social multi-criteria evaluation for urban sustainability policies. Land Use Policy, 23**,** 86-94.

Nurmi, H. (1999) Voting Paradoxes and How to Deal with Them, Springer-Verlag Berlin.

Pearce, D. (1993) Economics Values and the Natural World, London, Earthscan Publications Limited.

Perkins, E. (2001) Discourse-based valuation and ecological economics. Annual Conference of the Canadian Society for Ecological Economics. McGill University, Montreal, Canada.

Proctor, W. & Drechsler, M. (2003) Deliberative multi-criteria evaluation: A case study of recreation and tourism options in Victoria, Australia. European Society for Ecological Economics, Frontiers 2. Tenerife, Spain.

Pykäläinen, J., Kangas, J. & Loikkanen, T. (1999) Interactive decision analysis in participatory strategic forest planning: Experiences from state owned boreal forests. Journal of Forest Economics, 5**,** 341-364.

Smith, G. (2003) Deliberative Democracy and the Environment, London, Routledge Press.

Spash, C. L. (2007) Deliberative monetary valuation (DMV): Issues in combining economic and political processes to value environmental change. Ecological Economics, 63**,** 690-699.

Springael, J. & De Keyser, W. (2004) A new generation of multi-criteria based group decision support methods. The 17th International Conference on Multiple Criteria Decision Making. Whistler, B. C., Canada.

Stagl, S. (2003) Multicriteria Evaluation and Public Participation: In Search for Theoretical Foundations. Frontiers 2: European Applications in Ecological Economics. Tenerife, Spain.

Stagl, S. (2005) Alternatives for Environmental Valuation – Part II: Methods and Applications. Annual Sustainable Development Research Conference. University of Sussex.

Stirling, A. (1997) Multi-criteria mapping. Mitigating the problems of environmental valuation? Valuing Nature? IN FOSTER, J. (Ed.) Ethics, Economics and the Environment. London, Routledge.

Stirling, A. & Mayer, S. (2004) Confronting risk with precaution: A multi-criteria mapping of a GM crop. IN GETZNER, M., SPASH, C. L. & STAGL, S. (Eds.) Alternatives for Valuing Nature. London, Routledge.

Tompkins, E. L. (2003) Using stakeholders' preferences in multi-attribute decision making: Elicitation and aggregation issues. CSERGE working paper, ECM 03-13.

Varma, V. K., Ferguson, I. & Wild, I. (2000) Decision support system for the sustainable forest management. Forest Ecology and Management, 128**,** 49-55.

Vatn, A. (2004) Environmental valuation and rationality. Land Economics, 80**,** 1-18.

Vatn, A. (2005) Institutions and the Environment, Northampton, Edward Elgar Publishing Limited.

Zendehdel, K., Rademaker, M., De Baets, B. & Van Huylenbroeck, G. (in press) Qualitative valuation of environmental criteria through a group consensus based on stochastic dominance. Ecological Economics. doi: 10.1016/j.ecolecon.2008.05.013.