Deliberative Multi-criteria Evaluation: A case study of recreation and tourism options in Victoria Australia

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Abstract

Multi-criteria evaluation is a well-tried and effective procedure for structuring and aiding complex decision-making processes — especially those involving environmental considerations. Formal deliberative processes have also been successful in aiding understanding and meeting consensus in complex and difficult decision problems which involve more than one decision-maker. Here, both approaches are combined to assist a group of natural resource managers decide on a suitable option for recreation and tourism activities in the upper Goulburn Broken Catchment of Victoria, Australia. This approach seeks to combine the advantages of Multi-criteria Evaluation providing structure and integration in complex decision problems with the advantages of deliberation and stakeholder interaction provided by a Citizens' Jury. First, a set of options and decision criteria were identified by the decision-makers. Next, the criteria were ranked to identify disparities in priorities for the decision-makers. A stakeholder jury process was then carried out with the decision-makers given the charge of coming to consensus on a set of weights for the criteria. Experts were called in to provide information on those criteria with wide disparities in priorities and a facilitated deliberative process was carried out including the requirement for decision-makers to support and defend their positions. A probabilistic Multi-criteria Evaluation software tool called ProDecX was used interactively to aid the decision-makers in their deliberations. It allows the simultaneous consideration of several stakeholders priorities and the assessment of the dissent within the group of decision-makers with respect to the criteria and options. In the process it helped to guide the group to the agreement on a single preferred option. An important outcome of the process was the discovery of some crucial aspects of the decision problem that require deeper understanding and assessment if that preferred strategy is to have the desired results. Some suggestions for improving the process were provided, but, in general, the stakeholder jury was regarded as a helpful and useful procedure by the decision-makers that aided them in their understanding of the issues of a complex decision-making problem.

1 Introduction

The Goulburn Broken Catchment of Victoria, Australia, covers an area of 2.4 million hectares that stretches from just north of Melbourne in the south to the Murray River in the north. The catchment is characterised by a myriad of environmental problems including soil salinity, rising water tables and poor water quality. About 200,000 people live in the catchment and land-uses include irrigated dairying and horticulture in the upper lowland catchment, dryland grazing and cropping in the middle regions and hobby farming, tourism and recreational uses in the southern highland parts of the region. The case study reported in this paper refers to this part of the catchment.

The upper catchment is renowned for the opportunity for the nearby population of Melbourne (3.4 million people) to enjoy the magnificent scenery and tourism activities that are offered there including skiing, four wheel driving, bushwalking, camping, horseriding or just sightseeing. The influx of tourists each year however have caused serious environmental problems for the area which need to be addressed quickly. Many of these problems are related to water issues in the catchment which have flow on effects for users further downstream. Both the Goulburn and Broken Rivers flow into the Murray River which has its mouth near the city of Adelaide in South Australia. Issues which effect water in the upper catchment therefore may also effect water as far away as Adelaide.

In this study, the problem of how to address and solve the complex issues of tourism management are addressed using a deliberative process aided by Multi-criteria Evaluation. This work is part of a larger study that seeks to find out more about the nature and value of Ecosystem Services in Australia (*The Ecosystem Services Project*, `http://www.ecosystemservicesproject.org/`). In identifying and prioritising the ecosystem services and other decision criteria, recommendations for improved management of recreation and tourism in the upper catchment are made.

Ecosystem Services include the life support activities that ecosystems provide for us, largely in an unrecognised and unpriced way. Examples of these include pollination, nutrient cycling and water regulation. Humans derive benefits from the natural ecosystems in which they live. Often, however, through human intervention, these services from ecosystems fail and costly technological means are sought to make up for this gap. For example, when the important processes of nutrient provision and waste disposal in healthy soils fail, then farmers spend large amounts of money improving soil structure, reducing soil sodicity and applying fertilisers. However, apart from a few isolated examples, we have virtually no appreciation of the nature or the value of the services that ecosystems provide in Australia.

The impetus for the project is based on the innovative and emerging belief that ecosystems can and should be characterised and managed as capital assets (see, for example, Cork and Shelton [2000]; CSIRO [2001]). This will, in turn, lead to greater investment and collaboration in valuing ecosystems, changes in the policy and practice of land management and to the development of new technologies. These presently unaccounted and unpriced services should be incorporated into the decision-making processes of natural resource management and policy in order to achieve ecologically sustainable development. In identifying and valuing the Ecosystem Services of the catchment, recommendations will be made for overcoming these problems through improved management practices utilising these services.

This paper begins by giving an overview of the theoretical frameworks of Multi-criteria Evaluation (MCE) and the deliberative process, the Citizens' Jury, upon which this work is based. Some problems that may be encountered in undertaking each technique in isolation and the advantages that may result from taking a combined approach are then reported. Next, steps in the combined approach are identified, and then a case study of the Deliberative Multi-criteria Evaluation is detailed. Finally, some conclusions are discussed.

2 Incorporating Deliberation and Participation into Natural Resource Management — The Citizens' Jury

An important aspect of the decision-making stage of resource/environmental policy-making in a democratic society, is the question of 'who decides?' In recent years, increasing attention has been given to incorporating public participation into natural resource policy formulation (Ross et al. [2002]; Cassels and Valentine [1988]; Fagence [1977]). The advantages of allowing public involvement in natural resource decision-making have been well documented and such participation often strives for wider community understanding and therefore sanctioning of the policies concerned. In this way it is hoped that decisions are more likely to command assent and therefore lead to the desired outcomes if they have been formulated with public support. Van den Hove [2000] gives justification for participatory approaches to environmental problems based on the characteristics of environmental issues including complexity, uncertainty, large temporal and spatial scales and irreversibility. These physical characteristics can, in turn, have consequences for social characteristics of the environment therefore justifying a participatory approach to decision-making[1].

Out of this desire for community involvement in decision-making processes for environmental policy formulation came the growing amount of interest in Australia in recent years in a process which combines public participation with deliberation — the Citizens' Jury.

The Citizens' Jury has it's origins in Germany in 1969 with Dienel's *plannungzelle* (planning cell) technique [Dienel and Renn 1995]. The first Citizens' Jury was conducted in 1971 in the United States by Crosby [1999]. Since then, this approach has had widespread use in deciding health issues in Europe and in environmental issues in both Europe and the United States . It has had limited but growing use in Australia (see, for example, James and Blamey [2000]; Robinson et al. [2002]).

The Citizens' Jury is based on the model that is used in western-style criminal proceedings and often involves a public decision-making process (such as the allocation of health funds or the identification of protected natural resource areas). The typical jury ranges from around 10 to 20 participants. The jury can be selected either randomly or by use of a stratified random sample to make it representative of the population. The jury is usually renumerated for their efforts and is given a specific charge which is well worded, clear and direct. Ideally the process uses a facilitator and the jury is given sufficient time to deliberate, ask questions and call 'witnesses' (or 'experts'). This may take several days. A process involving great complexity and which requires many witnesses may take much longer. Witnesses are chosen on the basis of their expert knowledge and can and should be selected to represent differing viewpoints. The jury should be comfortable that adequate time has been given to all viewpoints. The final outcome is usually a consensus position reached by the jury and usually documented in a report to the relevant agency that has established the jury.

[1] These social characteristics may include 'conflicts of interests between actors', a 'plurality of legitimate standpoints' and 'diffused responsibilities and impacts'.

3 Structuring the Decision-making Process — Multi-criteria Evaluation

Multi-criteria Evaluation (MCE), also known as Multi-criteria Decision Analysis (e. g. Bana e Costa [1990]; Munda [1995]; Gal et al. [1999]), is a means of simplifying complex decision-making tasks which may involve many stakeholders, a diversity of possible outcomes and many and sometimes intangible criteria by which to assess the outcomes. In many public decision problems, such as those involved with environmental policy, the objectives of the decision may conflict and the criteria used to assess the effectiveness of different policy options may vary widely in importance. MCE is an effective technique in which to identify trade-offs in the decision-making process with the ultimate goal of achieving compromise. It is also an important means by which structure and transparency can be imposed upon the decision-making process. Its origins lie in the fields of mathematics and operations research and it has had a great deal of practical usage by public planners in such areas as the siting of health facilities, motorways and nuclear reactors (e. g. Bana e Costa [1990]). In recent years it has gained popularity as a tool for making decisions involving complex environmental, economic and social issues (e. g. Beinat and Nijkamp [1998]; Proctor [2001]).

A Multi-criteria Evaluation seeks to make explicit the logical thought process that is implicitly carried out by an individual when coming to a decision. In complex decision-making tasks, which sometimes involve many objectives and many decision-makers, this structured process may be lost in the complexity of the issues. In general, a MCE seeks to identify the alternatives or options that are to be investigated in coming to a decision, a set of criteria by which to rank these alternatives, the preferences or weights the stakeholders assign to the various criteria and an aggregation procedure by which the criteria-specific rank orders are aggregated into a single 'compromise' rank order. The last step should involve an extensive sensitivity and robustness analysis to explore how different preferences affect the outcome of the aggregation and how robust the compromise rank order is with respect to deviations in the preferences [Roy 1998]. The ultimate outcome is a preferred option or set of options that is based upon a rigorous definition of priorities and preferences decided upon by the decision-maker. Several iterations of the above process and interactions between the analyst and decision-maker can aid the decision-making. Although many specific types of MCE have been formulated, in the context of this research, MCE is primarily regarded as an aid in the process of decision-making and not necessarily as a means of coming to a singular optimal solution. As such, the MCE process is valued for the enlightenment and unravelling of issues that it can provide in the decision-making problem. The process adds to the knowledge of the decision-maker and is greatly aided by including the decision-maker in each step of the analysis. The approach followed in this current research is therefore very much within a 'heuristic' framework.

4 Advantages and Disadvantages of Both Approaches in Isolation

Multi-criteria Evaluation has the advantage of being able to provide a framework to complex decision-making problems that allows the problem to be broken down into workable units and to be structured in such a way that enables the complexities of the problem to be unravelled. This is done essentially through the process of identifying options, criteria and preferences. Applying MCE in a heuristic way enables the MCE to aid in the learning process of complex issues. In theory and in practice however, MCE does not adequately address the facilitation issue of interaction between analyst and decision-makers to elicit and revise preferences as part of the iterative process particularly with multiple decision-makers. With multiple decision-makers, MCE does not provide clear guidelines on how to analyse or aggregate multiple weights. Citizens' Juries, on the other hand, do allow for an effective approach of interaction between multiple decision-makers and for conducting an iterative process chiefly through the deliberative aspects of the jury approach. In effect, the Citizens' Jury approach aggregates multiple preference weights through deliberation to achieve consensus. In general however, Citizens' Juries have not addressed the problem of structuring the decision-making task. Lenaghan [1999] found that juries that had a structured and well-focused agenda performed and were able to engage much better than those that had to deal with large-scale unfocused problems.

A logical progression to overcome the problems and to enhance the advantages of both methods is to combine the two approaches. A new form of decision-making aid which combines the facilitation and deliberation qualities of the Citizens' Jury process with the analytical and integrating qualities of Multi-criteria Evaluation is now described.

5 A Combined Approach — Steps in a Deliberative Multi-criteria Evaluation

5.1 Choosing the jury

In a Citizens' Jury, the jurors can be selected based on a demographic overview of the population that will be affected by the decision. The choice of jurors can be made using a random sample or a stratified random sample of this relevant population. Citizens' Juries may use a selection process based on a telephone survey in which both demographic and attitudinal data is collected. Such data may include gender, age, place of residence, ranking of the environment in relation to other social issues, occupation, income, income source and level of education.

5.2 Choosing the options and objectives

The choice of options and of the overall objective or objectives of the decision (i. e. those that are to be met ultimately by the chosen option) are important and closely related steps in any decision-making process. Although the jury should choose the objectives and options, input from other sources, such as expert advice, can occur. The options may even be based on output from computer simulation models. Often, the options and objectives that are to be decided upon are already given, for example, by the political process. The objective can be as broad as necessary, but in the case of multiple decision-makers, overall agreement should be reached. The options could reflect each of the preferred scenarios of the decision-makers or could be based on an amalgamation of plans of the decision-makers. Massam [1988] suggests a benchmarking approach as a framework for the options which should include:

- the status quo
- an ideal best plan
- an hypothetical worst plan, and
- a plan of minimum satisfaction.

The options should be sufficient in number, however, to represent a realistic selection for the decision-maker but should not be too numerous to make the analysis unwieldy or unnecessarily complex. Often, options can be rejected on the basis of budgetary or other constraints.

The chosen objective(s) should reflect the desired outcome of the decision-making process to give clear and unambiguous purpose to the chosen option.

5.3 Selecting the criteria

The jury should be given the task of selecting the criteria which are designed to compare and assess each of the options and therefore must relate to the overall objective of the decision-making task. Initially, criteria can be very broad and then broken down into components or sub-criteria and even lower level sub-criteria. Ideally, the lowest level of the criteria structure are those which are measurable (quantitatively or qualitatively) and are known as indicators. In general, the criteria should be complete and exhaustive in that they cover all possible aspects of the decision-making problem and make the analysis complete; at the same time, the criteria should be mutually exclusive (non-redundant) so as to prevent 'double counting' of aspects of the decision-making problem and to allow the main 'trade-offs' to be identified clearly (see, e. g. Bouyssou [1990]). The criteria should be clearly defined and directly relevant to the defined problem. Because it is often necessary to break criteria down into sub-criteria in order to make meaningful measurements, they should be decomposable into smaller measurable units. For example, a criterion such as 'quality of life' may be measured as an index based on the sub-criteria of level of income, access to health care and level of education. This relates to the next attribute, which is that the criteria should be minimal so that no other smaller set of criteria can be measured. Finally, the number of criteria should ideally be restricted so that weighting the criteria does not become unmanageable or difficult. Advice on the number of criteria or sub-criteria in any group varies but most practitioners regard 7 to 12 criteria as the maximum [Yoon and Hwang 1995].

Decisions concerning the environment and natural resource management can often be broken down into the broad criteria groupings of 'ecological', 'economic' and 'social and cultural'.

5.4 Weighting the criteria

In Multi-criteria Evaluations, the preferences of the decision-maker are accounted for by the weighting placed on each of the criteria and sub-criteria. These weightings may range from equal importance of all criteria, to a ranking of most to least important or to a relative weighting of all criteria (such as "criterion x is twice as important is criterion y") (see, e. g. Bana e Costa [1990]). The weights may be qualitatively expressed, quantitatively expressed or a mixture of both. In analyses which involve many different decision-makers, this can be the most important and informative part of conducting the whole process. It allows stakeholders to express differing views explicitly and it helps identify those areas which are of most importance to them and which warrant careful investigation. The weightings make explicit those areas which may ultimately require possible trade-off solutions and thus they provide a greater focus for a complex decision problem.

When the analysis concerns only one decision-maker, the mathematical incorporation of the preference weights into the decision-making problem is relatively straightforward, because here the preferences are unique (coming only from one person) and the only task is to elicit these preferences. There exists a wide range of methods for the elicitation of an individual's preferences (Maystre and Bollinger [1999]; Beroggi [2000]). When more than one decision-maker is involved (a so-called group decision), the process becomes more complex and controversial, as now the preferences or weights are not unique but variable among the participants of the decision process. Assuming that the preferences of each decision-maker can be expressed by a vector of quantitative weights (one weight for each criterion), we are confronted with a set of weight vectors. One may reduce this variability and reduce the set of weight vectors to a single weight vector by taking a simple average, a modal or even a median figure over the range of the weights. However, such reductions may lose important trade-off information related to the outcomes of the analysis under extreme weightings. Moreover, decision-makers with weights that are very different from the calculated averages are most likely to disagree to such a technocratic enforcement of a 'consensus' and may not wish to participate in the process any further. There is no clear consensus in the literature on how to reduce such weight variability among decision-makers.

The jury process can be used to great advantage in determining the weights of the criteria. The jurors discuss the relative merits of each of the criteria and call expert witnesses if necessary to help them reach a consensus on the weights. If consensus is not reached initially, then those criteria of greatest contention in priorities would be the subject of greater scrutiny in the process (see below).

5.5 Assessing the options

Beside the weightings of the criteria, the second component required in a Multi-criteria Evaluation is the assessment of the options with respect to each individual criterion or sub-criterion. The result of this multi-criteria assessment is an Impact Matrix, where each of its elements represent the evaluation or impact of an option according to a particular criterion. Each criterion identifies a rank order of options determined by the degree to which each option performs in the particular criterion. Considering all of the criteria, the decision-makers (even if there is only one) are faced with a set of rank orders of options that are most likely to differ from each other, because an option may naturally perform well in one criterion and poorly in another. In order to obtain a single compromise rank order, these multiple rank orders have to be aggregated in some way.

5.6 Aggregating the criteria

There exists a wide range of aggregation algorithms (Bana e Costa [1990]; Gal et al. [1999]). The aggregation procedure used in this study is based on the PROMETHEE (Preference Ranking Organisation Method for Enrichment Evaluations) multi-criteria decision aid which uses an outranking procedure as the basis of its evaluation [Brans and Mareschal 1990]. This procedure is utilised through the software program ProDecX which is also able to explicitly account for uncertainty when assessing various options [Klauer et al. 2002][2].

In outranking methods, the information contained in the Impact Matrix is used to compare all options in a pairwise manner for each criterion. For each criterion i ($i = 1, \ldots, n$) a preference function Π_i is developed showing the preference of one option a to another option b under the specified criterion i.

The preference $\Pi_i(a, b)$ of a to b is assumed to depend on the difference between the performances $g_i(a)$ and $g_i(b)$ of the two options:

$$\Pi_i(a, b) = f(g_i(a) - g_i(b)) \tag{1}$$

[2]Uncertainty in the performances of the options is explicitly considered and lowers the pairwise preferences: the less sure one is that an option a performs better than another option b, the less strong the preference of a over b is. ProDecX contains a probabilistic model to measure this effect. For more details concerning the software, see Klauer et al. [2002] or contact M. Drechsler.

The total preference of a to b can then be expressed as a weighted summation of all the individual preference functions for all criteria $i = 1, \dots, n$:

$$\Pi(a,b) = \sum_{i=1}^{n} w_i \Pi_i(a,b) \tag{2}$$

The weights w_i determine the priority or importance of each of the decision criteria in deciding between the various options. The ranking of the m options can then be completed in two different ways. The first reflects how strongly a dominates all the other options:

$$\phi^+(a) = \sum_{j=1}^{m} \Pi(a,j) \tag{3}$$

The second reflects how strongly a is dominated by all the other options:

$$\phi^-(a) = \sum_{j=1}^{m} \Pi(j,a) \tag{4}$$

The two methods of ranking may not always coincide and will therefore (as in real world decision-making problems) lead to an incomplete rank order of the options (for details, see Brans and Mareschal [1990]). Often decision makers ask for a complete rank order of options. This may be obtained by calculating the net flux, $\phi^+ - \phi^-$, for each option. The higher the net flux the better the rank of the option. In the present study the net flux was used to rank the options.

In ProDecX, for each criterion, the weights are sampled from the weights given by the decision-makers in a fair way, i. e. the weighting of each decision-maker contributes equally to the final results. Given the various weights from the different decision makers, the software determines for each option the mean and standard deviation of the net flux. The standard deviation of the net flux is a very important indicator of whether there is consensus on the rank order of options or not. The smaller the standard deviation compared to the differences between the average net fluxes of two options the more conclusive the ranking, i. e. the higher the consensus.

5.7 Sensitivity analysis and deliberation

Sensitivity analysis is a well-known and widely used tool for the investigation of the impact of uncertainty and variability on the outcome of a particular analysis [Saltelli et al. 2000]. For instance, one might explore how sensitively the rank of an option depends on its performance in a particular criterion. An entirely new application appears in the present study where MCE is combined with a Citizens' Jury given the task of finding consensus. Here the main issue is the variability in the criteria weights among the various decision-makers. From the point of view of decision-making, the problem here lies in the fact that different sets of weights are likely to lead to different rank orders of options. The role of sensitivity analysis here is to explore how sensitively the variability in the rank order of options depends on the variability of each and/or the whole of the criteria weights. Knowledge of these sensitivities allows us to assess:

- how critical a consensus on the criteria weights is
- in which criteria is a dissent on the weights most responsible for the variability in the rank order, pointing to those criteria where deliberation and the effort of finding consensus should be targeted

- at which point in the decision process sufficient consensus on the criteria weights has been reached in order to come to a fairly unique rank order of options.

5.8 Interacting and iterating

The use of sensitivity analysis in the way described above considerably differs from conventional sensitivity analysis in that the analyst is not performing the calculations alone in his or her laboratory, but where close and real-time interaction with the decision-makers is crucial. This includes the continuous update of the decisive parameters (particularly, the criteria weights) and iterated analyses as the deliberation goes on. Often, interaction and further iterations can be facilitated by the use of computer software models that allow for faster manipulation of the data. Also the use of graphical interfaces can be linked to various parameters of the MCE to aid in the decision-making. In the Citizens' Jury, the process of interaction between the analyst, jurors and witnesses as well as allowing for several iterations of particular aspects of the analysis is crucial for ultimate compromise on the outcome to be reached.

For spatial data, one promising but little used technique for interacting with the decision-maker is the incorporation of geographical information systems into the Multi-criteria Evaluation. For example, for a decision concerning different areas of land being put to different purposes, it could be possible to link the outcomes of a Multi-criteria Evaluation to a graphical interface depicting these different land-use options.

6 Preparing the Stakeholder Jury

6.1 Outline of the preparatory steps

The jury chosen in this study comprised a group of natural resource managers (stakeholders) rather than randomly chosen members of the public (citizens) and has therefore been termed a Stakeholder Jury to distinguish it from the Citizens' Jury (the same procedures for the jury are applicable, however). This choice was made because of the history of the larger Ecosystem Services Project which this case study belongs to. The stakeholders had already been chosen to review issues involving recreation and tourism in the area and were therefore well placed to take part in this initial experiment on the Deliberative Multi-criteria Evaluation. Some of these stakeholders had also been involved in developing a strategy for recreation and tourism management that at the time of conducting the jury, was about to be implemented in the region. Randomly selected citizens can be used after refinement of this process in later stages of the Ecosystem Services Project.

A series of management options were devised by the group of natural resource managers in the area and a set of decision criteria developed by which these options could be assessed (see below). The options and criteria were devised at a meeting prior to the day that the stakeholder jury met.

Also prior to the jury meeting, a questionnaire was sent out to identify preliminary rankings on the set of decision criteria and to agree on a set of objectives.

The agreed objectives of the exercise were to:

- protect and enhance the environment and natural attributes of the catchment that attract recreational users
- balance recreational development and use of the catchment (particularly in riparian zones) with the social, environmental and economic values of the community.

The questionnaire revealed that the ranks of some of the criteria varied widely across the different stakeholders. For those criteria where there were wide disparities, expert witnesses were asked to provide information and to answer questions on the day of the jury .

An Impact matrix showing the value of each of the criteria under each of the different options was completed by experts from various organisations. During the stakeholder jury, the Multi-criteria Evaluation software, ProDecX, was used interactively with the jurors to show the effects of changing their inputs on the criteria weightings.

7 Options

The workshop on recreation and tourism options was held some months prior to the jury. The procedure for the workshop was to develop a set of future land-use and management options related to recreation and tourism in the upper catchment and to identify some decision criteria for assessing these options. The following options were developed to cover as exhaustive a range of possibilities as possible.

7.1 Business As Usual (Current)

This option is the current scenario for the recreation and tourism industry in the region. Carrying on with the usual practice raises a number of concerns. These concerns include the effects of growing numbers of tourists from population increases, improved vehicles and better roads making access easier, as well as increased international demand for recreation in the area.

7.2 Maximise Ecosystem Services Outcomes (Max ES)

This option essentially means a policy of no access to any of the recreation and tourism sites that are under threat from environmental damage (including access to National Parks and State Forests in the region). The benefits to Ecosystem Services would be immense but these would come at enormous cost to the local community from no domestic tourists and also costs to the state from a lack of international tourists. There would also be costs to all individuals in terms of the loss of aesthetic experience.

7.3 Maximise Social Outcomes (Max S)

This option emphasises employment for local people and therefore targets issues such as job creation and job training in the recreation and tourism industries. This includes jobs and training in such activities as ecotourism, four wheel drive tours, camping excursions, environment education tours and expansion of the local hospitality and accommodation markets. There is little concern for the impact on Ecosystem Services which are not noticeable to tourists (e. g. water quality) but the impacts of activities on visible Ecosystem Services (such as the aesthetic appeal of a site) would have to be taken into account as without these visible services there would be no tourism industry.

7.4 Maximise Economic Outcomes (Max Ec)

This option represents the policy of access to all areas and therefore achieves maximum short-term profits to the recreation and tourism industry. These measures would be undertaken regardless of environmental effects, e. g. there would be no concern for remedial work or conservation related infrastructure (boardwalks etc.).

7.5 The Sustainable Tourism/Environment/Society Mix (Mix)

This option essentially incorporates the items found in the Goulburn Broken Catchment Management Authority Upper Goulburn Recreational Waterway Strategy (`http://www.gbcma.vic.gov.au/ugic.html`). The plan represents a more balanced approach to the concerns related to environmental, economic and social issues.

7.6 Management Practices For Different Options

An understanding of the above options can be aided by the following framework that describes the makeup of each option in terms of specific management practices (see Table 1). For example, the current option has some elements of on-site management practices implemented but none of those related to riparion zone management, demand management or education.

On Site Management: In areas of minimum impact, these can be used to good advantage. They can take the form of fences to keep people away from sensitive areas or keep vehicles and horses out. Boardwalks and bridges have been used in many tourist sites to stop the impact of trampling (erosion) and driving (pollution). Provision of toilets can minimise the effects of wastes polluting sensitive areas (as well as improving aesthetic values). The provision of toilets was noted as a key issue in the options workshop. Properly constructed car parks can keep vehicles confined to non-sensitive areas and away from areas where erosion could be significant. Horse yards in areas that are popular for horse riding can limit the effects of trampling and grazing by unconstrained horses. Weed control is another necessary on-site management activity. It should be noted though that these sorts of man-made solutions can decrease the visual or aesthetic appeal for some people.

Riparian Zone Management: The riparian zone is that area beside the waterway that is essential to the health of the waterway. Correct management of the riparian zone can be crucial to the health of the waterway. It is also essential for the provision of shade. Riparian zone management can take the form of restricting access to these zones usually by fencing. Again, these sorts of interventions can decrease the aesthetic appeal.

Demand Management: Marketing programs may be very effective. Such activities could include: targeting marketing to more sustainable recreation activities; scheduling and closures of sites and limiting numbers at peak times; user charges to limit numbers and fund programs; the use of private land where appropriate to supplement the 'traffic' on public land; and targeting education, which can, over the long term, have significant impacts. This could include on-site education with pamphlets and signs to encourage users to take rubbish away, to keep out of certain areas and not to take firewood etc.

8 Criteria of Assessment

The options workshop also helped to identify the relevant assessment criteria. The criteria were grouped under three broad headings to reflect the desire for integrated and sustainable development in the catchment.

Table 1: Framework for Options

	Current	Max ES	Max Soc	Max Ec	Mix
On site Management:					
Fences	s	$\surd$	s	$\times$	s
Boardwalks	s	$\surd$	s	$\times$	s
Toilets	s	$\surd$	s	$\times$	s
Car Parks	s	$\surd$	s	$\times$	s
Horse Yards	s	$\surd$	s	$\times$	s
Weed Control	s	$\surd$	s	$\times$	s
Riparian Zone Management:					
Fencing	$\times$	$\surd$	$\times$	$\times$	s
Demand Management:					
Scheduling/closures/ limiting numbers	$\times$	$\surd$	$\surd$	$\times$	s
Marketing sustainable activities	$\times$	$\surd$	$\surd$	$\times$	s
Use of private land	$\times$	$\surd$	$\surd$	$\times$	s
Education:					
Signs/pamphlets	$\times$	$\surd$	$\times$	$\times$	s

$\surd$ = present, $\times$ = not present, s = some present

8.1 Ecosystem Services

The emphasis of the project was in studying the Ecosystem Services involved in the decision-making process and so all of the potential environmental criteria involved were Ecosystem Services. The Ecosystem Services criteria are described as follows:

1. *Maintaining Water Quality:* Maintaining the natural purity of the water is measured by the quantity of phosphorus (P) present in the water in milligrams per litre.

2. *Maintaining Water Quantity:* Preserving the natural flow of the water is important for downstream users and is measured using a discharge indicator in thousands of megalitres.

3. *Preserving Biodiversity/Native Biota:* Biodiversity (biological diversity) is perhaps most commonly defined as "the full variety of life on Earth." A qualitative indicator, where 10 signifies high biodiversity and 1, low, is used.

4. *Soil Maintenance through Sediment Filtration/Retention:* Maintenance of soil and water quality through the filtering of sediments and enhancement of soil stability. This is closely linked to vegetation cover. A qualitative indicator, where 10 signifies high sediment filtration and 1, low, is used.

5. *Erosion Control:* This can include the prevention of loss of soil by wind, runoff or other processes and the storage of silt in lakes and wetlands. A qualitative indicator is used to measure erosion control as defined above.

6. *Nutrient Management/Waste Assimilation:* This includes storage, internal cycling and processing and acquisition of nutrients e. g. nitrogen fixation. A qualitative indicator is used.

7. *Shading:* The provision of shade and shelter is closely related to vegetation and therefore biodiversity. A qualitative indicator is used to measure shading.

8. *Stream Health including instream and riparian zones:* This is dependent on the level of aquatic life, the vegetation quality, stream physical form, stream flow and water quality. Here the Index of Stream Condition is used to measure stream health (see `http://www.vicwaterdata.net/isc/intro.html/`).

9. *Aesthetics/Scenic Views:* This refers to the level of satisfaction derived from the visual appearance of the landscape. Aesthetic appeal is a personal quality. Often, any intervention that takes a landscape away from its natural state may be regarded as diminishing the aesthetic appeal of that area or landscape. For example, such interventions may include roads, signs, boardwalks, weeds and vehicles. However, some of these items may also be necessary to stop the landscape from deteriorating. Also some people may regard diversity in the landscape as important and so a mix of native and agricultural land uses may be aesthetically appealing. Again a qualitative indicator is used to measure aesthetic appeal.

8.2 Social/Cultural

The social and cultural criteria that were considered as being important in the decision-making process on an option for recreation and tourism in the catchment were as follows:

1. *Public Access:* This includes the number of people that are allowed to visit a site as well as the means by which they can visit. Here an indicator of 10 for high public access and 1 for low public access is used.

2. *Jobs:* The level of full-time and part-time employment that a particular scenario may involve. This is measured by total number employed.

3. *Maintenance of Cultural and Heritage Values:* The provision of measures that will maintain the integrity of sites of cultural and heritage significance. A qualitative binary indicator is used to measure this with a 0 indicating that the cultural and heritage values are not maintained and 1 indicating that they are.

4. *Education:* The provision of educational campaigns can assist in the maintenance of sites and is measured qualitatively using a 0 for not present and 1 for presence of educational campaign.

8.3 Economic

The economic criteria used in the decision-making process were limited to those that could be readily measured using existing data and included:

1. *Costs:* These are the monetary costs (both direct and indirect, to individuals and governments in the region) involved in the particular scenario. They can involve costs of establishing facilities at sites, weed control, fencing, lost incomes, visitor fees etc. These costs are measured in dollars.

Table 2: Impact Matrix

	Indicator	Current	Max ES	Max Soc	Max Ec	Mix
Ecosystem Services:						
Water Quality	mg/l P	0.02	0.005	0.05	0.1	0.0
Water Quantity	Dis. $10^9 l$	150	250	100	125	150
Biodiversity	QI[1]	6	10	3	5	10
Sediment Filt.	QI	3	8	6	8	8
Erosion Control	QI	7	10	7	4	7
Nutrient Man.	QI	3	8	7	3	8
Shading	QI	5	10	6	2	8
Stream Health	ISC[2]	35–41	42–50	35–41	26–34	35–41
Aesthetics	QI	5	8	6	2	7
Social and Cultural:						
Public Access	QI	5	1	7	10	5
Jobs	'000	15	18	20	25	18
Cult./Her. Sites[4]	BI[3]	0	1	1	0	1
Education[4]	BI	0	0	1	0	1
Economic:						
Costs	$mill	2.5–3.5	0	2.5–3.5	0	18.3
Benefits	$mill	5.5–6.5	0	6.4–49	4.3–40.1	9–57.3

[1]Qualitative Index: High = 10, Low = 1
[2]ISC = Index of Stream Condition: Very Poor = 0–19, Poor = 20–25, Moderate = 26–34, Good = 35–41, Very Good = 42-50
[3]Binary Index: 1 = present, 0 = not present
[4]These were added during the stakeholder jury.

2. *Benefits:* These are the monetary benefits (both direct and indirect) involved in the particular scenario. These may be the benefits from increased incomes of tourist operators, accommodation providers etc. These are also measured in dollars.

9 Impact Matrix

An Impact Matrix showing the values of each of the different criteria under each of the different options was completed using expert input from various organisations (Table 2). These experts were from state natural resource and forestry management organisations, regional water management organisations, CSIRO ecologists, private consultants who had carried out research in the region as wall as reports that were relevant to the information required. The matrix included both qualitative and quantitative indicators as well as ranges for some indicators that were uncertain.

10 The Stakeholder Jury — Procedure and Results

The jury was asked to consider the information presented to them (e. g. in the Impact Matrix and by the expert witnesses) in a facilitated and deliberative process[3]. Their charge was to come to a unanimous decision with respect to a set of weightings for the assessment criteria. The decision process, including the effect of a set of weightings on the final ranking of the recreation and tourism options, was aided by interactive use of the ProDecX software. The day was split into two sessions — the morning session with expert presentations and discussions and the afternoon session, with iterations of criteria weighting, software interaction and deliberation.

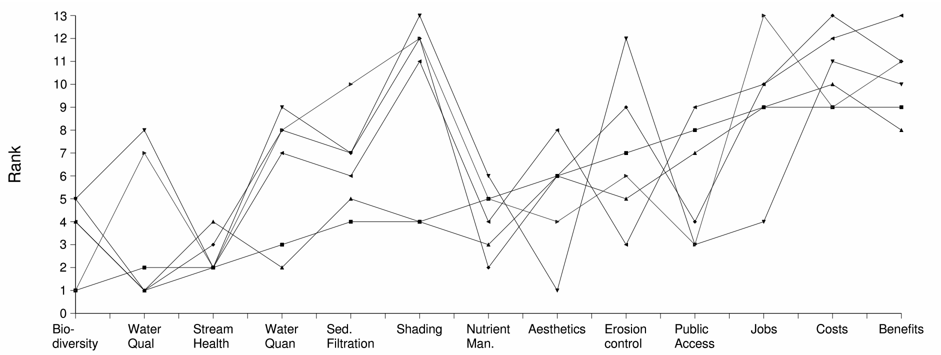

Figure 1: Ranking of criteria; where a value of 1 represents the highest rank and a value of 13 represents the lowest.

10.1 The Morning

The day started with descriptions of the process, the charge and the software to be used. An overview of jurors' priorities was provided showing the considerable differences in the ranking of these priorities for certain criteria (Figure 1). Also the results of the ProDecX run were shown indicating a top ranking to the Maximise Social Outcomes (Max S) option[4] (Figure 2) as it had the highest average net flux. The next best options were Maximise Economic Outcomes (Max Ec), Sustainable Mix (Mix), Maximise Ecosystem Services (Max ES), and lastly, Business as Usual (Current).

An important observation is that in the three best options, Max S, Max Ec and Mix, the uncertainty, i. e., the standard deviation of the net flux, was much larger than the differences between the average net fluxes. This indicates that dissent on the criteria weights was so high that a conclusive ranking was not possible, i. e. no consensus on the relative ranking of these three options was achieved. Only the two worst options, Max ES and Current had such small average net fluxes that they were clearly outperformed by the three best options. An objective of the jury was then to improve consensus on the weights and come to a more conclusive ranking of the options.

[3]The 'judge' was Dr. Gail Kelly, a Community Psychologist from CSIRO with many years experience in the research and facilitation of processes involving participation and environmental issues.

[4]This caused some amount of concern to the jury as the Sustainable Mix option (ranked third in the initial ProDecX run) is, in fact, the strategy which is about to be implemented in the Catchment and which is supported by the organisations that were represented by the jury members. The lower ranking of the Sustainable Mix option could indicate that it is lacking in the delivery

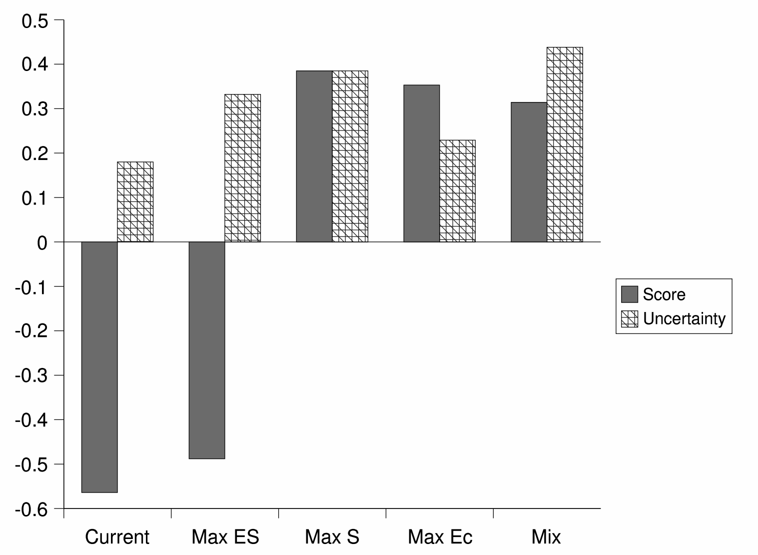

Figure 2: Score and uncertainty of options prior to jury.

First, the jurors were asked to decide whether the three broad categories of criteria (the Ecosystem Services, Economic and Social and Cultural groups) should be weighted equally to allow for the larger number of Ecosystem Services criteria compared to the other criteria groups. After some discussion, they all agreed that such a broad weighting would reflect the desire for sustainable development in the region. Also at the request of one of the jurors, two additional criteria were added under the Social and Cultural category: the maintenance of cultural and heritage values and the provision of education.

The first witness to be called was from the local water authority and gave an overview of water quality and quantity issues relevant to the consideration of different recreation and tourism options. The issues covered included the status of storage dams, cumulative effects, effects of different types of recreation and tourism on water quality and quantity and monitoring. A great deal of discussion followed and questions from the jurors centred around the adequacy of monitoring, lessons learned from overseas experiences and whether or not education of tourists would be effective in maintaining water quality.

The next expert witness was the environmental manager from a local ski resort who spoke on public access and aesthetics. His talk highlighted issues such as sense of place, cultural identity, the importance of life fulfilling Ecosystem Services, the cultural icons of mountains and the injection of money into the local economy as a result of these aspects. The discussion afterwards centred around the positive effects of restricting public access such as environmental preservation, and also the issue of open access leading to an increased knowledge by the public about environmental issues. Discussion also highlighted certain user groups causing considerable environmental damage e. g. four wheel drive vehicles, motorbikes, horses and campers and whether these groups should have their access restricted. One idea that was proposed was to encourage tour groups to educate people on the effects of tourism on the environment. One way of doing this would be to introduce a code of practice for tour operators to agree to.

The third witness, from a state natural resource management authority discussed issues concerning soil erosion. Those covered included the fact that road usage de-

of some outcomes ranked highly by the jury.

termines sediment production rates, where ninety percent of sediment runoff comes from roads and depends on the surfaces, age of road, soil type etc. The removal of vegetation from riparian zones also effects soil erosion. Horses and off-road vehicles can be damaging users and the best management practices available to stem these effects include culverts and road surfacing. The total number of vehicles and horses as well as points of access (e. g. to streams) were also key considerations. An important point that was raised was the concern with the current lack of resources needed to manage these problems. One possible solution that was discussed was a levy on users in high-damage categories (e. g. four wheel drive vehicles). It was considered however, that political will was a fundamental requirement to impose such measures and greater research into providing incentives for solutions from markets and private firms was required.

The forth expert (a member of the local parliamentary council) presented information on jobs and economic issues. He spoke of the bonuses to local jobs and industry resulting from recreation and tourism activities. Again the discussion reverted to public access issues and managing numbers and whether or not lessons could be learnt from other experiences with 'user pays' schemes. Also identified was a need to measure the effects of public access on the riparian zones adjacent to rivers and streams (which in turn requires an exact definition of the extent of this zone). One question that was raised was whether or not it is possible to engage private landholders in recreation and tourism activities and, if so, if this would provide the experiences required by the public. Finally, the jury also agreed that the multiplicity of public land managers needs to be limited in some way.

After the expert presentations, questions and discussions, the jury was asked to provide a weighting (as opposed to just a ranking) of the various assessment criteria to reflect each individual jurors priorities. Each juror was given one hundred cannelini beans each, with one third of the beans to be divided between the Ecosystem Services criteria, one third between the Social and Cultural criteria and one third to the Economic criteria. After the weighting exercise, the jurors and expert witnesses were allowed to take part in informal discussions over lunch.

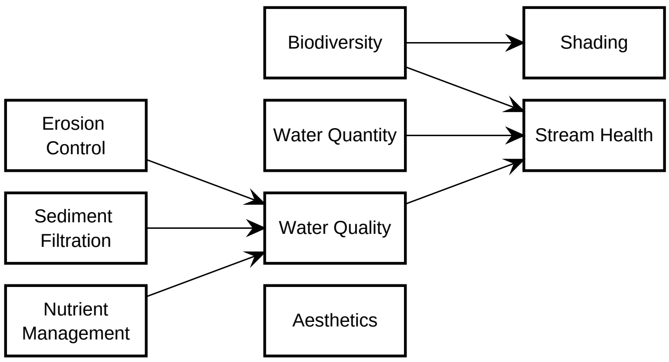

Figure 3: Causal links between various Ecosystem Services criteria.

10.2 The Afternoon

The resulting criteria weights were fed into ProDecX and also graphed on a whiteboard so that all jurors could see each others positions. Those with outlying priorities were asked to defend their positions. The initial discussions revealed that the nine Ecosystem Services criteria could be limited to only four (Water Quality, Water Quantity, Biodiversity and Aesthetics) as these were all that were needed for the jurors to make decisions on recreation and tourism options.

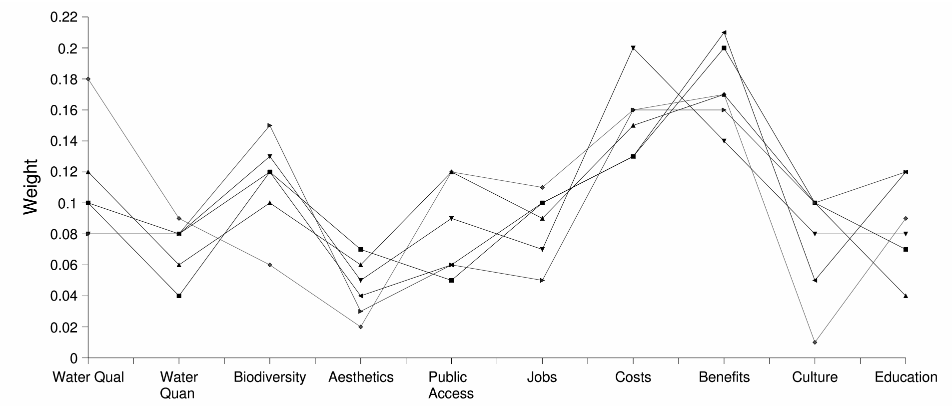

Figure 4: Weighting of criteria.

They argued that Stream Health is influenced by Biodiversity, Water Quality and Water Quantity. Shading is also influenced by Biodiversity and vegetation cover. Erosion control, Sediment Filtration and Nutrient Management determine Water Quality. Therefore the nine Ecosystem Services criteria can be adequately covered by just four: Water Quality, Water Quantity, Biodiversity and Aesthetics (Figure 3).

After the reassessment of the necessary Ecosystem Services criteria, the weighting exercise was again carried out and the results graphed on the whiteboard. Each broad criteria group was then discussed one at a time, with outliers identified and jurors asked to defend positions and whether they would vary them or not. As soon as a final position was agreed to, the weightings (Figure 4) were fed into ProDecX. The resulting outcome was the Sustainable Mix option with the highest average net flux (Figure 5). One can also see that the uncertainty (standard deviation) in the net fluxes has decreased considerably, indicating that the ranking is now much more conclusive and consensus much higher developed than before the start of the process.

11 Sensitivity Analysis and Discussion

A detailed sensitivity analysis was carried out after the jury process to further assess the decision problem. First the broad group weightings (agreed to by the jury to be 33 per cent for the Ecosystem Services criteria, 33 per cent for the Social criteria and 33 per cent for the Economic criteria) were systematically varied. In the first instance a group weighting of 40 per cent was given to the Ecosystem Services criteria and the others were set at 30 per cent each. None of the permutations of different group weightings made any difference to the overall rankings of the options. Next, some of the outliers found in the final weightings of the criteria were, in turn, fed into ProDecX. The first to be used (keeping all other weightings consistent with the final agreed values) was the high weight of 0.18 for Water Quality. Then the low outlier of 0.06 for Biodiversity and finally the 0.20 outlier for Monetary Costs. These tests also did not alter the overall ranking of the options.

An analysis of the changes in the rankings of options after the jury process did reveal some important aspects of the procedure. Before the jury met and using a straightforward qualitative ranking (Figure 1) of the criteria resulted in an overall outcome of the Max S option being ranked first, Max Ec second and the Mix option third. The next run of the ProDecX software was done after quantitative weightings

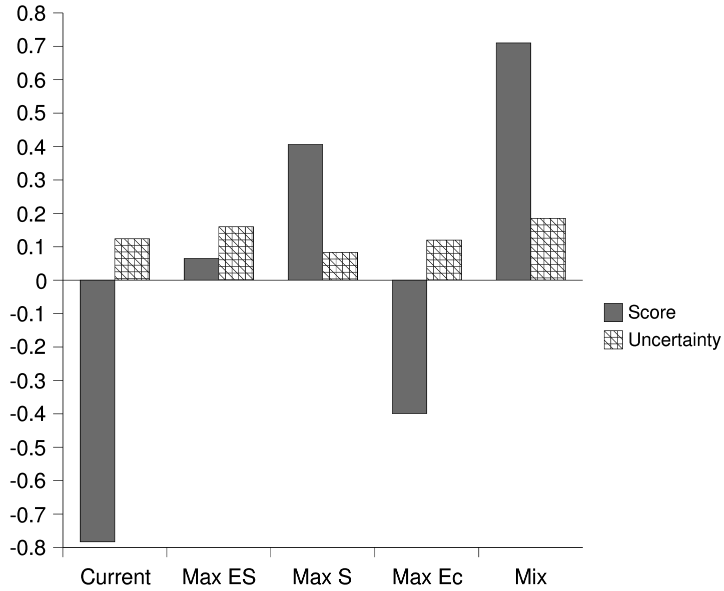

Figure 5: Final score and uncertainty of options.

of the criteria were undertaken using the beans and also after the expert witnesses held their presentations. Furthermore, the jurors were asked to give the all of the Ecosystem Services criteria the same total weight as the whole of the Social, and the Economic criteria (1/3 for each criteria group) which had not been the case in the qualitative ranking in Figure 1. The main changes in the rankings of the options that occurred at this time were in greatly worsening the rank of the Max Ec option and greatly improving the position of the Max ES option. Because of the various changes in the procedure before this step it is difficult to attribute causes to these different rankings (e. g. the effect of the expert presentations). The largest change to the overall rankings came when some of the Ecosystem Services criteria were dropped. This resulted in the Mix option being ranked first then followed by the Max. S and then the Max ES options. Even after going through each set of criteria in turn to try and reach, as far as possible, a consensus on the weights, the overall rankings of the options did not vary very much. The difference that was made was that the uncertainty measures were reduced and therefore the rank orders were given a higher probability of occuring.

These findings mean that, in this particular instance, obtaining exact consensus on the weights of the criteria was not important as a range of weights (for each criterion) was sufficient to obtain consensus on a preferred option. However, of crucial importance was the process of each person defending their criteria weightings because of the important information that was revealed. For example, because of this process, jurors could in turn bring out the main issues that were important to them in choosing a criterion weight and, as it turned out, some of these legitimate issues had not been considered by some of the other jurors. Also, from the findings, a critical part of the process was in determining the exact criteria to be considered and this only occurred after a significant amount of discussion by the jurors and experts that ultimately led to the simplification and non-duplication of the various decision criteria.

12 Conclusions

This paper has introduced some advantages and disadvantages of two decision-aiding techniques and has argued that advantages may be enhanced and disadvantages overcome by combining the two approaches. Some practical steps on how this might be achieved have been presented here and these steps were applied to a case study identifying and prioritising Ecosystem Services in the Goulburn Broken Catchment of Victoria, Australia. In this application it was shown how the advantages of Multi-criteria Evaluation, in providing structure and integration in complex decision problems, was combined with the advantages of deliberation and stakeholder interaction provided by a Citizens' Jury.

The Deliberative Multi-criteria Evaluation of recreation and tourism options in the upper Goulburn Broken Catchment highlighted the fact that maintaining the current regime of recreation and tourism management was not an appropriate option. The process did support a change to the Sustainable Mix strategy but emphasised the need for greater research on public access issues, the effects of education on tourists and environmental damage, methods for the recovery of management costs and the role of market and other incentives in limiting environmental damage of recreation and tourism activities.

The exercise also identified some aspects of the procedure itself which could be improved upon such as the need for greater discussion of the steps in the process at the start and more explanation of the criteria and the Impact Matrix.

Although the software in its present version allowed for the simultaneous consideration of several decision-makers, the input of multiple weightings turned out to be cumbersome, as the weights had to be entered for each stakeholder separately. Moreover, there was no possibility to show the weightings of all decision-makers at once on a single screen. As this was felt necessary by the jurors, in the present study, a white board had to be used for depiction and adjustment of weights which then were copied into the software by the analyst. This slowed down and partly obstructed the real-time interaction between decision-makers, analyst and software, such that a full Multi-criteria Evaluation could be carried out only in the beginning and in the end of the process. This deficiency is currently being remedied, so that the weights of all decision-makers can be presented and edited on a single screen and the software will allow for fully interactive manipulation of multiple weightings, as well as convenient and fast sensitivity analyses.

In conclusion, the process identified to the decision-makers the importance of breaking down the decision problem and consequently being able to investigate the correct information to try and solve the problem. This involves asking the right questions at the start of the process and for researchers to know the priorities of the decision-making criteria and which of those criteria are important to measure. On the whole, the jurors found the process interesting, enlightening and enjoyable with the highlight for most of them being the revelation of different jurors' priorities and their defence of these positions.

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