When is a decision problem not a nail?

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At the outset I need to emphasise that my interest in MCDA (*Multiple Criteria Decision Analysis*) is primarily in its application to natural resource management decision-making. Within that realm of application, I suspect that, in my initial enthusiasm several years ago, I was guilty of falling into the trap of "When all you have is a hammer, everything looks like a nail". Over time, it has become clearer to me that on the one hand, the field of MCDA provides a multitude of tools which can indeed address a wide array of problems, but, on the other, there are questions that need to be answered using other tools.

There have been a wide range of natural resource management questions that we have addressed with MCDA, and there are a multitude of tools in the MCDA toolkit. However, firstly, either goal programming or a simple "value measurement" approach seem to answer most needs and, secondly, the bulk of the applications followed the same clear stages. These were:

1. Problem structuring to define the questions to be addressed, to identify the alternatives and the criteria with which to evaluate the alternatives (which are often organised into a hierarchical 'value tree'),
2. Evaluation of the alternatives according to each criterion separately and weighting of the criteria (using so-called "swing weights"),
3. Aggregation of the separate evaluations,
4. Sensitivity and other analyses of results, and
5. Feedback to participants.

Particularly in the value measurement approach, all stages (except for stage 4) occurred in workshops with specialists and other stakeholders, with the MCDA analyst acting as sole or co-workshop facilitator. The dual role was sometimes difficult to perform, and it became clear that workshops of larger than say 10 participants required both a facilitator and an analyst. This is because, in these types of applications, the participatory process (e.g. ensuring that everyone participates or that no-one dominates) is as important as the substantive process of ensuring that questions are asked so as to elicit valid responses for scores and weights. The way the questions are asked needs to be tailored to the particular group of participants. Some might quickly grasp the various concepts, while, with the right kinds of questions, swing weights and non-linear value functions can be elicited from less technically- or mathematically-minded (including non-numerate) participants.

Therefore, another common thread in all applications was to ensure that the overall model was easily understandable to all participants and the final decision-maker. The decision workshop format is therefore a popular and useful approach, particularly in a participatory democracy setting.

The third common thread in natural resource management problems is that there are often three main points of view, namely, "ecology", "social" and "economic" or alternately, "sustainability", "efficiency" and "equity". The actual criteria

A section of the Sand River (Mpumalanga). Exploration of the consequences of land-use changes helped to identify ways in which both conservation and social gains could be achieved (Photo: Dr J. Turpie).

for evaluation of the alternatives will depend on the particulars of each project, but usually fall under these three main headings.
Although the overall process was similar for most of the studies, the particulars of each study meant that they fell into roughly four groups of types of application. The groups are described below and illustrated with some details from case studies.

Description, sorting, ranking, choice
The first group of applications required extensive "problem structuring" in order for the group to gain a common understanding of what the main questions were, and which of these could usefully be addressed in an MCDA format. As the questions to be addressed were not immediately apparent at the start of the work, alternatives and criteria had not yet been defined. These would therefore be explored during the course of the project. The approach followed was that of value measurement MCDA.

Once problem structuring was over and alternatives defined, the alternatives needed to be either sorted into categories such as "suitable for more detailed research" or "not suitable at all", and/or ranked from most desirable to least, and/or a "best" alternative could be identified for implementation. Thus, these were problems that implied that the tasks to be undertaken included description, sorting, ranking and choice.

Applications which fell into this group included a study, the impetus for which came from the rapid expansion of forestry in the Maclear district of the Eastern Cape Province. This expansion had both conservation implications (for the under-protected afromontane grasslands) and social implications (due to the disruption to the farming community caused by the sale of farms to the forestry company). Eventually, scenarios were defined which encompassed a range of potential future forestry expansions (extent and location) and potential processing (sawmills or a pulpmill). This made it clear that, with some constraints on where planting occurred, more expansion could take place without seriously affecting conservation goals, although social effects would be similar wherever planting occurred. Another study arose because of the need to rehabilitate the Sand River (Mpumalanga) in order to maintain ecosystem functioning which was being compromised due to both forestry and irrigation practices. In addition, there was an urgent need for social upliftment and economic development in order to curtail the cycle of poverty and resource over-exploitation. Here, the scenarios developed encompassed a range of changes to the main current land-uses in the catchment (e.g. forestry, irrigation, conservation, dryland agriculture). In this case, fairly large gains in conservation could be obtained by reducing forestry to 50% of its current extent. This amount of reduction was not unrealistic as it was estimated that at least 25% would have to be removed to conform with current forestry practice (e.g. plantations which were too close to rivers, or on steep slopes). Also, relatively large social gains could be obtained by changing access to areas for the harvesting of natural and secondary resources.

Aspects of the Sand catchment scenario that was preferred overall after evaluation based on 19 criteria (fitting into the three main points of view) are currently being implemented. In the case of the Maclear study, studies were undertaken to further examine certain land-types which were critical from a conservation point of view. The studies not only gave guidance to decision-makers as to the "preferred direction" of development, but also provided a wealth of information in terms of the trade-offs implied by scores and weights, between for example ecological and economic criteria.

Sorting, ranking, choice
In the case of the second group of problems, the question to be addressed was already defined as substantial problem structuring had already occurred. This problem structuring occurred, generally, as part of a broader study, and was not necessarily guided by "MCDA think", and so additional sessions were still necessary to refine certain aspects. Usually, the alternatives were also already defined as part of this broader process (meaning that a good range of alternatives was not always included: e.g. including a "worst" and "best" from each of the main points of view).

Sometimes, various criteria and scoring systems (or indices) had also already been defined within the broader process. Therefore, the problem structuring stage was often limited to identifying additional criteria and the refinement of existing scoring systems and procedures to ensure that subsequent aggregations were valid. This was undertaken in decision-workshop format as for the previous group of applications and the value-measurement MCDA approach was also used.

Perhaps a further difference between these first two groups of applications is in how early the decision analyst became involved in the problem structuring. In the first group, the MCDA analyst was involved from the early problem structuring stages, and could more easily ensure that the set of alternatives and criteria were appropriate for the value-measurement approach. In the second group, the analyst had to more-or-less "fit in" with decisions and approaches decided on as part of a broader process. However, the flexibility of

MCDA (and hopefully of the MCDA analyst) meant that integration between previous efforts and the requirements of MCDA was usually quite painlessly and seamlessly achieved.

Sorting, ranking

In the third group of applications, the aim was to classify and / or prioritise a set of resources. Usually this sort of problem arises due to limited funding; for example, for research and management. The alternatives are the complete set of the entity in question, for example all 250 South African estuaries, or all 176 South African linefish species. The alternatives are therefore given, and so problem structuring is limited to defining and structuring the criteria and developing scoring systems or indices. In the case of the prioritisation of linefish species, the criteria included conservation criteria (e.g. endemicity, abundance, vulnerable life-history stages) and criteria reflecting the importance of the species to the fishing community (e.g. economic value, number of people involved). The linefish species could then be grouped into those that were of high management importance from a conservation point of view, those that were of high importance to fishers, and those that were ranked highly according to both groups of criteria. Different strategies of research and management would be appropriate for these three different groups of fish. In the case of estuaries, the emphasis was on classifying them from the point of view of their conservation importance, so that protection and management efforts could concentrate on those of highest conservation priority.

Design

In the last type of application, the intention is to *design* an "optimal" alternative. Here, a goal programming approach is appropriate. For example, in terms of the National Water Act of 1998, an ecological and basic human needs "Reserve" needs to be defined for each river. The Reserve is designed so as to allow for the particular degree of protection and use, defined by the management class selected for the river in question. In this case, a value-measurement based scoring system had already been developed to evaluate reductions or augmentations in flow in terms of ecological impacts. The goal program that we developed selected a reduction or augmentation level for each of ten parts of the flow regime (dry season flows, wet season flows and different classes of floods), in order to minimise the ecological impacts (as represented by the scores) for a particular total flow. In this way, the amount of water required for the ecology could be minimised while ensuring that a particular management class was maintained. Thus, more water could be made available for other users.

Conclusions

It can therefore be said with confidence that MCDA provided an array of flexible, appropriate, useful and user-friendly approaches (hammers, screw-drivers, planes) to a wide variety of types of application (nails, screws, planks), and that the MCDA "intervention" was generally well-received. However, two caveats could be noted. Firstly, there remain decisions that require a different approach. For example, where damages to natural resources require compensation to be paid to the people affected, the valuation techniques of environmental economics may be appropriate. Secondly, there are still those who, before involvement in an MCDA application, are rather wary or suspicious, particularly, when weights are mentioned. However, during each application, the participants obtained sufficient understanding of the approach to appreciate and accept the validity of "swing weights", and to undertake the tasks required of them with relative ease and even enjoyment. ♦