

## Multi-criteria decision analysis (MCDA)

### Introduction

MCDA is an “umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter” (Belton and Stewart, 2002, p. 2). The basic idea of MCDA methods is to evaluate the performance of alternative courses of action (e.g. management or policy options) with respect to criteria that capture the key dimensions of the decision-making problem (e.g. ecological, economic and social sustainability), involving human judgment and preferences. They are rooted in operational research and support for single decision-makers but recently the emphasis has shifted towards multi-stakeholder processes to structure decision alternatives and their consequences, to facilitate dialogue on the relative merits of alternative courses of action, thereby enhancing procedural quality in the decision-making process (Mendoza and Martins 2006).

### Keywords

Multi-criteria decision analysis; Multi-criteria evaluation; Decision support tools; Non-monetary valuation.

### Why would I chose this approach?

MCDA methods are used to address complex decision-making situations with multiple and often conflicting objectives that stakeholders groups and/or decision-makers value differently. A typical example of a decision-making situation assisted by MCDA methods is determination of an appropriate water regulation policy, which has a variety of economic, ecological and social consequences regarded as desirable by some stakeholders (e.g. downstream farmers) and undesirable by others (e.g. recreational fishermen).

MCDA methods can be used to address trade-offs between multiple ecosystem services because they allow comparison of ecological objectives with socio-cultural and economic ones in a structured and shared framework. They can incorporate ecological criteria such as carbon sequestration and water quality; economic criteria such as costs and economic impacts of alternative courses of action; and socio-cultural criteria such as cultural heritage and aesthetic values. MCDA methods can also be used to combine information about the performance of the alternatives with respect to the criteria (scoring) with subjective judgments about the relative importance of the evaluation criteria in the particular decision-making context (weighting).

MCDA is a decision support tool and hence it has been mostly used for priority setting, i.e., ordering alternatives according to the participants’ and/or decision makers’ value positions. The results can be aggregated to present a single preference order of the alternatives for the whole group. However, this requires inter-personal comparison of how much we value various stakeholder groups’ opinions. The other option is a disaggregated way to illustrate how different stakeholders have weighed the criterion and consequently prioritized the alternatives, with an aim to better understand the various viewpoints related to the problem. The valuation element in MCDA (normalization and weighting) can also be used for

awareness raising by enabling citizens/stakeholders/decision-makers to probe their preferences and underlying value positions.

MCDAs have been applied on local as well as regional and some cases also national level (see Kiker et al. 2005), mostly on a spatial resolution more than 10 km<sup>2</sup>.

### What are the main advantages of the approach?

- Covers wide range of ecosystem services;
- Trade-offs can be evaluated;
- Can facilitate multi-stakeholder processes, transparency and discussion about the subjective elements in policy analysis;
- Can structure an assessment along both cognitive and normative dimensions;
- Uncertainty can be addressed by sensitivity analysis.

### What are the constraints/limitations of the approach?

- Representativeness (only a small group of stakeholders usually involved);
- Some criteria such as cultural heritage or provisioning services vital for sustenance might not be amenable for trade-offs;
- Allows manipulation and closing down of policy discourses if not used in participatory and transparent way;
- Requires commitment from stakeholder to be involved throughout the process.

### What types of value can the approach help me understand?

MCDAs are highly appropriate to elicit both anthropocentric and non-anthropocentric values, including ecological, sociocultural and monetary values of ecosystem services. Not all MCDAs can however address incommensurable criteria such as rights and duties, hence their applicability is limited in the case of eliciting bequest values.

### How does the approach address uncertainty?

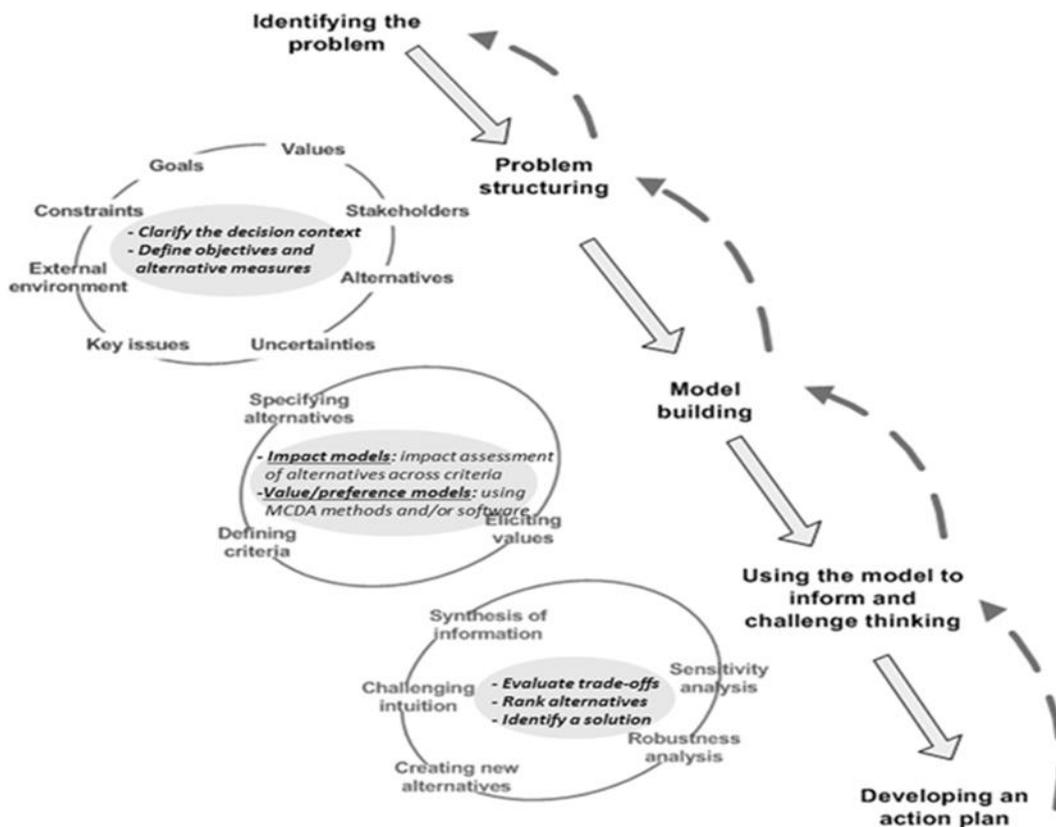
Uncertainty can be addressed by sensitivity analysis.

### How do I apply the approach?

The basic steps in a MCDAs process are presented in Figure 1. The first steps are related to clarifying the decision context and structure the problem according to the objectives and evaluation criteria as well as the alternatives to be examined. The next step is the model building. In this step, the performances of the alternatives are assessed with respect to the criteria. The results are usually compiled into an impact matrix using natural measures (e.g. Euros or hectares), proxy measures (e.g. the number indicator species can be used as a yardstick of biodiversity); and constructed measures, which report the achievement of the objective using a scale tailored to the decision context (Keeney and Gregory, 2005). Next, the measurement values are translated into performance scores (scoring). For example, in Multi-Attribute Value Theory (MAVT), this is carried out by constructing value functions for each criterion that normalize individual impacts to a common scale of comparison. The value functions define the preferences for each criterion 'internally', i.e., how much a person values incremental changes in the measurement values of a single criterion in different parts of the scale (intra-criterion evaluation). The next phase is weighting where

participants are asked to assign weights to the evaluation criteria (MAVT), or rank them (Rank-based methods use ordinal scale instead of cardinal scale), according to their preferences and value judgments (inter-criteria evaluation). The outcome of the analysis is the overall value for each alternative reflecting its overall performance under all criteria taken together compared to the other alternatives. Under certain assumptions (see e.g. Keeney and Raiffa 1976), one can use an additive model to obtain the overall values for each alternative by multiplying the criteria-wise performance scores with corresponding criteria weights and then summing them up. The results can either be fully aggregated or disaggregated according to stakeholder groups (see e.g. Mustajoki et al. 2011).

Figure 1. The basic steps in a Multi Criteria Decision Analysis (MDCA).



## Requirements

Requirements		Comments
<b>Data</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data is available</li> <li><input checked="" type="checkbox"/> <b>Need to collect some new data (e.g. participatory valuation)</b></li> <li><input type="checkbox"/> Need to collect lots of new data (e.g. valuation based on surveys)</li> </ul>	Participatory MCDA applications require a close contact with key stakeholders throughout the process, at least in the weighing stage. MCDA methods can make use of existing data but usually additional information (e.g. biophysical assessment or economic analyses) is required after defining the evaluation criteria with stakeholders.
<b>Type of data</b>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Quantitative</li> <li><input checked="" type="checkbox"/> Qualitative</li> </ul>	MCDA allows both for quantitative and qualitative information (scales can be used to

		translate qualitative information into quantitative scores).
<b>Expertise and production of knowledge</b>	<input checked="" type="checkbox"/> <b>x Working with researchers within your own field</b> <input checked="" type="checkbox"/> <b>x Working with researchers from other fields</b> <input checked="" type="checkbox"/> <b>x Working with non-academic stakeholders</b>	MCDA applications usually require interdisciplinary teams that work with stakeholder representatives
<b>Software</b>	<input checked="" type="checkbox"/> <b>x Freely available</b> <input checked="" type="checkbox"/> <b>x License required</b> <input checked="" type="checkbox"/> <b>x Advanced software knowledge required</b>	Some software are freely available but their use requires some software knowledge and knowledge on how to interpret the results.
<b>Time resources</b>	<input checked="" type="checkbox"/> <b>x Short-term (less than 1 year)</b> <input type="checkbox"/> Medium-term (1-2 years) <input type="checkbox"/> Long-term (more than 2 years)	6-24 months.
<b>Economic resources</b>	<input type="checkbox"/> Low-demanding (less than 6 PMs) <input checked="" type="checkbox"/> <b>x Medium-demanding (6-12 PMs)</b> <input type="checkbox"/> High-demanding (more than 12 PMs)	MCDA processes can be carried out in less than 6 months if data is available and stakeholders can work intensively; it can also take more than 12 PMs, depending on the level of ambition and demands for preciseness.
<b>Other requirements</b>	Software and decision analyst to use the software is usually needed	

## Where do I go for more information?

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