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**ACRONYM** : **S**cience **P**olicy **I**ntegration for **C**oastal **S**ystems **A**ssessment

## **REPORT**

### MULTI-CRITERIA ANALYSIS SPECIFICATION SHEET AND SUPPORTING MATERIAL

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**Note to the reader - How to use this material**

This report has been designed as a hyperlinked pdf document.

The main text in the specification sheet synthesises the economic assessment method, its relation to systems approach and the appropriate use of the method. It also gives some hints on how to best present the results of your assessment to stakeholders, along with an example of the use of the method.

The text gives you access to links to the accompanying material available in the rest of the report (page numbers are also provided along the links in case you would like to print this report).

A back button on the bottom of each page of supporting material helps you go back to the main text.

## SPECIFICATION SHEET

### Multi-criteria analysis

#### Method and assumptions

Multi-criteria analysis (MCA) is comparing measurable sets of criteria to assess in how far different options (e.g. investment, project, policy, strategy options) are achieving intended objectives and/or result in unintended side-effects. Cost effectiveness and cost-benefit analysis can be seen as special cases, in which some of the negative effects are expressed as monetary costs (cost effectiveness analysis, read more [here](#), p. 8) or all negative as well as positive effects are measured as far as possible in monetary terms (cost benefit analysis). Commonly multi-criteria analysis is understood as an assessment method that does not try to monetise everything, but to supply an unrefined view on the many different dimensions of the multiple effects of a certain policy/project/investment option. Nevertheless multi-criteria analysis can integrate monetary values like investment costs as one of the many dimensions it takes into account.

Key elements of the MCA method are the performance matrix, the weighting and the ranking process. The performance matrix gives an overview on the scoring of all evaluated options with respect to all criteria taken into account. To compare alternative options scoring on different criteria scales in different directions (trade-offs) it is necessary to put weights representing the relative importance associated with the respective criteria on the scoring results. There exist a variety of possibilities to rank the different scoring patterns of alternative options: linear additive models, successive pair wise comparisons, multidimensional outranking methods and methods using qualitative data and/or fuzzy sets for ranking procedures.

The problem with this method lies in the complexity of its results. It is known from psychological experiments that it is difficult to make judgments on different alternatives taking into account more than seven criteria at once. But a multi-criteria analysis can easily supply dozens or hundreds of criteria. Without aggregation and/or weighting with the help of indicators, decision makers and stakeholders will be overstrained and disoriented. On the other hand, aggregation and weighting in itself is a difficult process relying heavily on strong and influential assumptions and value judgments. Therefore also the multi-criteria analysis has its methodological problems that should be revealed and discussed openly. Moreover, MCA results should be tested for their robustness in the course of a sensitivity analysis varying criteria scoring, weighting and ranking procedures.

#### Relation to systems approach

Since assessment results derived from MCA usually represent values within a single year, the method is not especially well adapted to take into account the dynamic aspects of the systems approach. On the other hand, the multidimensionality of the MCA approach is able to give a good representation of the complexity of the decision problem – which fits quite well with the systems approach perspective stressing the equal importance of the ecological, economic and social dimensions. Theoretically, multi-criteria analysis is not

biased towards a single dimension of effects. Practically this non-biased nature must be carefully kept during the weighting and ranking processes. If properly and transparently done, it can serve as an appropriate tool to implement systems approach thinking in decision making processes.

### **When this method is especially to be used**

Multi-criteria analysis does not try to melt everything into one dimension (i.e. money). It shows the effects of baseline developments and management scenarios on the multiple dimensions of the ecological, economic and social systems. Therefore it is well-suited in situations when valuation of central dimensions of the decision problem is not accepted by relevant stakeholders. That is often the case concerning the valuation of biodiversity – where many stakeholders see no sense in identifying the existence or extinction of a certain species with monetary values, since the irreversibility of the potential loss is seen as inconsistent with the concept of substitutability lying behind the valuation approach. The same is often the case if the protection of human lives is the object of the valuation exercise. MCA is able to represent the critical criteria in the performance matrix within their original dimensions – leaving it up to the decision maker to weight their scoring values against that of other criteria.

### **How to best present results to stakeholders?**

The results of a multi-criteria analysis should be presented and interpreted carefully. Advice should also be given to stakeholders to be cautious with respect to the use of the results.

While presenting the results to stakeholders, bear thus in mind the limitations of the method:

- The performance matrix representing the scoring of many different options on many different criteria might be very complex.
- The process of weighting comprises sensitive value judgments.
- The process of ranking non-dominated alternatives might influence the outcome.
- Therefore it might be difficult and time-consuming to come to a common view on the performance matrix and to identify consensual decision options in one exercise.
- If weighting and ranking procedures remain controversial, it might be impossible to reach an agreement on optimal decisions.

Some approaches to answer those limitations:

- The choice of relevant criteria, scoring scales, weighting and ranking procedures should be presented and discussed very transparently.
- If there is disagreement with one of the steps of the multi-criteria analysis, the step in question should be reformulated in a consensual way and the consequences of this reformulation should be analysed. This could be prepared in advance in the course of a sensitivity analysis – especially if potentially sensitive aspects prone to conflicting views are identified in advance.

- Pre-tests with focus groups can help to identify criteria seen as relevant and to discuss different weighting options towards these criteria. This can also be prepared or supported with surveys via interviews or online questionnaires.
- Multi-criteria analysis results can be compared with cost effectiveness or cost benefit analysis outcomes to show the differences and congruencies between the different approaches. This can help to move stakeholders and practitioners out of potential perceptions biases they bring with them into the discussion or workshop situation. Such a comparison can also help to show (or question) the robustness of the different assessment approaches.

### Example of use of the method

Within the SPICOSA project, multi-criteria analysis has mostly been used in order to account for the multi-dimensional aspects of the policy issue: indeed, MCA may be seen as very appropriate for the purpose of integrated assessments including together ecological, economic and social concerns.

An example of the implementation of this method in relation to the results of an integrated dynamic model based on Systems Approach is the Thau Lagoon case study, which provides an assessment of a water policy aiming at mitigating microbiological contamination. This example is very simple as it ends with the estimation of a set of indicators in relation to the effects of various decision options, but it does not enter into the ranking nor the weighting of these indicators for two reasons: first, the ranking and weighting of indicators raises numerous methodological problems and, second, it may be seen as inconsistent with the holistic character of Systems Approach, which requires that stakeholders should be able to permanently re-assess their own judgment regarding the possible evolutions of the system.

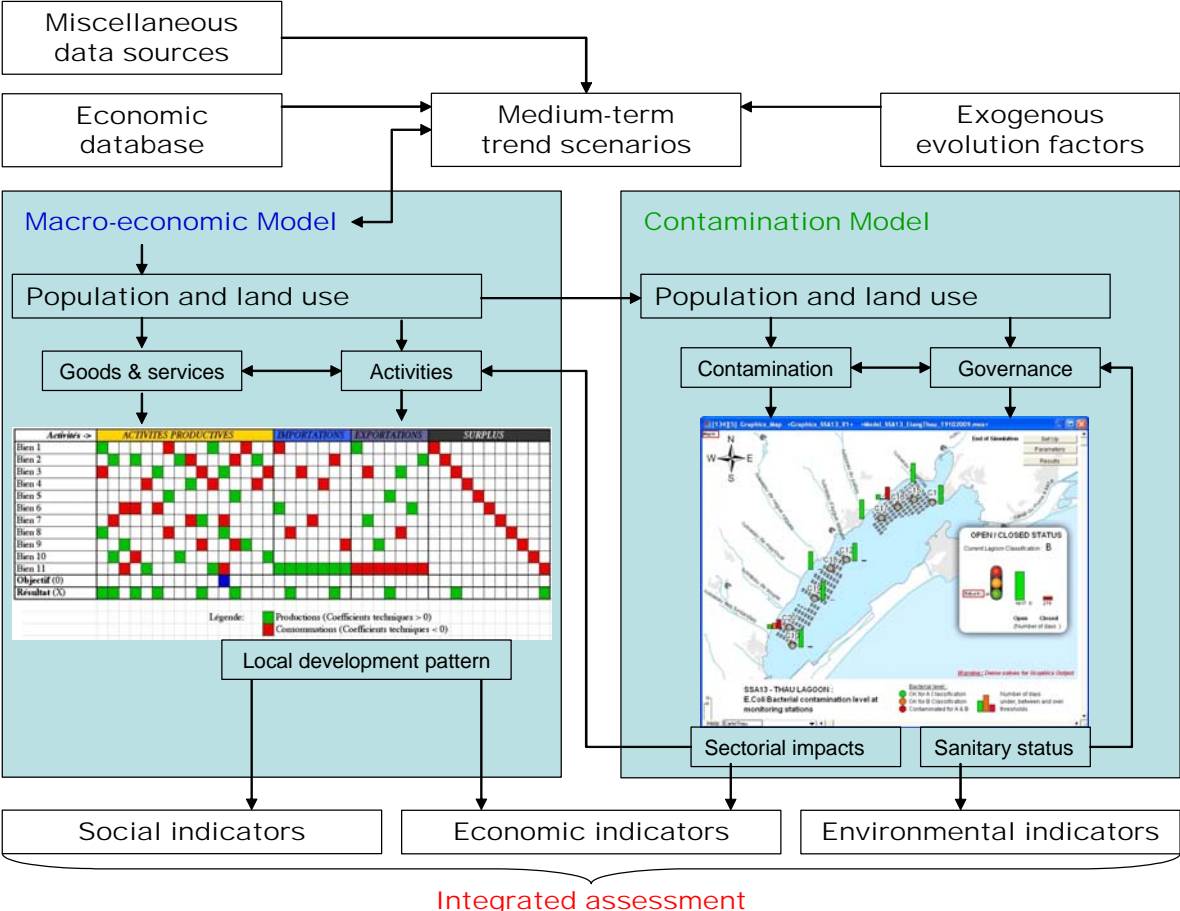
The case study team worked with representatives of the local management bodies in order to make the objectives of the water policy explicit. Following this clarification, the objectives were specified into a series of principles, the respect of which could be assessed through one or more criteria, whose fulfillment could be checked with performance indicators. The articulation between principles, criteria and indicators is depicted in Table 1.

Table 1: Principles, criteria and indicators for the MCA of scenarios in the Thau Lagoon.

<i>Principles</i>	<i>Criteria*</i>		<i>Indicators</i>
<b>Improving water quality</b>	Bathing water quality	+	Number of bans (days)
	Shellfish farming water	+	Number of bans (days)
	Lagoon reputation	+	Lagoon classification
<b>Maintaining local employment</b>	Shellfish farming vulnerability	-	Number of businesses facing negative results
	Employment in traditional activities	+	Number of full-time equivalent in traditional activities
	Total employment	+	Number of full-time equivalent
<b>Economic development</b>	Goods and services production	+	Total turn over of all sectors
	Economic dependency	-	Imports/Exports trade ratio
<b>Public budget savings</b>	Public expenses for water treatment devices	-	Investment and running costs

\* The sign +/- indicates if the criteria is expected to be maximized (+) or minimized (-).

The integrated assessment framework which was used to carry out the multi-criteria analysis was expected to provide indicators related to the local development pattern and to the water pollution mechanisms and its direct impacts on human activities. For that purpose, the modelling approach consisted in coupling a macro-economic model of the coastal territory (MEPP: model of physical economy and prospective) and a pollution model of the lagoon and its watersheds, which includes microbiological contamination sources, water treatment system, human activities in the lagoon and the governance mechanisms (see Figure below). The models function on different time-steps and answer different aims: the macro-economic model time-step is annual, and it allows for long-term prospective; the pollution model has a daily time-step, and it allows for internal adjustment regarding the sanitary status and its impacts. Both models provide indicators which can be computed into annual accounts for the multi-criteria analysis.



*Thau Lagoon modeling approach for multi-criteria analysis: coupling a macro-economic model and a pollution model.*

In the Thau Lagoon study site, the integrated assessment of policy options was carried out following two steps. In a first step, the policy options were subject to the above mentioned multi-criteria analysis. In a second step, the most performing policy options as regards the ecological and social criterion were submitted to a specific cost-effectiveness analysis, which consisted in comparing the total costs induced by public expenses against the performance indicators of one or another principle.

## **Further references**

Department for Communities and Local Government (2009): Multi-criteria Analysis – A Manual, London. Free download:

<http://www.communities.gov.uk/documents/corporate/pdf/1132618.pdf> , accessed 01/2011

## Cost effectiveness analysis

The purpose of a cost effectiveness analysis is to find out how predetermined targets (e.g. threshold values for nutrients or other pollutant loads in a catchment) can be achieved at least cost. Theoretically speaking, the least cost allocation of pollution abatement strategies is found if the marginal costs of the proposed measures are equal. The marginal costs of these abatement measures can for example be defined as the increase in total abatement costs when pollution loads are decreased by 1 ton or 1 kilogram per year. As long as marginal costs are not equal, it is theoretically possible to obtain the same level of pollution reduction at lower costs by shifting emission reduction from high cost measures to lower cost measures.

The steps involved in conducting a cost effectiveness analysis are described below:

Step 1: Define the environmental objective involved

Step 2: Determine the extent to which the environmental objective is met

Step 3: Identify sources of pollution, pressures and impacts now and in the future over the appropriate time horizon

Step 4: Identify measures to bridge the gap between the reference (baseline) and target situation

Step 5: Assess the effectiveness of these measures in reaching the environmental objective

Step 6: Assess the costs of these measures

Step 7: Rank measures in terms of increasing unit costs

Step 8: Assess the least cost way to reach the environmental objective

These steps are taken in sequence, but important feedbacks may exist between steps. As information becomes available about the problem, the source-effect pathway and possible solutions, the same step may be revisited several times. The outline of the various steps shows that carrying out a cost effectiveness analysis is a multi-disciplinary exercise, requiring the input of and collaboration between different scientific disciplines, such as natural scientists, economists and technical engineers, but also the input of policy and decision-makers as they determine the scope and objective of the analysis.

A number of approaches are used in practice at varying levels of complexity, scale, comprehensiveness and completeness for carrying out a cost effectiveness analysis. A distinction is made between bottom-up and top-down approaches. The bottom-up approach focuses on technological details of measures and their impact on individual enterprises (micro level), whereas top-down approaches usually consider the wider economic impacts of pollution abatement measures and strategies, often without detailed technical specification of the proposed measures (macro level). Bottom-up approaches can also be characterised as technical engineering approaches, often including detailed information about the technical characteristics of production processes and only limited information about the financial engineering costs of emission abatement technologies. Top-down approaches on the other hand focus more on the economic relationships and consequences involved and less on the technical specification of measures.

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