Guideline for using the MultiCriteria Analysis tool

A complete MCA application comprises four components: the decision tree, the composite analysis graph, the consequence table, and the sensitivity analysis (Figure 13). Users can define priorities, and compare and evaluate the relative performance of the alternatives across a set of criteria, calculated as a weighted sum of scores. Advanced users can define new decision trees and upload or manually insert required data in the consequence tables, making the MCA tool readily applicable to new case studies.
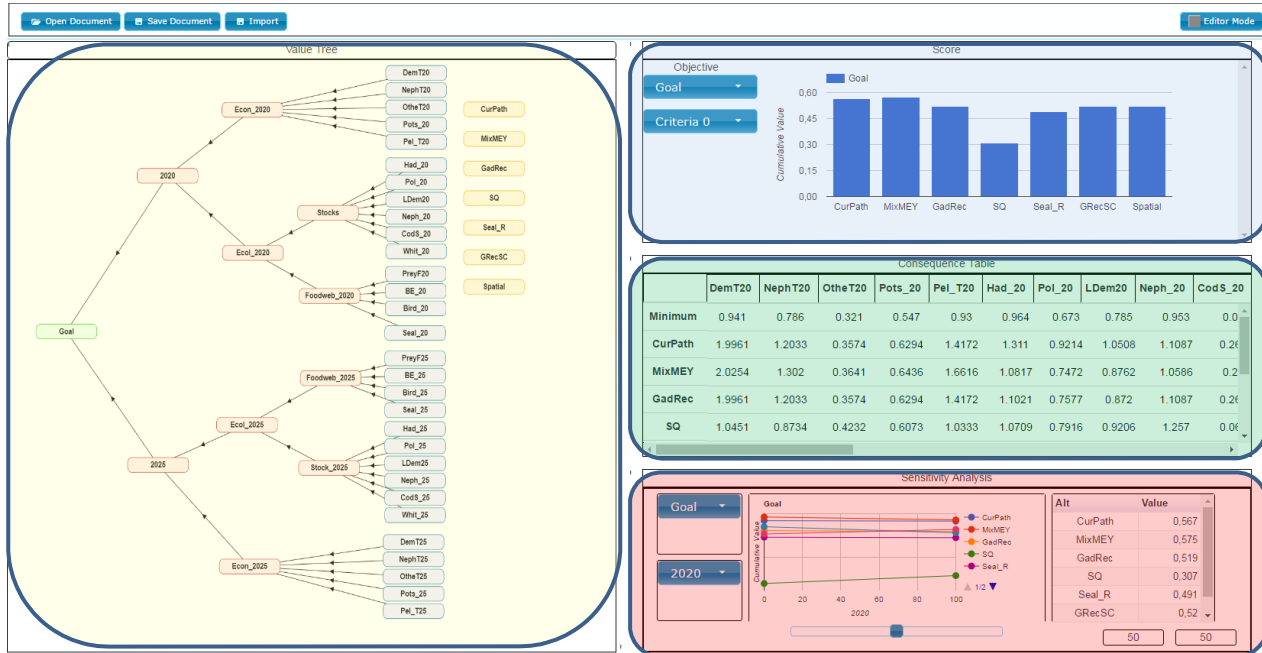

FIGURE 13: INTERFACE OF THE MULTI-CRITERIA ANALYSIS TOOL: DECISION TREE (YELLOW), COMPOSITE ANALYSIS (BLUE), CONSEQUENCE TABLE (GREEN) AND SENSITIVITY ANALYSIS (RED)

1.1.1.1   Decision tree

The decision tree is constructed in collaboration with stakeholders to reflect the main aspects of the evaluation, arranged into a hierarchical structure. From the left to right, the decision tree includes four types of elements. The type of each element and potential descriptive information is revealed by clicking on them:

- Goal: This is the placeholder for the formal but abstract goal that each alternative should aim to achieve (e.g. "sustainable and prosperous fisheries")
- Objectives: these are higher and lower order objectives that reflect main types of concerns as arranged into a logical and hierarchical order. In the example of Figure 10, the decision tree includes two higher-level objectives, respectively relating to the short-term concerns ("2020") and long-term concerns ("2025"). Each of these branches are subsequently divided into two lower level sub-objectives, respectively relating to economic concerns ("Econ_2020") and ecological concerns ("Ecol_2020), which in turn is subdivided into "stocks" and "foodweb".
- Attributes: the indicators that each of the objectives on the lowest level are evaluated against. For instance, Econ_2020 is evaluated against the forecasted economic performance (total revenue) of five fleet segments (DemT20, NethT20, etc.) for each alternative.
- Alternative: the management alternatives to be evaluated. If the user knows that an alternative is clearly inferior or irrelevant in some way, it can be excluded from the evaluation

by double-clicking on the alternative, and checking the button marked "Exclude alternative". This simplifies the presentation of outcomes in the composite analysis. The alternative can be brought back later if needed by unchecking the exclusion button.

The user can define value functions in an interface that appears when double-clicking on an attribute (Figure 14). The value function is shaped by adding points (double click) to a desired place in the graph area.
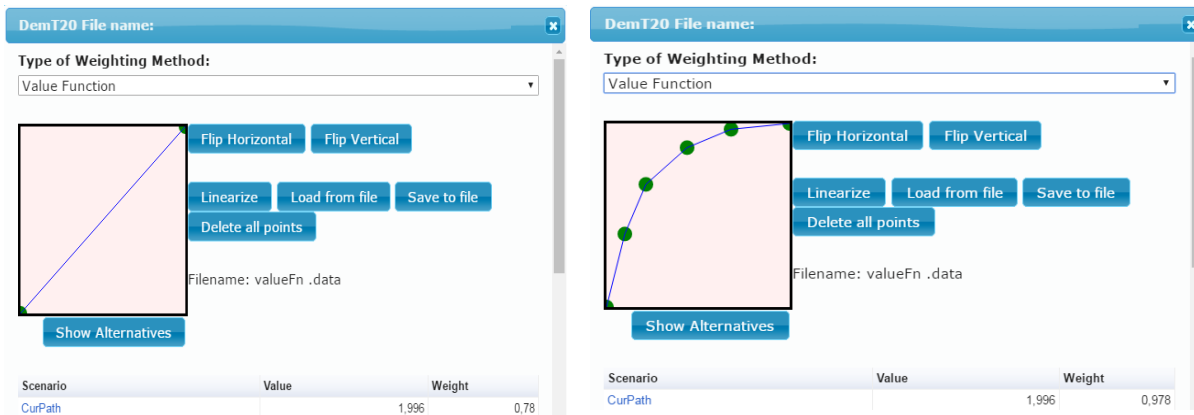

FIGURE 14: INTERFACE FOR DEFINING UTILITY FUNCTIONS — PRE-SET LINEAR FUNCTION (LEFT) AND USER-DEFINED UTILITY FUNCTION (RIGHT)

The default value function is linear, and increases (vertical axis) from 0 to 1, where 1 signifies a maximum utility score. The horizontal axis represents the range of the indicator in question within defined minimum and maximum limits in the original scale of the attribute (euros, tonnes, full time equivalent jobs ets.

The user can invert the value function ("flip vertical") for indicators for which an increase in the indicator value involves a decreased utility (indicator of cost, pollution or other harm). The user may also define any shape of the value function, provided that it starts at 0 and ends at 1 (or the opposite).

For haddock SSB, for instance, the x-axis reflects SSB and the y-axis reflects utility on a scale from 0-1. If we imagine that the SSB_{MSY} for haddock is around the middle of the diagram, the users might want to define a utility function as illustrated above, reflecting that increases in SSB above SSB_{MSY} are less important than any increase until that point.

The user can define the relative priority of different concerns by assigning weights to different objectives. This is done in an interface that becomes available when clicking on a node in the decision tree (Figure 15). The decision weights can be defined either by moving a slider or by typing a number.

FIGURE 15: INTERFACE FOR DEFINING DECISION WEIGHTS IN THE MAREFRAME MULTI-CRITERIA ANALYSIS TOOL

1.1.1.2 Composite analysis

Once decision weights and utility functions are defined, the composite analysis allows the user to assess the overall performance of each alternative with a selected level of detail (Figure 16).
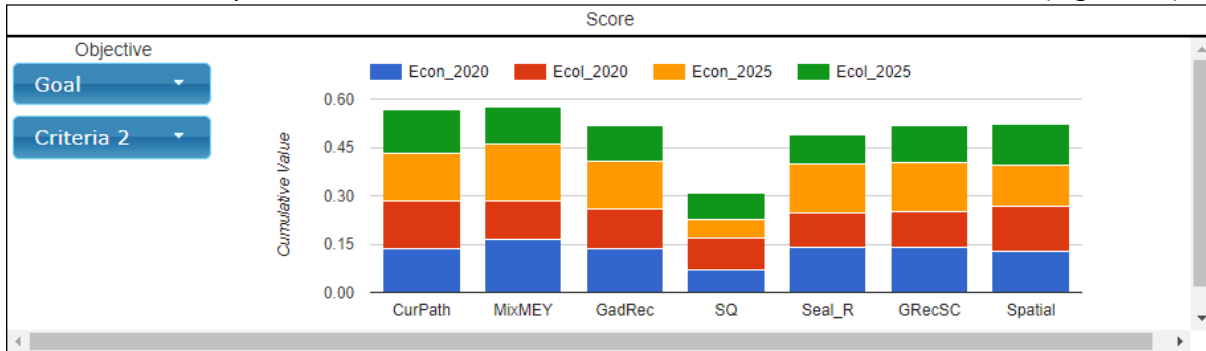

FIGURE 16: THE COMPOSITE ANALYSIS INTERFACE IN THE MAREFRAME MULTI-CRITERIA ANALYSIS TOOL

In the example shown, the management alternative (scenario) "MixMEY" performs best overall, closely followed by "CurPath". The user has here chosen to display the overall performance of the alternatives ("Goal") with an intermediate level of detail ("Criteria2"). The composite analysis interface allows the user to inspect the contributions of each indicator to the overall performance in different levels of details. For instance, as the indicator "Econ_2015" provides a large contribution to the overall result, the user could inspect why this is so in more detail by selecting that "Econ_2025" is displayed in relation to indicators on the lowest level, i.e. "Criteria 3" (Figure 217).
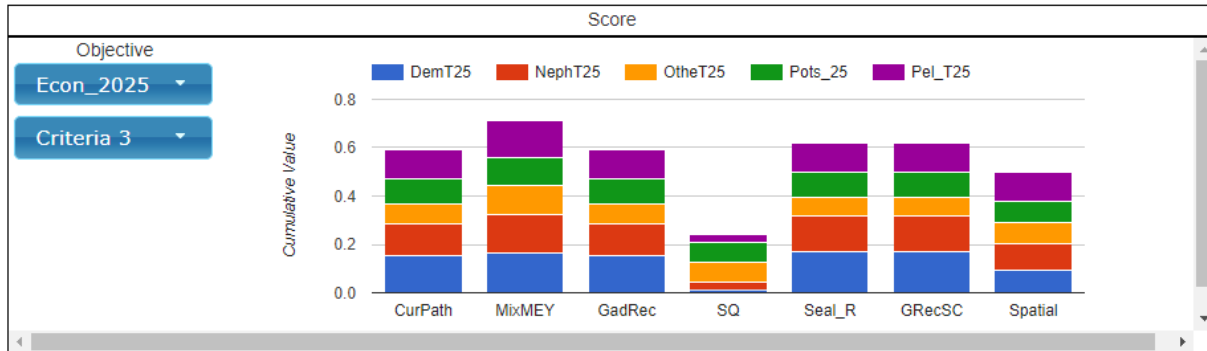

FIGURE 27: THE COMPOSITE ANALYSIS INTERFACE IN THE MAREFRAME MULTI-CRITERIA ANALYSIS TOOL. THE FIGURE SHOWS AN EXAMPLE OF AN INTERFACE IN WHICH THE USER CAN ANALYSE HOW THE DIFFERENT SCENARIOS PERFORM WITH REGARD TO OBJECTIVES ON DIFFERENT LEVELS OF ANALYSIS. THE FIGURE SHOWS THE RELATIVE PERFORMANCE OF SCENARIOS WITH REGARD TO A SUB-OBJECTIVE (ECON_2025).

1.1.1.3 Consequence table

The consequence table (Figure 318) displays the expected performance for the different alternatives on the criteria. The consequence table allows the user to inspect the forecast that is used in the analysis.

In the illustrated example, the estimates shown are rendered relative to a reference period (average values for the period 2011-2013). For instance, the estimated outcome for DemT20 for the "Current Path" alternative is 1.9961, predicting that the revenue of demersal trawls will double by 2020 compared to the reference period if this alternative is pursued.

Consequence Table

	DemT20	NephT20	OtheT20	Pots_20	Pel_T20	Had_20	Pol_20	LDem20	Neph_20	CodS_20	V
Minimum rating	0.941	0.786	0.321	0.547	0.93	0.964	0.673	0.785	0.953	0.058	
Baseline	1.618	1.109	0.394	0.628	1.379	1.418	0.844	0.97	1.168	0.184	
CurPath	1.9961	1.2033	0.3574	0.6294	1.4172	1.311	0.9214	1.0508	1.1087	0.2605	
MixMEY	2.0254	1.302	0.3641	0.6436	1.6616	1.0817	0.7472	0.8762	1.0586	0.264	
...	...	...	...	...	...	...	...	...	...	...	

FIGURE 38: THE CONSEQUENCE TABLE IN THE MAREFRAME MULTI-CRITERIA ANALYSIS TOOL

The minimum and maxim limits are set to define the boundaries for the indicator range. In the example, the lower and upper limits were respectively set to 0.90*the lowest indicator value across the alternatives and 1.10 * the highest indicator value across the alternatives.

The user can revise the entries in the consequence table, but the changes will only apply to the interface of the user in question and will be reverted to original values after the work session unless the changes are saved as a local file (see section 4.2.2.3 below).

1.1.1.4 Sensitivity analysis

The sensitivity analysis interface (Figure19) allows the user to explore the robustness of the evaluation with regard to changes in decision weights or in the forecasts. The sensitivity analysis of the MCA also allows for an exploration of sensitivity of evaluation outcomes with regard to uncertainty in the estimation of indicator values in the consequence table (e.g. uncertainty in the SSB level). The user can change the weighting of indicators by moving the slider left or right, between values of 0 and 100. For exploring sensitivity of the scores (value functions), the scale will range between the minimum and maximum values given in the consequences table.

In the example shown, the MixMEY strategy outperforms all other alternatives regardless of the weight given to short-term concerns (2020), although the "CurPath" alternative performs just about as well if all decision weight is given to short-term concerns. In turn, the relative ranking of "Spatial" (pink line), "GadRec" (orange line), and GRecSC (pale blue line) is sensitive to the short term vs. long-term tradeoff; GRecSC will perform best among these alternatives for a decision weight lower than 68 (relative to a decision weight of 100 for 2025 concerns) whereas "Spatial" will perform better for a higher prioritisation of short-term concerns.
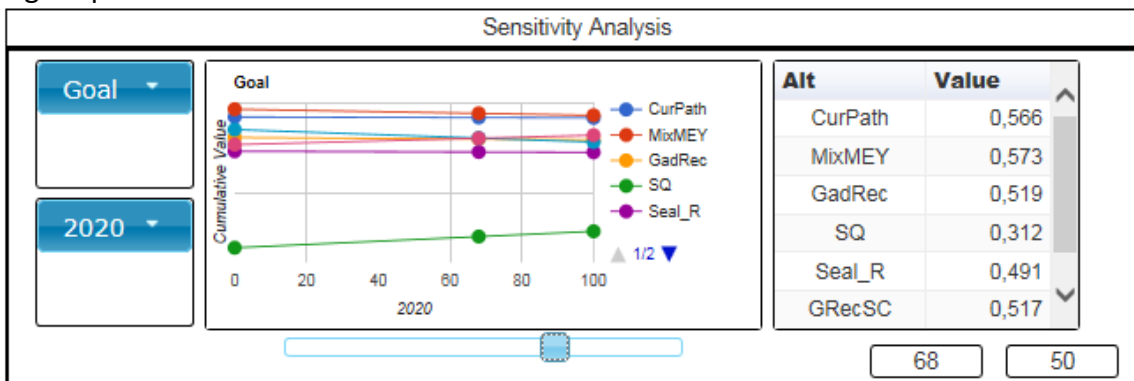

FIGURE 19: THE SENSITIVITY ANALYSIS INTERFACE IN THE MAREFRAME MULTI-CRITERIA ANALYSIS TOOL

1.1.2 Input for the MCA and how to create and save a MCA

The scenario visualisation tools can utilize any quantitative data in the form of point estimates that provides information on the variables in question. The data can be uploaded as a single file by the web-administrator or be entered manually. The user can revise the entries and save the changes as a local file, but the data entries for the MCA tool on the web can only be permanently changed by the web administrator. Data can be uploaded to the consequence table in Excel-format. When adding new data to an existing MCA structure, the order of the indicators must be in the same order as the ones in the consequence table.

1.1.2.1 How to upload new data for an existing MCA model

In the editor mode, the user can revise individual data entries in the consequence matrix manually. If the consequence matrix is large (due to a large number of attributes or alternatives or both), it is convenient to upload a new data set from a file. The MCA program defines the required file structure once the value tree is defined. The input file to be uploaded needs to be a csv file and have the format shown in Error: Reference source not found below.

Note that instances of the small letter "x" in the column to the right are required for the uploading to succeed).

TABLE 1: FORMAT OF THE CSV-FILE WITH DATA INPUTS FOR THE CONSEQUENCE TABLE THAT CAN BE UPLOADED FOR THE MAREFRAME MCA PROGRAM.

	AttributeA	AttributeB	AttributeX		
Minimum limit	Min A	Min B	Min X		
Alternative1	Data A1	Data B1	Data X1	Description of Alternative1	x
Alternative2	Data A2	Data B2	Data X2	Description of Alternative 2	x
AlternativeX	Data A3	Data B3	Data X3	Description of Alternative X	x
Units	Unit A	Unit B	Unit X		
Maximum limit	Max A	Max B	Max X		
Attribute Descriptions	Description of alternative A	Description of alternative B	Description of alternative X		

1.1.2.2 How to create a new MCA

A new MCA can be constructed from scratch in the following location on the MareFrame web site:
- Case studies -> "test case" -> link to MCA[1]

This opens an empty MCA page, in which the user can construct a new model.

Alternatively, the user can open an existing case study, activate the "editor mode", delete all elements of the existing case, and then build the new MCA, but this involves more work than the previous approach.

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1   http://mareframe.mapix.com/dev/MCA2/DST.html?model=testcase

The best way to construct the new MCA is as follows:

1) Complete the consequence matrix with descriptions as in the format shown in Error: Reference source not found
2) Upload the csv file to the MareFrame MCA page. This imports the attributes with names and descriptions and data values into the MCA.
3) Create, name and connect objectives to complete the value tree. This is done in "editor mode" as follows.
   a. Add new element.
   b. Double-click to modify the element, double-click on the default name given to the element (e.g. "Objective1") and change the name to the required name.
   c. Use the mouse to drag the element to the desired location in the value tree space (conventionally with higher order objectives to the left and lower order objectives to the right, followed by attributes and alternatives further to the right (see existing case studies using MCA for examples)
   d. Connect elements with arrows using the "connect tool". The arrows must go from attributes to lower order objectives and then to the higher level objective(s). The alternatives should not be connected to other elements with arrows.
4) The new MCA will now include data and correct names for each element and can be saved locally as a new MCA file (see below).

1.1.2.3 Saving a new or modified MCA

Users can save a new or modified MCA as follows:

1) Click "save document"
2) Click on "Download" in "Filename xxx.xdsl" located just below the value tree window (Figure 420)
3) The file will be sent to the user's default download folder and will be given a default name (e.g. "model(1).xdsl."). The files and can renamed provided that the name ends with the required file specification, i.e. ".xdsl". The user can store and share files, e.g. through email.

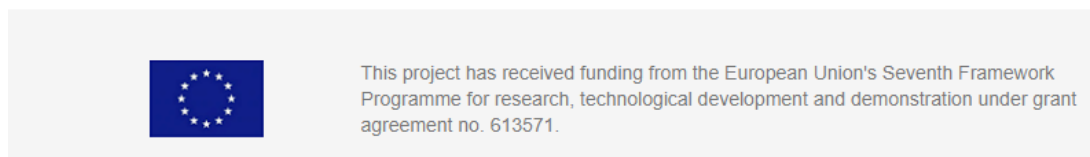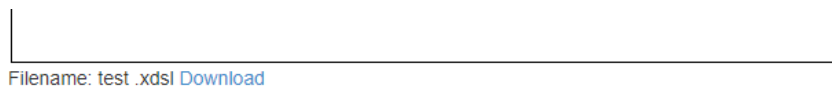Filename: test .xdsl Download

FIGURE 40: EXCERPT SHOWING THE LOCATION OF THE FUNCTION TO DOWNLOAD/SAVE A MCA FILE LOCALLY

Note that steps provided here are general. Certain aspects of the download procedure may differ depending on the web browser being used.

1.1.3 Programs for the MultiCriteria Analysis tool

The MCA tool is developed as a web application. The great advantage of web-applications are there is

no installation process. All the user needs is a browser. Going to the application urls[2] will load everything, and after there is no dependency on a web connection, every calculation is performed in the browser

The MCA web-application is written in typescript, which translates the code to JavaScript. JavaScript is the most used programming language for web applications. 3rd party libraries used are jQuery, easeljs and Google Charts.

The jQuery framework[3] is used for general HTML document traversal and event handling, like buttons or sliders.

Easeljs is used for the value tree elements and connections and for value function design.

Google Charts[4] is used for MCA tables and graphs.

The CreateJS framework for the MCA model interface[5].

The source code for MCA is available at: https://github.com/Tokni/Mareframe-BBN-MCA-VS15/tree/css

2   http://mareframe.mapix.com/dev/MCA2/DST.html
3   https://jquery.com/
4   https://developers.google.com/chart/
5   http://www.createjs.com/