



ARANGE Deliverable DX.Y

Improve the way you
evaluate forest management
alternatives

05.05.2014

Eva-Maria Nordström, Karin Öhman



ARANGE - Grant no. 289437- Advanced multifunctional forest management in European mountain ranges

Document Properties

Document number	FP7-289437-ARANGE / Dx.x
Document title	Deliverable reference number and title
Author(s)	
Date of last revision	
Status	Final/draft
Version	
Dissemination level	PU/RE/CO
Relation	WP x, related to WP x, WP x....

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 289437.

Keywords:

Abstract:

up to 500 characters (with blanks)

TABLE OF CONTENTS

1	Preface	5
2	Introduction to multi-criteria decision analysis (MCDA)	6
2.1	Step 1. Frame the decision problem	6
2.2	Step 2. Define alternatives	7
2.3	Step 3. Weighting of objectives	8
2.3.1	Simple Multi-Attribute Rating Technique (SMART).....	8
2.3.2	Analytic Hierarchy Process (AHP).....	9
2.4	Step 4. Local evaluation of alternatives.....	9
2.5	Step 5. Global evaluation	10
3	User guide for PlanEval.....	12
3.1	Arange case study example	12
3.2	What is PlanEval?.....	13
3.2.1	How to install PlanEval.....	13
3.2.2	Creating a new project.....	14
3.3	Frame the decision problem	14
3.3.1	Create the objective hierarchy	14
3.3.2	Add and define stakeholders.....	15
3.4	Define alternatives	16
3.4.1	Add alternatives	16
3.4.2	Define the outcome for each alternative	17
3.5	Weighting of objectives	18
3.5.1	Choose methods	19
3.5.2	Assigning weights for each objective and stakeholder	19
3.6	Local evaluation of alternatives.....	21
3.6.1	Choose methods	21
3.6.2	Local evaluation of alternatives for each stakeholder	22
3.7	Global evaluation	23
3.8	Tips and tricks.....	25
4	Further reading.....	27

1 Preface

The purpose of this document is to present the partners in the ARANGE project (www.arange-project.eu) with an approach for evaluating forest management alternatives based on the output and importance of various ecosystem services. The approach presented is based on multi-criteria decision analysis (MCDA) methodology and the document starts with a short introduction to MCDA to provide the readers not already familiar with MCDA with a background and a basic understanding of the methodology. We also introduce a software for MCDA, PlanEval, and provide a guide for how to use it based on an example case from the Swedish ARANGE case study area.

The development of this document was financially supported by ARANGE.

If you have any questions or need support, please contact the authors of the report:

Eva-Maria Nordström, email: eva-maria.nordstrom@slu.se

Karin Öhman, email: karin.ohman@slu.se

Postal address:
Department of Forest Resource Management
Swedish University of Agricultural Sciences (SLU)
SE-903 81 Umeå, Sweden

2 Introduction to multi-criteria decision analysis (MCDA)

In real-world planning for sustainable forest management, we often face complex problems where different values have to be taken into account. High quality forest inventory data and reliable models are of course required, but part of the problem is that objective information is not sufficient to solve the problem. The subjective preferences of the decision maker(s) are at least as important and need to be identified and included in the planning process. Multi-criteria decision analysis (MCDA) is a set of decision analysis methods that can be used to address such problems that are characterized by multiple and conflicting objectives. Through a structured process, MCDA will support the decision maker(s) in making trade-offs between objectives in order to identify alternative solutions that fulfill these objectives in the best possible way. Further, MCDA methods enable comparison of values measured by different scales which means that values need not be converted into monetary terms. MCDA was originally developed as a tool for a single decision maker, but the multi-objective character makes MCDA very useful also in participatory planning and group decision making when we want to include the opinions of several stakeholders.

There are two major groups of MCDA methods: multi-attribute decision analysis (MADA) and multi-objective decision analysis (MODA) methods. The major difference between these two groups is the number of alternatives that can be considered. MODA methods can be used to generate a number of relevant alternative solutions by identifying a subset of alternatives from a very large or continuous set of potential alternatives. In a forestry context, MODA methods could be used to generate treatment schedules for a stand or management plans for a landscape that cannot be improved with respect to one objective without impairing the outcome for other objectives. For example, common MODA methods are goal programming and compromise programming. MADA methods, on the other hand, can be used to select the best alternative solution from a limited number of options. For example, MADA could be used in situations where it is necessary to evaluate the performance of a limited number of treatment schedules or management plans with respect to economic, ecological and social values. A common MADA method is, for instance, the Analytic Hierarchy Process (AHP).

In this work, we will present and use two MADA methods since they are appropriate for supporting us in evaluating a limited number of distinct management alternatives. When using MADA methods, the MCDA process can be structured in a number of steps. In this section we will describe these steps briefly in general and in next section we will show how MCDA is implemented in PlanEval following these steps.

2.1 Step 1. Frame the decision problem

The aim of this step is to identify all relevant stakeholders and to define the decision problem by identifying the relevant objectives and the relationships between them. A stakeholder is

someone who is affected by or can affect the decision problem; that is, someone who should be included in the decision process and whose preferences should be accounted for. Simply put, an *objective* is a statement of something that the stakeholder wants to achieve. Objectives usually have a direction so that they are either of the type “more is better” or “less is better”, but they may also be expressed as target values that one wants to achieve with neither negative nor positive deviations. Objectives are structured in an objective hierarchy, a tree-like structure where the objectives are organized according to how they relate to each other. The lowest-level objectives at the end of each branch are here called *attributes* and are used to measure how well different alternatives perform in terms of a certain objective.

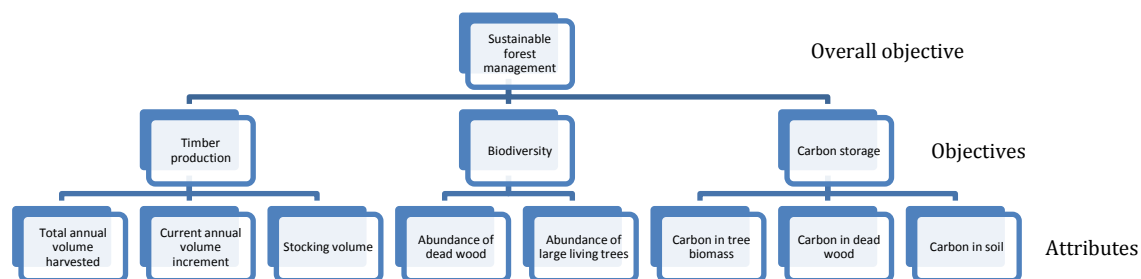


Figure 1. Example of an objective hierarchy.

The framing of a decision problem should be considered carefully as it will influence the outcome. In fact, problems are sometimes so complex that the task is not only a matter of solving a problem but also of defining what the problem is.

2.2 Step 2. Define alternatives

The aim of this step is to identify or create a number of relevant alternatives and assess possible impacts of each alternative. *Alternatives* are the means for achieving the stated objectives; for instance, treatment schedules (i.e., sequences of management activities such as thinning, final felling, and planting etc. that are applied over time) for a stand or management plans for a landscape. Alternatives must be defined carefully because in the end the solution is confined to the given alternatives unless the MCDA process is iterative and new alternatives can be added at a later stage. In general, too many alternatives can make the evaluation very demanding. Experiences from forest planning studies indicate that three to five alternatives seems to be appropriate. These alternatives should in most cases not be too extremely directed toward any single objective but still cover major outlines rather than minor variations.

2.3 Step 3. Weighting of objectives

The aim of this step is to assign weights to objectives and attributes according to the preferences of the stakeholders¹. *Preferences* are subjective judgments made by the stakeholder(s) on the importance of objectives and attributes. The weights will thus represent the importance of each objective/attribute and are used in step 5 to determine the ranking of the alternatives.

Here we focus on two different MCDA methods that can be used for assigning weights to the objectives and attributes: Simple Multi-Attribute Rating Technique (SMART) and Analytic Hierarchy Process (AHP). These methods are both available in PlanEval and the principles for these methods will be described in the following.

2.3.1 Simple Multi-Attribute Rating Technique (SMART)

When SMART is used, points are assigned in turn to the objectives/attributes. Each level and branch of the objective hierarchy is considered in turn. The stakeholder is first asked to give a score of 100 to the most important objective/attribute of the level (and branch) in question and then proportionally smaller scores to less important objectives/attributes on the same level. Several objectives/attributes can be given the same score if the stakeholder so chooses. If all objectives/attributes are equally important, the stakeholder should assign a score of 100 to all. This process is repeated until scores have been assigned to the objectives/attributes for each level and branch of the objective hierarchy.

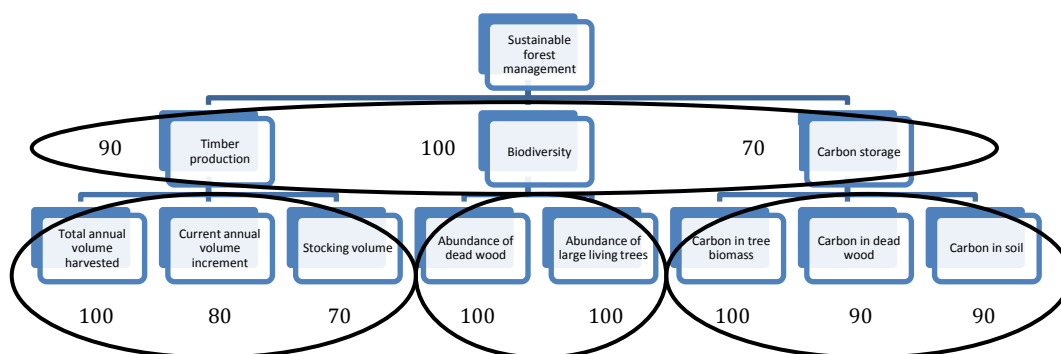


Figure 2. Illustration of how the weighting works with the SMART method. A score of 100 is assigned to the most important objective(s)/attribute(s) and then proportionally smaller scores are assigned to less important objectives/attributes. This weighting procedure is repeated for each level and branch in the objective hierarchy (circled with black), in this case four times.

¹ The term *stakeholder* will be used throughout the document with the intention to include all different kinds of decision makers that are included in the process.

2.3.2 Analytic Hierarchy Process (AHP)

AHP is based on pairwise comparisons of objectives/attributes meaning that two objectives/attributes are compared at a time. The importance of one objective/attribute compared to the other is stated by using the so called Saaty scale which is a ratio scale based on five main grades (Table 1). The pairwise comparisons are repeated until the objectives/attributes on the same level and belonging to the same branch of the hierarchy have all been compared with each other. This process is repeated until pairwise comparisons have been made for each level and branch of the objective hierarchy.

Table 1. A summary of Saaty's ratio scale (Saaty 1977)

Intensity of importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

Assigning appropriate weights to objectives/attributes can be confusing and difficult and AHP is intended to make the process more intuitive and to simplify the comparison of the objectives/attributes by asking the stakeholder to focus on only two objectives/attributes at a time. However, a problem connected to the pairwise comparisons is that the stakeholder may be inconsistent. For instance, if the stakeholder has said that A is more important than B and B is more important than C, then A must be much more important as C; otherwise the preferences are not consistent. If the stakeholder would say that C is more important than A, this would be a very serious inconsistency that indicate a problem with the understanding of the method or uncertainty in the preferences. Mostly, inconsistencies are not this serious but appear because the strength of preferences expressed using the Saaty scale is not perfectly consistent. An example of a slight inconsistency could be to say that A is more important than B, B is more important than C and then that A is more important than C (rather than much more important). The inconsistency can be calculated and in the methodology an inconsistency of 10% (0.10) is considered acceptable. In reality it may be higher and experience shows that the inconsistency increases with the number of comparisons. Good support in the pairwise comparison process is essential to counteract this problem. If the inconsistency is high it may in some cases be necessary to repeat the comparisons to try to ensure that preferences are not misleading. Here we will not describe how the inconsistency is calculated since there is software that can do this.

2.4 Step 4. Local evaluation of alternatives

This step is similar to the previous one, but the aim is to evaluate the alternatives with respect to how well they perform in terms of each attribute. This is why the step is called "local evaluation of alternatives" – only one attribute at a time is considered when the alternatives are evaluated. Moreover, the evaluation of the alternatives is based on the outcomes in terms of the attributes and not only, as the weighting of objectives, on the subjective preferences of the stakeholder.

The same or a different method than the one used in the weighting of objectives may be used. If SMART is used, the stakeholder should give a score of 100 to the alternative that he or she thinks performs best for that particular attribute and proportionally smaller scores to the other alternatives according to the rules described above. This is repeated for all attributes. If AHP is used, pairwise comparisons are done in a similar way as for the objectives, but now the alternatives are compared in a pairwise fashion with respect to one attribute at a time.

2.5 Step 5. Global evaluation

The aim of this step is to make an overall ranking of the alternatives. This ranking is based on both the weighting of the objectives in step 3 and the local evaluation of alternatives with respect to each attribute in step 4, and this is why it is called “global evaluation”.

First, the scores (if SMART is used) or pairwise comparison outcomes (if AHP is used) are normalized and converted into values or weights ranging between 0 and 1. (This is automatically calculated in PlanEval.) Then, the overall values of the alternatives can be obtained by using an additive value function

$$v(x) = \sum_{i=1}^n w_i v_i(x_i)$$

where n is the number of attributes, w_i the weight of attribute i ², x_i the outcome of alternative x with respect to attribute i (the result of step 3), and $v_i(x_i)$ the evaluated performance of alternative x with respect to attribute i expressed as a value in the 0–1 interval (the result from step 4). The weight w_i indicates the relative impact of attribute i to the overall value, when the performance of this attribute is changed from its worst level to its best level.

This step involves calculations but no further input from the stakeholder if there is only one stakeholder. If there are several stakeholders that have weighted the objectives and evaluated the alternatives individually, their separate rankings of alternatives have to be added together somehow. Usually this is done by calculating the arithmetic mean of these individual rankings. Sometimes a weighted mean is used which means that the stakeholders will have different influence on the overall ranking.

The result of this step is an overall ranking of the alternatives that shows which alternative is the most suitable one considering the preferences of the stakeholders and the alternatives available. To analyze the results further and understand trade-offs better, it is appropriate to make a sensitivity analysis where the weights of objectives and evaluations of alternatives are systematically changed to see how this affects the final ranking of alternatives.

² This is the overall weight of attribute i which results from multiplying the weight assigned to the attribute with the weight(s) assigned to the objective(s) higher up in the hierarchy (done in step 3).

Finally, what we have to remember is that MCDA is a decision support method that does not produce an absolute truth, but carrying out the five steps of the MCDA process will help a decision maker to understand the problem better and make a decision based on both facts and subjective preferences.

3 User guide for PlanEval

3.1 Arange case study example

To illustrate how PlanEval can be used to support forest management planning we will use an example from the Swedish ARANGE case study area Vilhelmina. In this example we focus on a mature, 110 year old spruce stand and the problem of how to manage this stand. In this case there are three basic management alternatives: even-aged forestry, continuous cover forestry (CCF) or no management. These alternatives will have different effects on the stand and the output of ecosystem services from the stand. The ecosystem services used for evaluation in this example are some but not all of the ecosystem services identified as important within the ARANGE project. The performance of the alternatives in terms of the attributes will be evaluated as an average over 100 years in this case, but other measures would be possible, e.g, the level of the attribute achieved at the end of the 100 years.

The objective hierarchy includes objectives on three levels below the overall objective and ten attributes in total (figure 3).

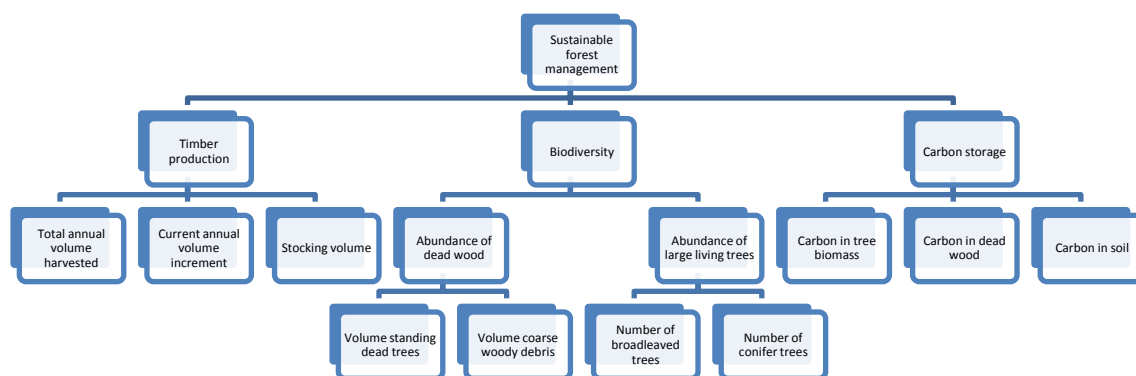


Figure 3. The objective hierarchy for the case example.

The alternatives are described in relation to how they perform in terms of the ten attributes (table 2).

Table 2. Description of the three forest management alternatives based on their output in terms of the attributes

Attribute	Even-aged forestry	CCF	No management
Total annual volume harvested	3.5	1.4	0.0
Current annual volume increment	2.4	1.8	1.8
Stocking volume	70.5	151.9	216.4

Volume standing dead trees	1.0	5.4	6.4
Volume coarse woody debris	2.1	10.3	13.1
Number of broadleaved trees	5.8	127.0	116.2
Number of conifer trees	452.9	262.2	312.7
Carbon in tree biomass	29.7	59.3	79.1
Carbon in dead wood	1.0	2.7	3.7
Carbon in soil	49.9	50.3	48.8

3.2 What is PlanEval?

PlanEval is an MCDA based software designed for forest management planning problems. It is part of the Heureka forest management decision support system and was especially developed for evaluating plans generated with the forest planning application “Heureka-PlanWise”. However, PlanEval can be downloaded and used standalone from the other Heureka applications which will be the case in the ARANGE project.

3.2.1 How to install PlanEval

The very first step is to register as a Heureka user and to download PlanEval:

- 1) Go to the registration page for Heureka <http://www.slu.se/sv/centrumbildningar-och-projekt/sha/heureka/register/>. Change language to English if needed. (If you do not want to register go directly to: http://heurekaslu.org/wiki/Download_and_install and jump to step 4)
- 2) Fill in your name, the name of your organization and your email address and click the “Register” button. A download link will be sent to your email address.
- 3) The link will direct you to the “Download and install” page on the Heureka wiki. Download PlanEval by clicking on the version number next to PlanEval in the list of applications (choose the ClickOnce installation option).
- 4) Follow the instructions for installing PlanEval.

PlanEval is a so called “ClickOnce installation” which means that the program is installed under the user’s profile. This is recommended because the software is then automatically upgraded when new versions are available (if you accept). The old version will be removed without causing any problems to your existing projects. Another advantage is that the user does not need administrator’s privileges to install the programs, which simplifies things when installing on a “public” computer (such as PCs in a computer lab at the university).

3.2.2 Creating a new project

Once you have installed PlanEval and opened the program, you can create a new project by (see figure 4):

- 1) First click on “New project”, (A).
- 2) Write the name of the project in the dialog box that appears and click OK, (B)

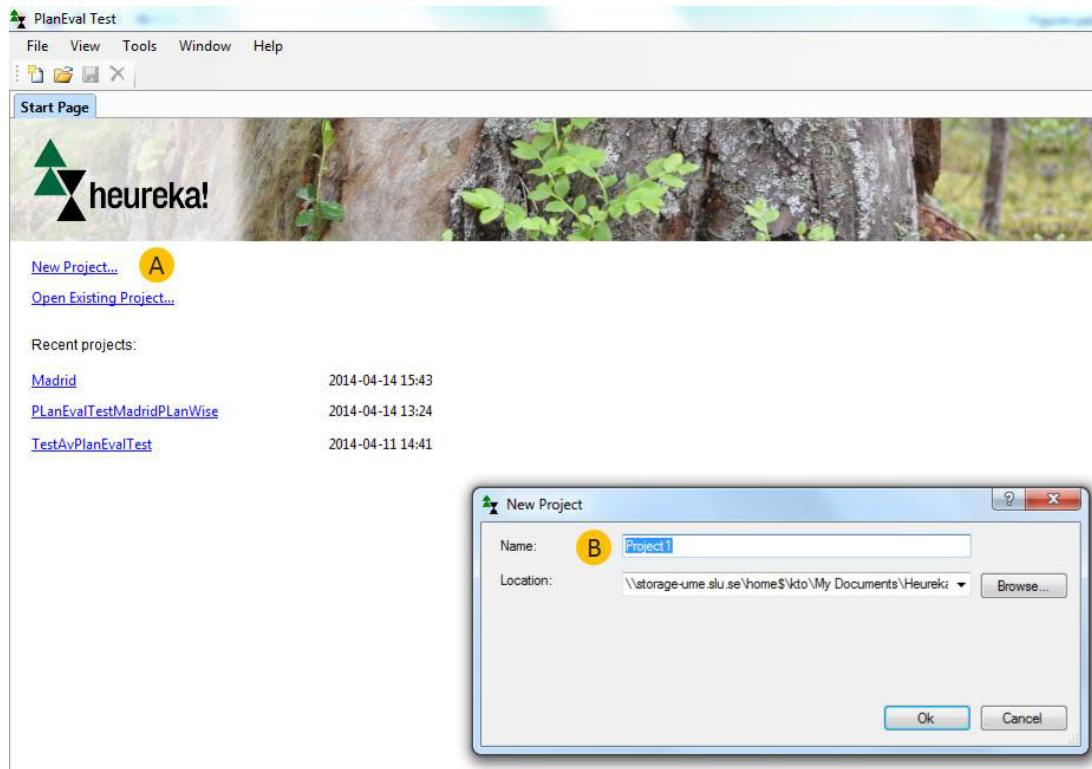


Figure 4. The Start page in PlanEval.

3.3 Frame the decision problem

This section focus on how you define your objectives that will be used for evaluating the alternatives in your project, how you add additional stakeholders and how you define which objectives/attributes each stakeholder is allowed to weigh (in step 3) and which alternatives they are allowed to evaluate (in step 4).

3.3.1 Create the objective hierarchy

In PlanEval, objectives and attributes are arranged in a hierarchy. As explained in section 2.1, an objective is a statement of something that the stakeholder wants to achieve and usually have a direction so that they are either of the type “more is better” or “less is better. The lowest-level objectives in the hierarchy are called attributes and are used to measure how well different

alternatives perform in terms of a certain objective. The hierarchy is created in the “Objective” tab. When you open your project for the first time, the default hierarchy consists of only one objective. However, you can add as many objectives you want and give them suitable names. To start adding objectives and criteria to your project (see figure 5):

- 1) Select the “Objective” tab.
- 2) Right-click on the objective that you want to add a sub-objective to (A).
- 3) Select “Add objective”.
- 4) Write the name of the objective in the dialog, (B). (If you already have added several stakeholders you can here mark the stakeholders that are allowed to weight this objective.)
- 5) The name of an objective can be changed by right-clicking on the objective and then selecting “Rename node”.

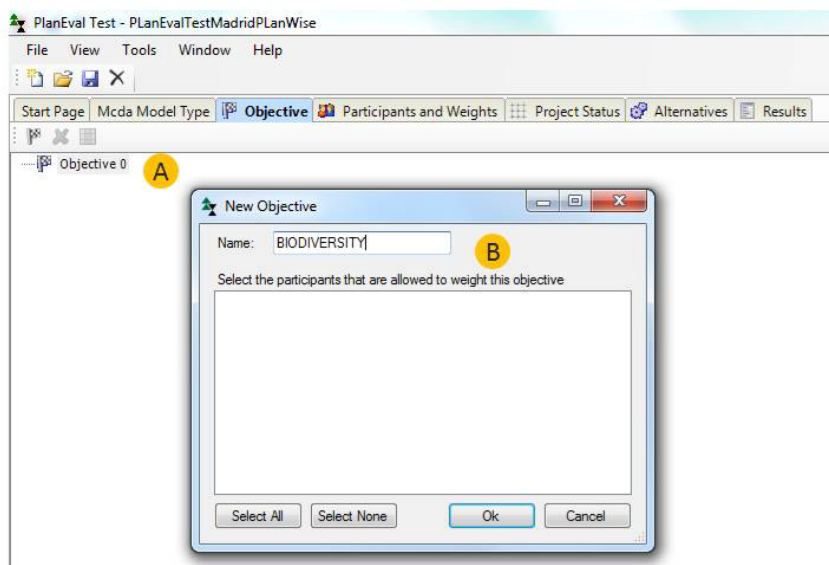


Figure 5. The objective tab.

3.3.2 Add and define stakeholders

When you open your project the first time there is only one stakeholder, the so called “master stakeholder”. This stakeholder could be described as being the “default decision maker”. If there are some objectives which no other stakeholders are assigning weights to or alternatives that are not evaluated by any other stakeholders, the weightings and evaluations of the master stakeholder will be used to fill these gaps in the global evaluation. Additional stakeholders are added to your project by (see figure 6):

- 1) First select the “Participants and Weights” tab.
- 2) Click on the icon for “Add new participant” in the upper left corner, (A).
- 3) Write the name on the stakeholder in the dialog that appears, (B).

- 4) Select the objectives and attributes that the stakeholder is allowed to evaluate, (C) and click OK. Note that if you select an objective, e.g., biodiversity, this means that the stakeholder is allowed to weigh the objectives/attributes that are on the level immediately below. If you want to allow the stakeholder to weigh all objectives/attributes further below, you have to select all the objectives below (but not the attributes, e.g., the objectives at the lowest level). If you select the attributes, e.g., number of conifers, this means that the stakeholder is allowed to evaluate the alternatives against this attribute.
- 5) Repeat step 2-4 until all stakeholders are added.
- 6) The definitions on which objectives and attributes a stakeholder is allowed to weigh can always be changed by clicking on the icon for “Settings”, (D).

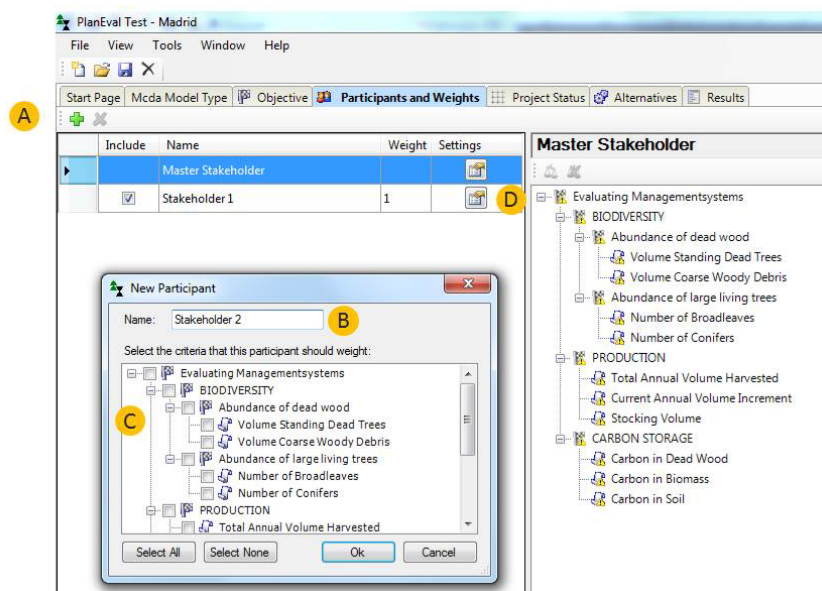


Figure 6. The Participants and Weights tab.

3.4 Define alternatives

This section describes how you add alternatives to your project and how you define the alternatives by adding information on how they perform in terms of the attributes.

3.4.1 Add alternatives

In PlanEval, alternatives can be added in two ways. You can either import alternatives generated with the Heureka PlanWise application or you can add alternatives manually. However, within the ARANGE project only the last option, to add alternatives manually, will be used.

An alternative is added by, (see figure 7):

- 1) Select the “Alternatives” tab.

- 2) Click on the “Add user defined alternative” icon, (A).
- 3) Write the name on the alternative in the dialog and click OK (B).
- 4) After all alternatives are added, you must ensure that the alternatives you would like to include in your evaluation are checked (C).
- 5) An alternative could always be deleted by right-clicking the alternative and then selecting delete.

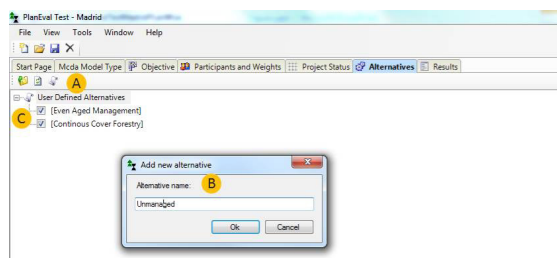


Figure 7. The Alternatives tab.

3.4.2 Define the outcome for each alternative

When the alternatives are added, we need to define them by adding information on them. This we do by describing the outcomes of each alternative in terms of the attributes.

When you use PlanEval standalone (i.e., without importing alternatives from Heureka PlanWise), the outcome for each alternative and each attribute (lowest level objective) can be defined in two ways, by entering values manually or by using pre-existing figures.

Manually: The outcome for each alternative for one criterion can be entered manually by (see figure 8):

- 1) Select the “Objective” tab.
- 2) Right-click on the attribute you would like to enter a value for, e.g., Volume standing dead trees, and select “Configure Value” (A).
- 3) Select the tab for “Manual values”, (B).
- 4) Write down the values for all alternatives in the dialog, (B).
- 5) Click OK.

Figures: The outcome for each alternative for one attribute can also be shown with figures, e.g. graphs or even photos, by (see figure 9):

- 1) Select the “Figures” tab.
- 2) Right-click on the criteria you would like to enter a value for e.g. Current annual volume increment, (A).
- 3) Browse to the location where the figure is saved, (B).
- 4) When a figure is selected for each alternative click OK.

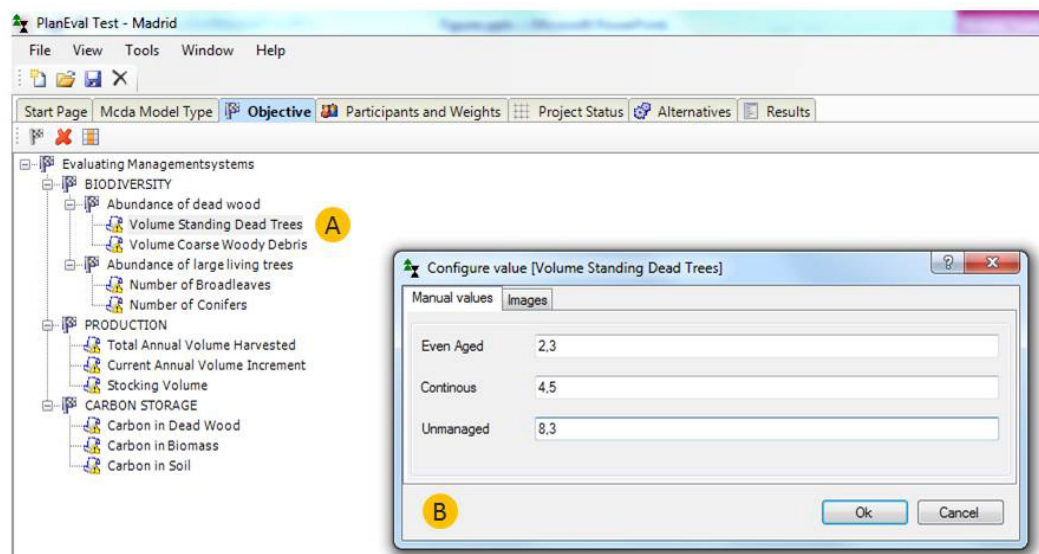


Figure 8. The Objective tab.

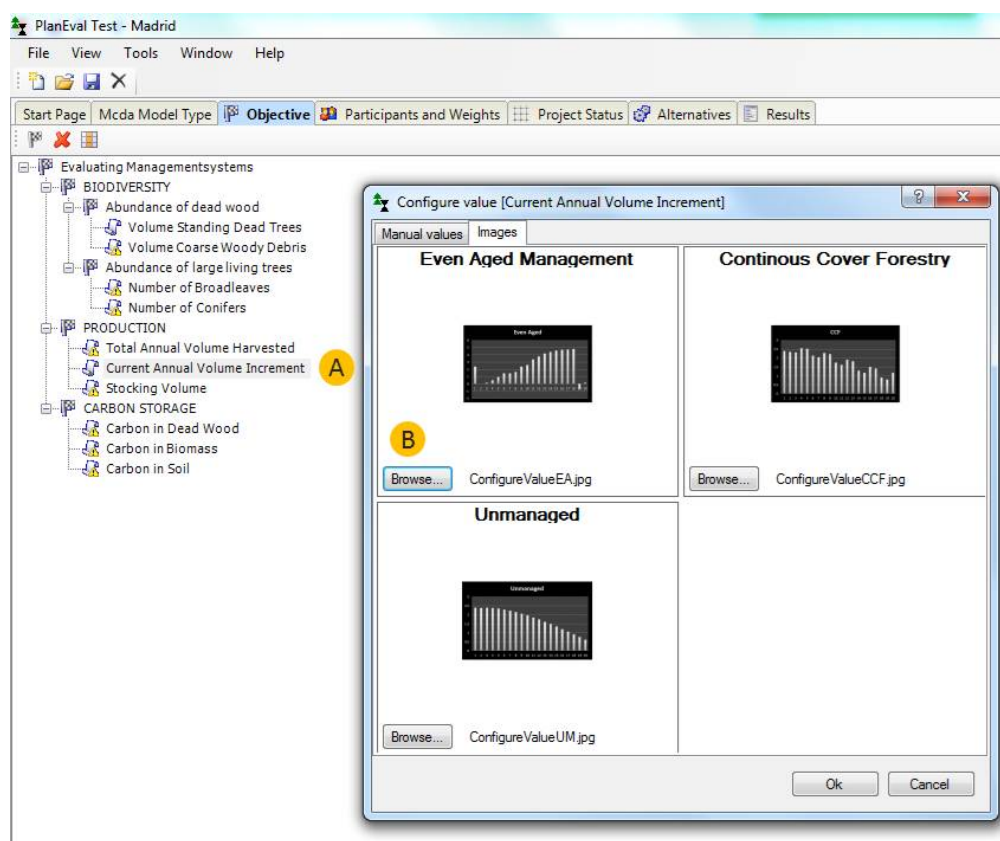


Figure 9. The Objective tab.

3.5 Weighting of objectives

This section describes how we can define weights for our objectives. Weights represent the importance of each objective and are used in the ranking process to determine the ranking of the alternatives. Changing the weights of the objectives affect the rankings assigned to different alternatives.

3.5.1 Choose methods

The method for setting weights is selected in the “Mcd Model Type” tab, see figure 10. In the drop-down list of methods, select the method you want to use (A). The two methods available are “AHP” and “Direct points” (i.e., SMART).

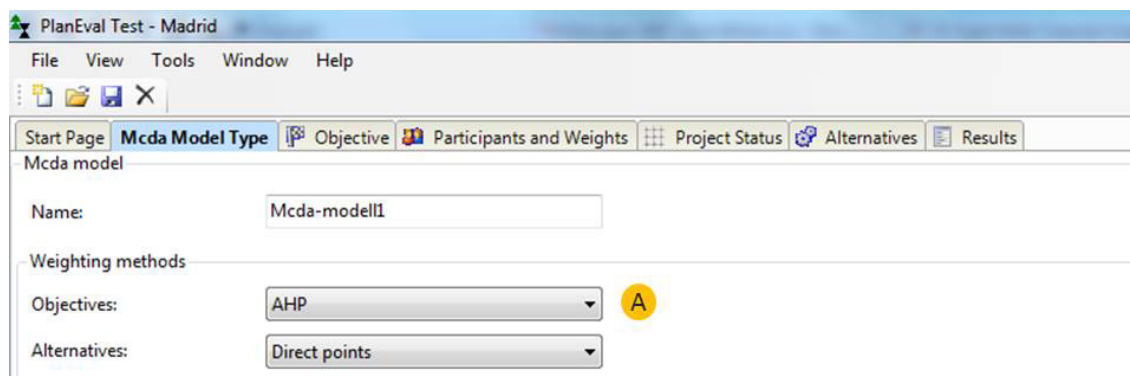


Figure 10. The Mcd Model Type tab.

3.5.2 Assigning weights for each objective and stakeholder

The weights for each objective can be set by (see figure 11):

- 1) Select the “Participants and Weights” tab.
- 2) Select the stakeholder that you are representing, e.g., stakeholder 1 (A).
- 3) In the hierarchy window, right-click the objectives that weights are to be entered for, e.g., Biodiversity (B). Depending on which method that is used different dialogs will appear.

When the SMART method is used, weights are established by assigning points to the different objectives. This can be done in two ways (see figure 12a): Either you enter a number between 0 and 100 in the box next to the criteria (A) or you move the cursor on the scale (B). E.g. If you think that “Abundance of Dead Wood” is the most important sub-objective for “Biodiversity” you assign 100 points to that objective and less points to the other sub-objective.

When the AHP method is used, the objectives are compared pairwise at each level against the objective that is one level above in the hierarchy, in this case “Biodiversity” (see figure 12b). If you think that “Abundance of Dead Wood” and “Abundance of Large living trees” are equally important for the objective “Biodiversity” you leave the cursor (C) as it is (Equally) and click on the “Next” button (D). However, if you think that “Abundance of Dead Wood” is more important you move the cursor to the right and then click “Next” (D). When you click “Next” (D), you will automatically go to the next comparison for the objective. Once all comparisons are done for the objective, in this case “Biodiversity”, press the OK button.

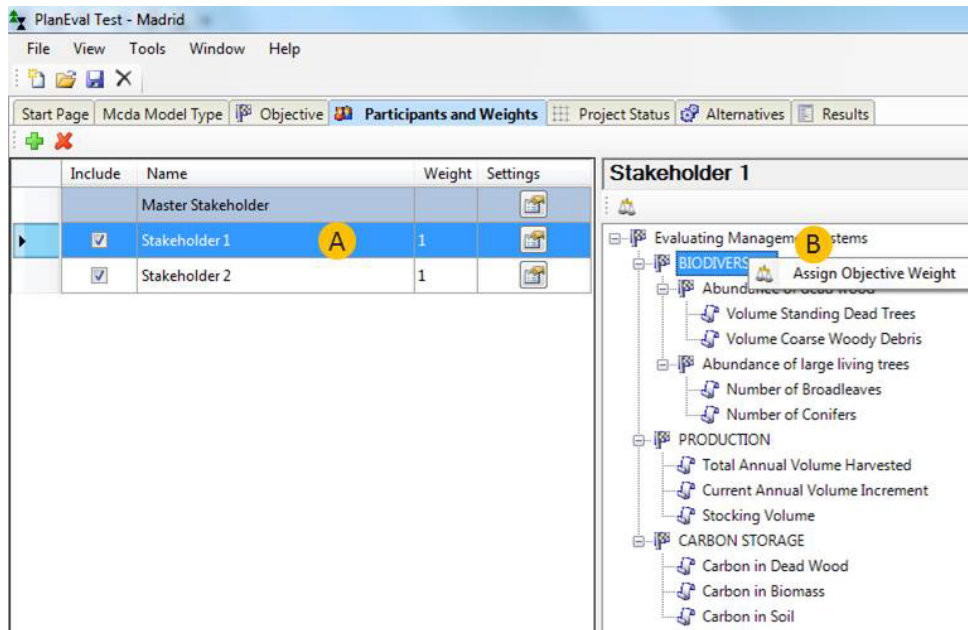


Figure 11

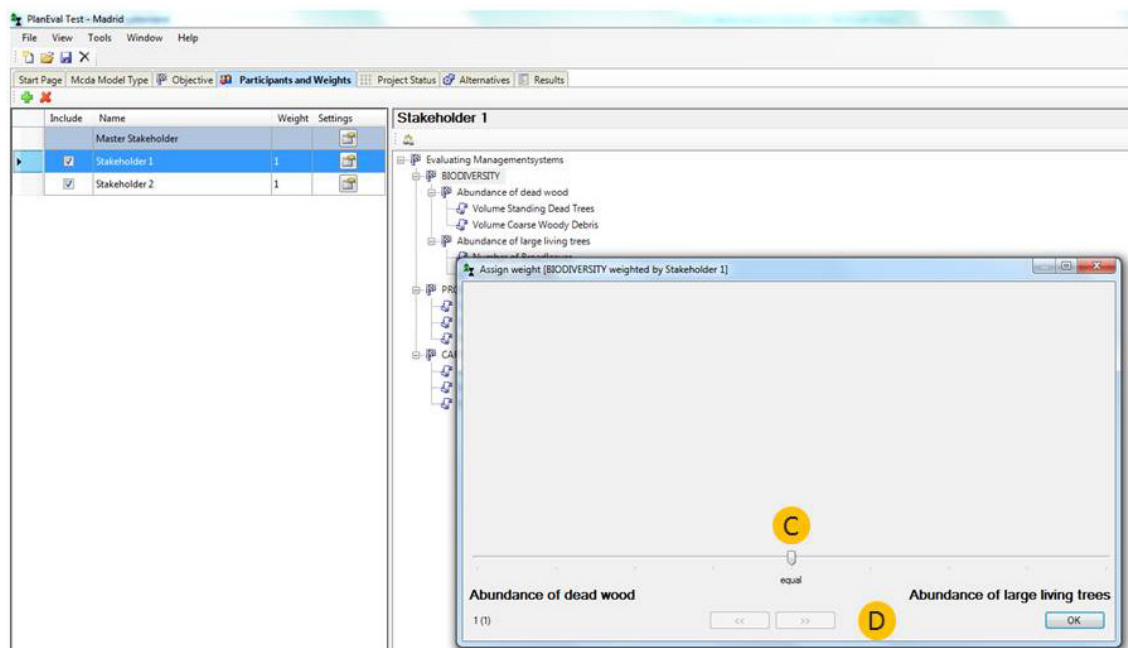


Figure 12a

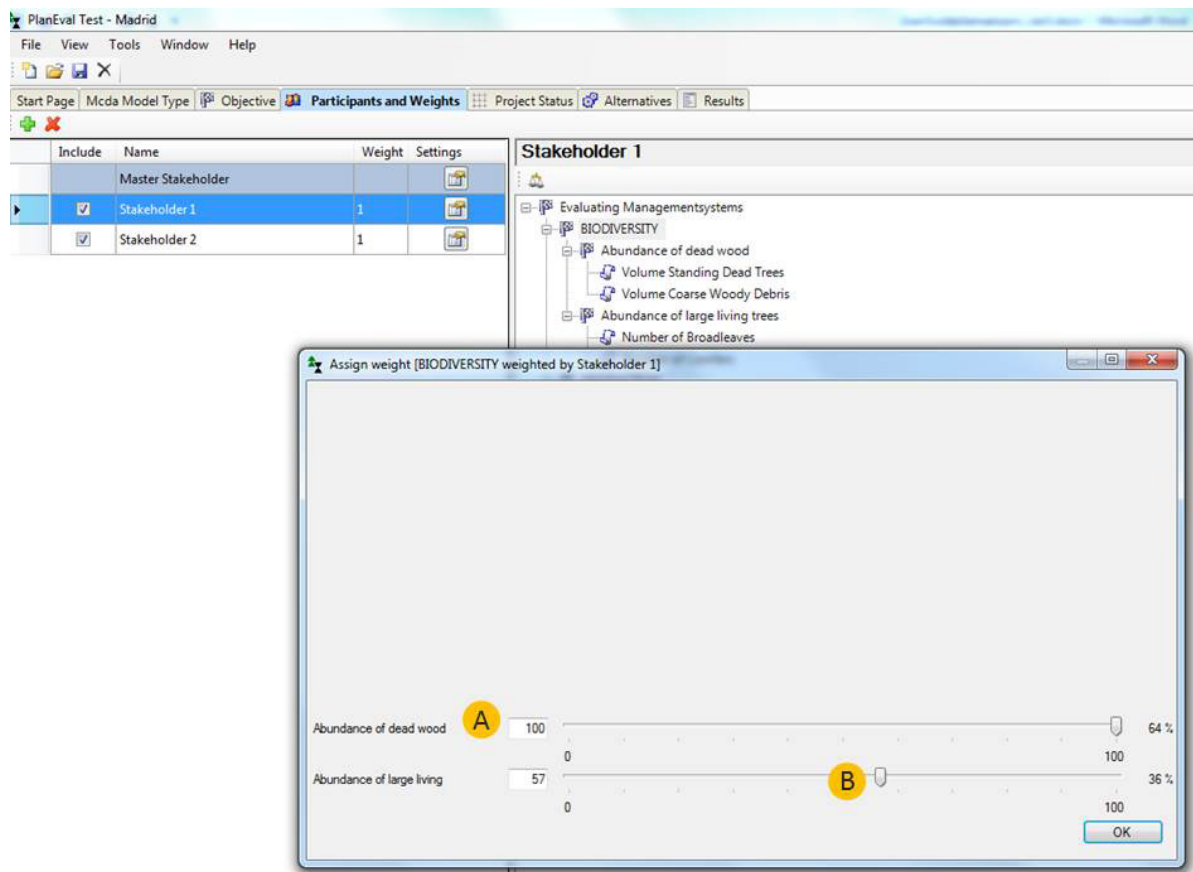


Figure 12b

3.6 Local evaluation of alternatives

This section focus on how we make a local evaluation of each alternative against each attribute i.e. the objective at the lowest level. Performance scores are assigned to each alternative in terms of every attribute to represent how satisfying the alternative is.

3.6.1 Choose methods

The method for evaluating the alternatives is selected in the "Mcds Model Type" tab (see figure 13). In the drop-down list, select the method you want to use (A).

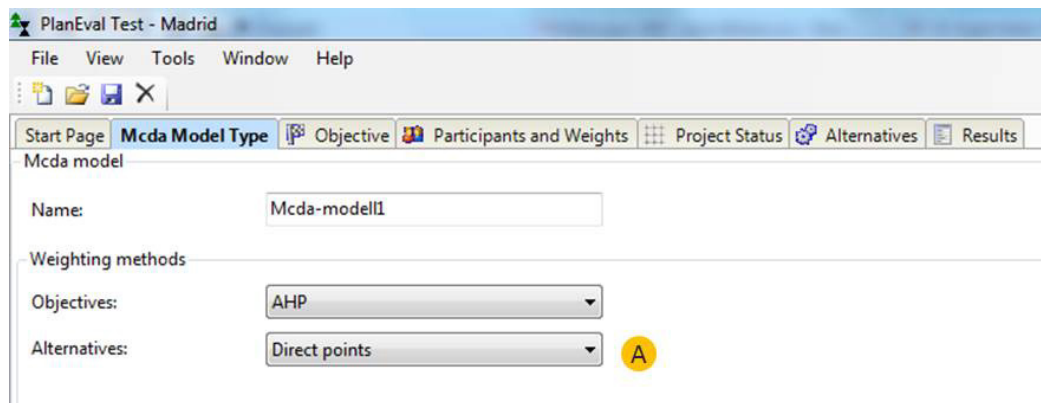


Figure 13. The Mcda Model Type tab.

3.6.2 Local evaluation of alternatives for each stakeholder

The alternatives are evaluated for each attribute and each stakeholder by (see figure 14):

- 1) Select the “Participants and Weights” tab.
- 2) Select the stakeholder you would like to enter evaluations for, e.g., stakeholder 1 (A).
- 3) In the hierarchy window, right-click the attribute you would like to enter evaluations for, e.g., “Volume standing Trees” (B). Depending on which method that is used different dialogs will appear.

When SMART is used, evaluations are established by assigning points to the different alternatives. This can be done in two ways (see figure 15): Either you write a number between 0 and 100 in the box next to the criteria, (A) or you move the cursor on the scale (B). For instance, if you think that the unmanaged alternative best fulfills the attribute “Volume standing dead trees” you assign 100 points to that alternative.

When AHP is used you will compare the alternatives two and two against the attribute, e.g., “Volume Standing Dead Trees” (see figure 15). If you think that the Even Aged and the CCF alternatives are equally good in terms of the attribute “Volume Standing Trees” you leave the cursor as it is and click “Next” (D). However, if you think that the CCF alternative is better you move the cursor to the right and then click “Next” (D). When you click “Next” (D), you will automatically go to the next comparison for the attribute. Once all comparisons are done for the attribute, in this case “Volume Standing Dead trees”, press the OK button.

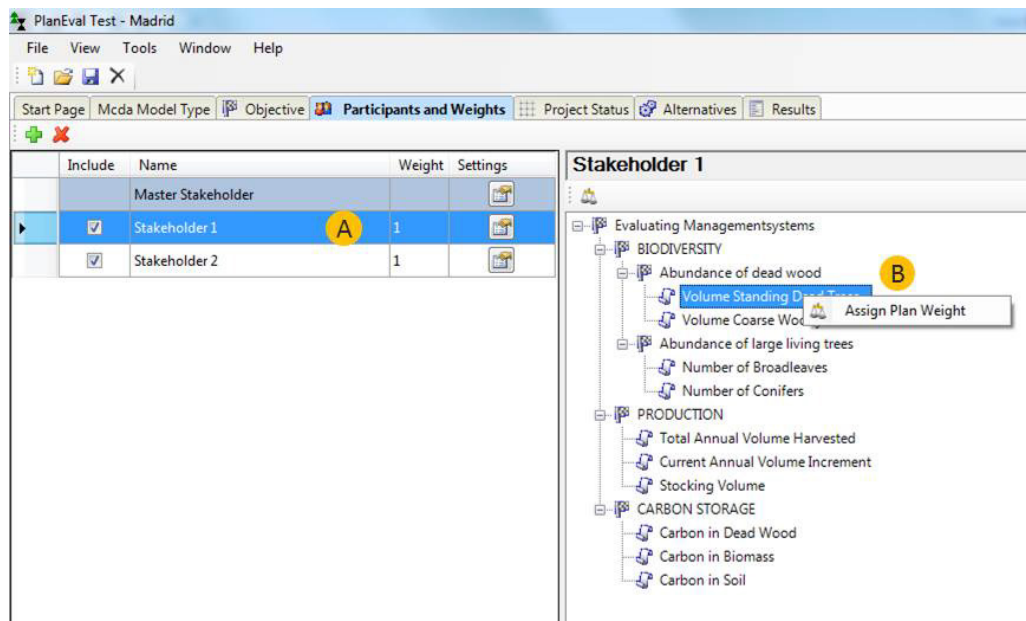


Figure 14. The Participants and Weights tab, evaluation of alternatives.

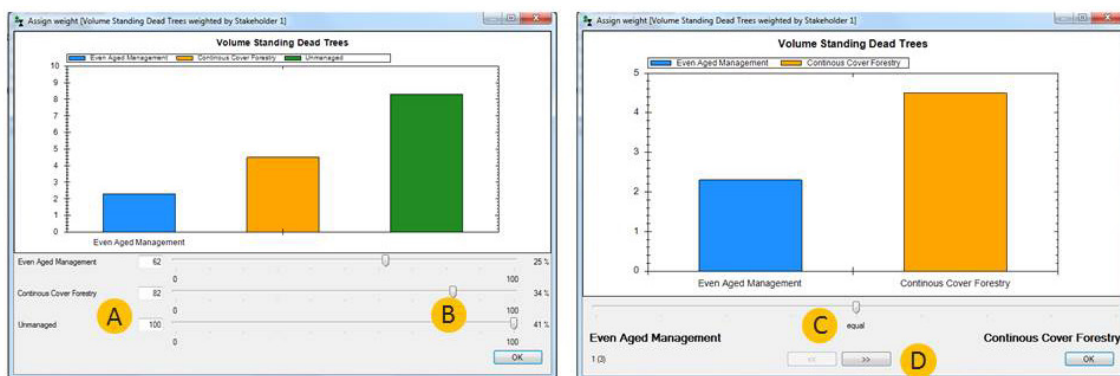


Figure 15. The dialogs for SMART and AHP.

3.7 Global evaluation

When the objectives have been weighted according to their relative importance and the alternatives have been evaluated with respect to each attribute, we can examine the resulting global evaluation of the alternatives. The global evaluation is an overall ranking of the alternatives that shows which alternative is the most suitable one considering the preferences of the stakeholders and the alternatives available. The results are presented both in table form and in charts, for each level in the hierarchy and for each stakeholder separately and all together (aggregated) (see figures 16 and 17):

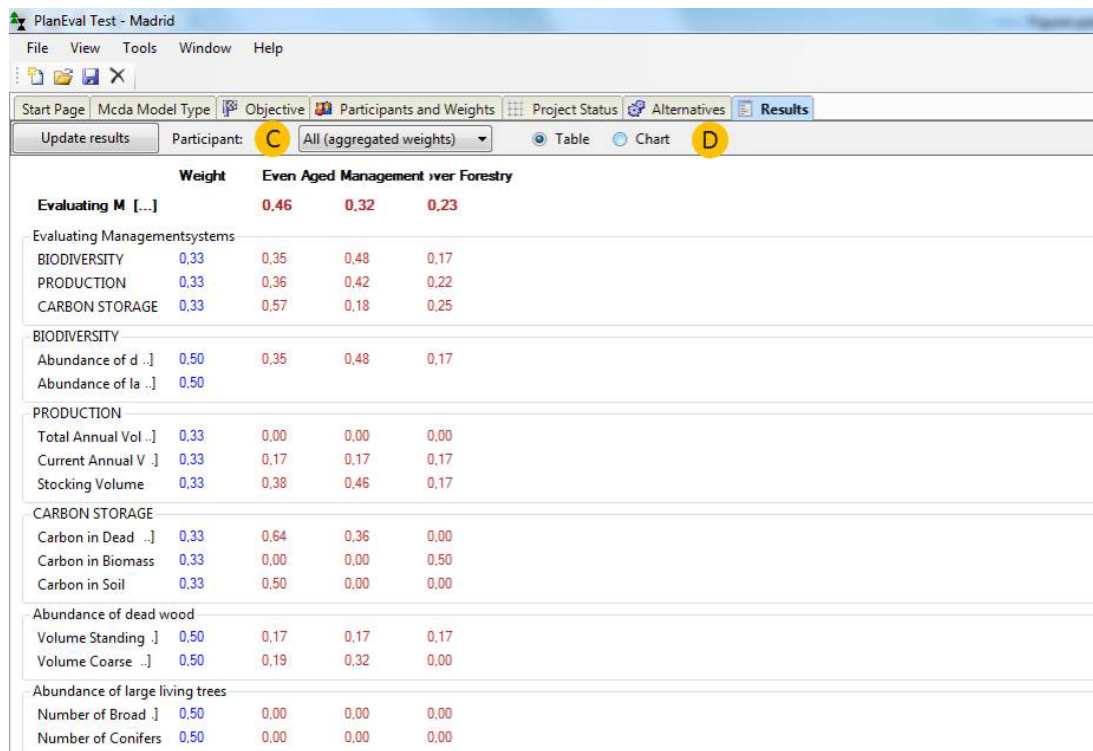
- 1) To change from table view to chart view, select “chart” (D).
- 2) To view another level in the hierarchy, select the level you want to see in the hierarchy window (A)

- 3) To see the resulting weights for the objectives behind the ranking of alternatives, select “child node” (B)
- 4) To change from aggregated results to view results for each stakeholder, select the stakeholder in question from the participant list (C).

Note that when AHP is used for weighting the objectives or evaluating the alternatives it is important to pay attention to the Inconsistency Ratio to the right in the result window. The Inconsistency Ratio is calculated for each pairwise comparison matrix for each stakeholder. Thus, the Inconsistency Ratio is only reported for each stakeholder and not when you look at the aggregated results. If the Inconsistency Ratio is larger than 0.10 you should examine the weightings and evaluations together with the stakeholder to identify possible inconsistencies in the comparisons.



Figure 16. The Results tab, Chart view.



	Weight	Even Aged Management over Forestry		
Evaluating M [...]		0,46	0,32	0,23
Evaluating Managementsystems				
BIODIVERSITY	0,33	0,35	0,48	0,17
PRODUCTION	0,33	0,36	0,42	0,22
CARBON STORAGE	0,33	0,57	0,18	0,25
BIODIVERSITY				
Abundance of d ...]	0,50	0,35	0,48	0,17
Abundance of la ...]	0,50			
PRODUCTION				
Total Annual Vol ...]	0,33	0,00	0,00	0,00
Current Annual V ...]	0,33	0,17	0,17	0,17
Stocking Volume	0,33	0,38	0,46	0,17
CARBON STORAGE				
Carbon in Dead ...]	0,33	0,64	0,36	0,00
Carbon in Biomass	0,33	0,00	0,00	0,50
Carbon in Soil	0,33	0,50	0,00	0,00
Abundance of dead wood				
Volume Standing ...]	0,50	0,17	0,17	0,17
Volume Coarse ...]	0,50	0,19	0,32	0,00
Abundance of large living trees				
Number of Broad ...]	0,50	0,00	0,00	0,00
Number of Conifers	0,50	0,00	0,00	0,00

Figure 17. The Results tab, table view.

To analyze your results further and understand trade-offs better, you can make a sensitivity analysis. Go back to the “Participants and Weights” tab and try for instance to change the weights of objectives to see how that changes the final ranking of alternatives.

3.8 Tips and tricks

- In the “Project status” tab you can see if all objective weights are set and all evaluations of alternatives are done for each stakeholder (See figure 18)

PlanEval Test - Madrid

File View Tools Window Help

Start Page Mcds Model Type Objective Participants and Weights **Project Status** Alternatives Results

Objective	Master Stakeholder	Stakeholder 1	Stakeholder 2
Evaluating Managementsystems	Weights set	Weights set	Weights set
BIODIVERSITY	Weights set	Weights set	Weights set
Abundance of dead wood		Weights set	Weights set
Volume Standing Dead Trees		Weights set	Weights set
Volume Coarse Woody Debris		Weights set	Weights set
Abundance of large living trees		Weights set	Weights set
Number of Broadleaves		Weights set	Weights set
Number of Conifers		Weights set	Weights set
PRODUCTION		Weights set	Weights set
Total Annual Volume Harvested		Weights set	Weights set
Current Annual Volume Increment		Weights set	Weights set
Stocking Volume		Weights set	Weights set
CARBON STORAGE		Weights set	Weights set
Carbon in Dead Wood		Weights set	Weights set
Carbon in Biomass		Weights set	Weights set
Carbon in Soil		Weights set	Weights set

Figure 18. Project Status tab.

4 Further reading

Introduction to MCDA:

Ishizaka A., Nemery P. 2013. Multi-Criteria Decision Analysis. Methods and software. John Wiley & Sons, New York.

An introduction to MCDA in participatory forest planning:

Nordström, E.-M. 2010. Integrating multiple criteria decision analysis into participatory forest planning. Doctoral thesis. Swedish University of Agricultural Sciences, Umeå.
URL: http://pub.epsilon.slu.se/2385/1/Nordstrom_E_101027.pdf

An example on where MCDA is used in combination with scenario analysis:

Nordström E.-M., Holmström H., Öhman K. 2013. Evaluating continuous cover forestry based on the forest owner's objectives by combining scenario analysis and multiple criteria decision analysis. Silva Fennica vol. 47 no. 4 article id 1046. URL: <http://dx.doi.org/10.14214/sf.1046>