



1st Iberian Conference on Multi-Criteria Decision Making/Analysis

WEB-MAUT-DSS: A web-based DSS based on MAUT to deal with partial/incomplete information

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<https://vps155.cesvima.upm.es/web-maut-dss/>

WEB-MAUT-DSS

- Improved web-based version of the generic multi-attribute analysis (GMAA) system.
- Based on the **Decision Analysis methodology** (Belton, 1990)
- Decision-making problems with **partial/incomplete information**
 - Uncertainty about the performances of the alternatives under consideration by means of probability distributions or ordinal information
 - Imprecision concerning the quantification of the decision-maker preferences
- Hierarchically elicited weights using different weighting methods
- **Additive multi-attribute utility** model
- **Sensitivity analysis** tools that take advantage of the imprecise available information to provide further insights about the robustness of the results.
- Developed using **Shiny** that allows to build interactive web apps straight from **R**.

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 - Component utility assessment
 - Weight elicitation
6. **Evaluating alternatives**
7. **Sensitivity analysis**
 - Non-dominated and potentially optimal alternatives
 - Weight stability intervals
 - Monte Carlo simulation techniques on weights

1. Main menu and screen

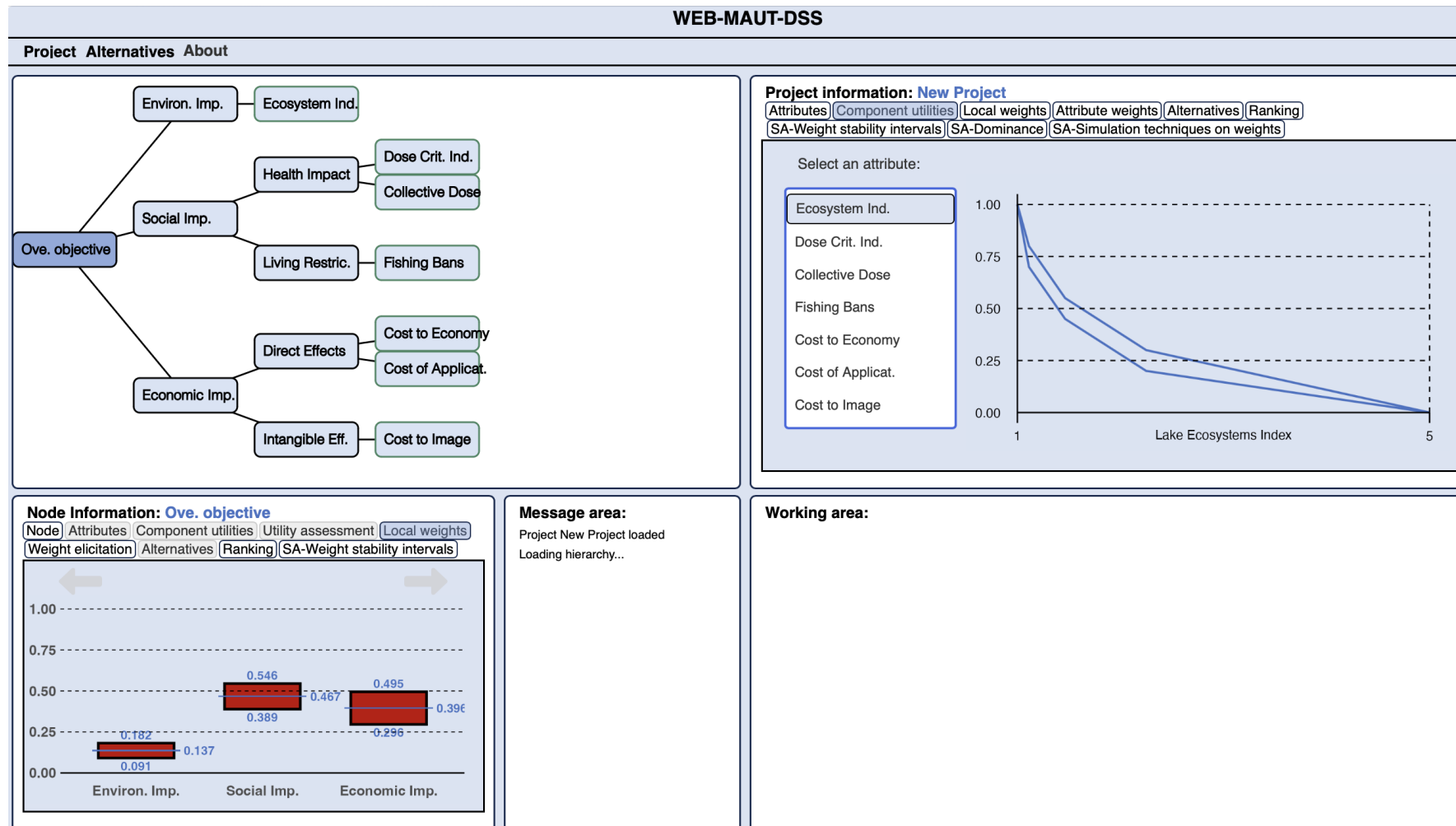


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1. Problem identification

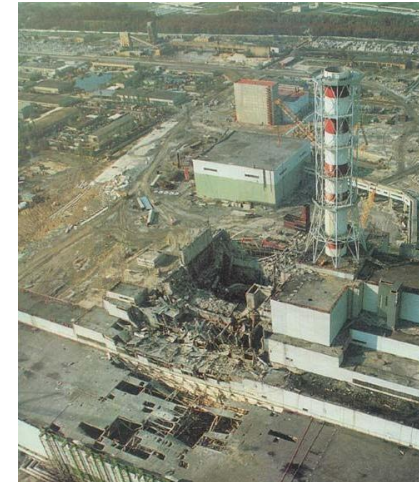
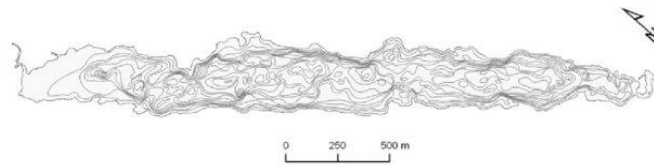
Problem scenario: Øvre Heimdalsvatn

It was contaminated after the Chernobyl accident (1986)

^{137}Cs contamination \rightarrow 130 kBq/m²

Lake features:

- small subalpine lake
- mean depth of 4.7 m
- maximum depth of 13 m
- surface area of 0.78 km²
- catchment area of 23.6 km²
- highest point of the catchment area is 1843 m above sea level
- mean annual precipitation is 800 mm



Author: Reidar Borsgstrom

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3.1 Problem structuring. Objective hierarchy

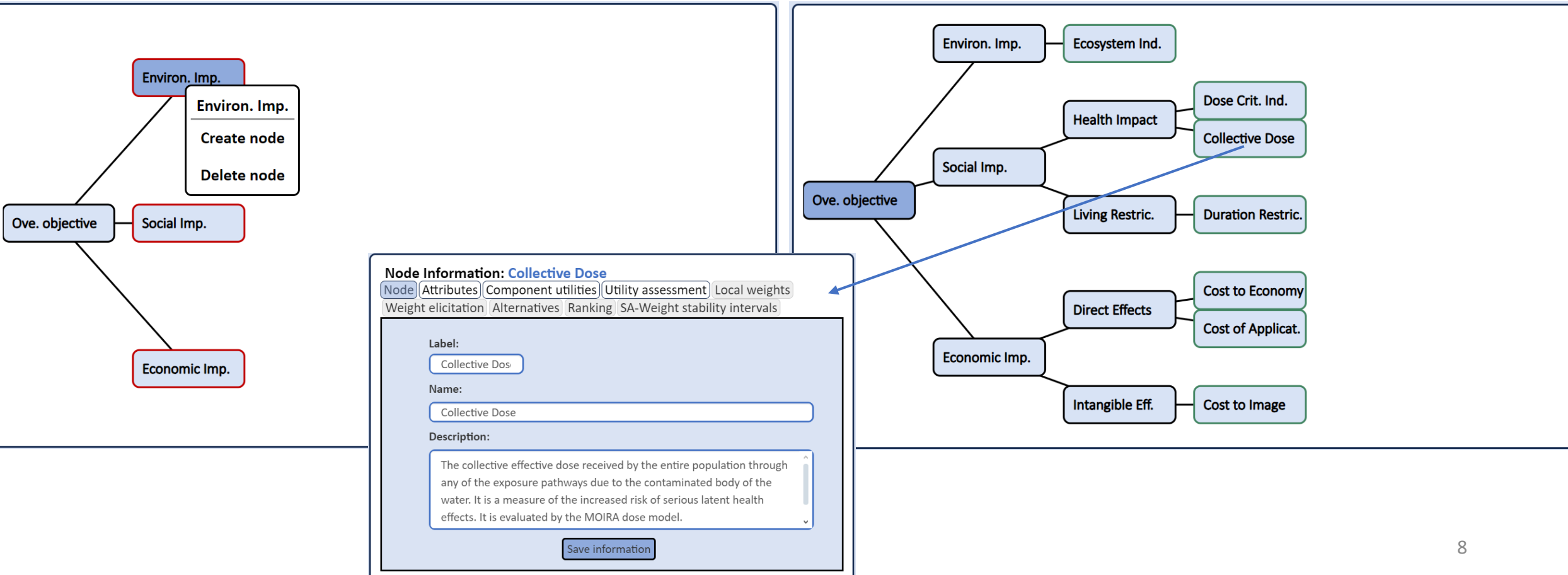


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3.2 Problem structuring. Attributes

Node Information: Ecosystem Ind.

Node | **Attributes** | Component utilities | Utility assessment | Local weights
Weight elicitation | Alternatives | Ranking | SA-Weight stability intervals

☒ Continuous

Units:

Minimum value:

Maximum value:

☐ Discrete

Insert attribute value (label):

Attribute values:

☒ Most preferred

Attributes for evaluating countermeasures

Attribute	Measure (units)	Level	
		Worst	Best
X_1 : Lake ecosystem index	LEI	5.00	1.00
X_2 : Radiation dose to critical individuals	milliSv	2.47	0.76
X_3 : Collective radiation dose	mSv \times person	72.3	20.30
X_4 : Duration of restrictions	months	36	0
X_5 : Cost to economy	euros $\times 10^2$	426.00	0.00
X_6 : Cost of application	euros $\times 10^2$	702.00	0.00
X_7 : Cost of image	constructed scale	0.00	1.00

Project information: New Project

Attributes | Component utilities | Local weights | Attribute weights | Alternatives | Ranking
SA-Weight stability intervals | SA-Dominance | SA-Simulation techniques on weights

Select an objective:

Ecosystem Ind.
 Dose Crit. Ind.
 Collective Dose
 Cost to Economy
 Cost of Applicat.
 Cost to Image
 Fishing Bans

☒ Continuous

Units:

Minimum value:

Maximum value:

☐ Discrete

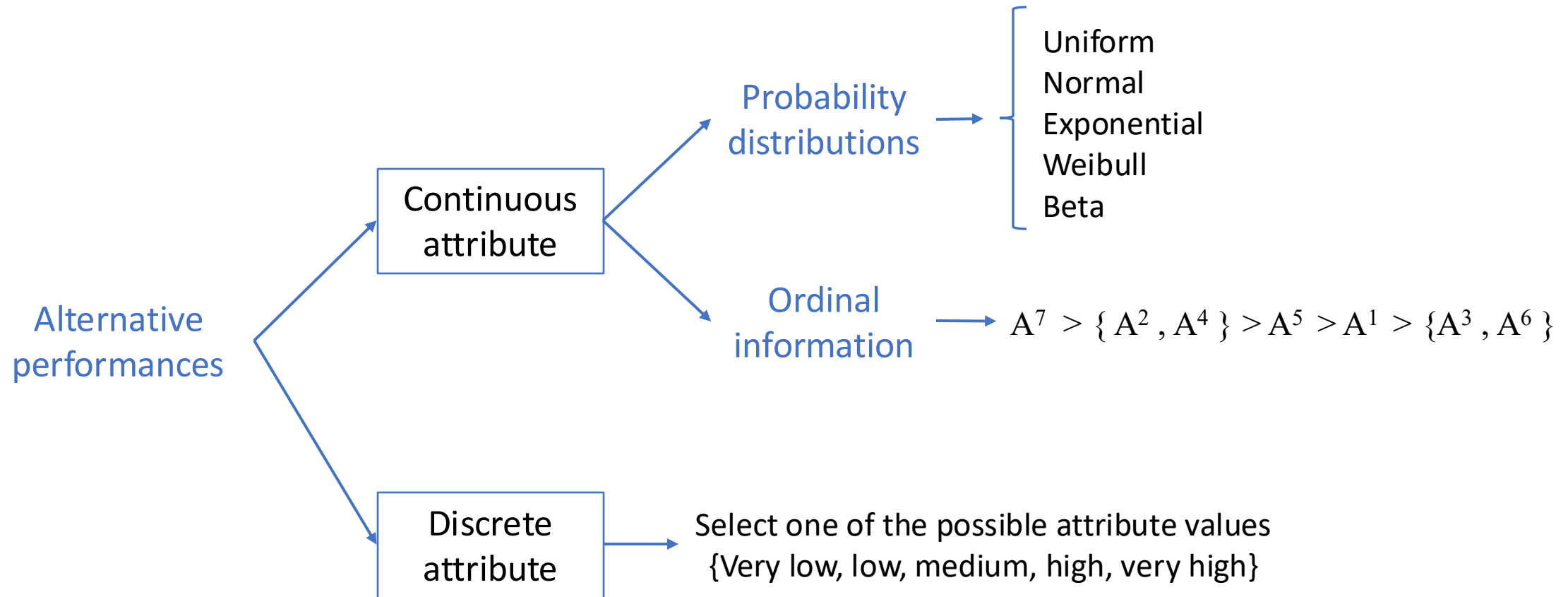
Attribute values:

☐ Most preferred

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4. Alternatives and performances



4. Alternatives and performances

Alternative and performance management in the WEB-MAUT-DSS

Project information: **New Project**

Attributes | Component utilities | Local weights | Attribute weights | **Alternatives** | Ranking
SA-Weight stability intervals | SA-Dominance | SA-Simulation techniques on weights

Attribute	Type		S1			S2		
Ecosystem Ind.	Continue	Uniform	5	5	Uniform	4	5	Unifo
Dose Crit. Ind.	Continue	Uniform	2.2	2.47	Uniform	1.8	2.3	Unifo
Collective Dose	Continue	Uniform	64	72.3	Uniform	56	65	Unifo
Cost to Economy	Continue	Uniform	0	0	Uniform	130	170	Unifo
Cost of Applicat.	Continue	Uniform	0	0	Uniform	0	25	Unifo
Cost to Image	Continue	Uniform	1	1	Uniform	1	1	Unifo
Fishing Bans	Continue	Uniform	0	6	Uniform	0	10	Unifo

Insert alternative

Update performances

- ☒ Attribute
☐ Alternative

Collective Dose ▼

Update

Remove alternative

▼

Remove

Working area: **Update performances**

Attribute Name: Range: (,)

	Probability Dist.	Param. 1	Param. 2	Discrete values	
S1	Uniform ▼	64	72.3	▼	missing
S2	Uniform ▼	56	65	▼	missing
S3	Uniform ▼	21	27	▼	missing
S4	Uniform ▼	61	70	▼	missing
S5	Uniform ▼	21	29	▼	missing
S6	Uniform ▼	56	61	▼	missing

4. Alternatives and performances

Alternative and performance management in the WEB-MAUT-DSS

Project Alternatives About

Save Alternatives

Load Alternatives

→

	A	B	C	D	E	F
1						
2						
3		Attribute	category	Attribute values/range		
4		Ecosystem Ind.	Continuous	1	5	
5		Dose Crit. Ind.	Continuous	0,76	2,47	
6		Collective Dose	Continuous	20,3	72,3	
7		Cost to Economy	Continuous	0	426	
8		Cost of Applicat.	Continuous	0	702	
9		Cost to Image	Continuous	0	1	
10		Fishing Bans	Continuous	0	36	
11						
12						

Attribute information
Performances
+

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2		Attribute	type	S1			S2			S3			S4	
3		Ecosystem Ind.	Continuous	Uniform	5	5	Uniform	4	5	Uniform	3,5	5	Uniform	1.5
4		Dose Crit. Ind.	Continuous	Uniform	2,2	2,47	Uniform	1,8	2,3	Uniform	0,8	1,3	Uniform	2.2
5		Collective Dose	Continuous	Uniform	64	72,3	Uniform	56	65	Uniform	21	27	Uniform	61
6		Cost to Economy	Continuous	Uniform	0	0	Uniform	130	170	Uniform	380	426	Uniform	0
7		Cost of Applicat.	Continuous	Uniform	0	0	Uniform	0	25	Uniform	10	50	Uniform	130
8		Cost to Image	Continuous	Uniform	1	1	Uniform	1	1	Uniform	1	1	Uniform	0.3
9		Fishing Bans	Continuous	Uniform	0	6	Uniform	0	10	Uniform	30	36	Uniform	0
10														
11														
12														

Attribute information
Performances
+

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5.1. Quantifying preferences. Component utility assessment

Component utility assessment in the WEB-MAUT-DSS

Node Information: Dose Crit. Ind.

Node | Attributes | Component utilities | **Utility assessment** | Local weights

Weight elicitation | Alternatives | Ranking | SA-Weight stability intervals

Continuous attribute

Discrete attribute

Assess

☒ Direct assessment
☐ Lottery-based assessment

Working area: Discrete attribute. Component utilities

Attribute values	Component utilities
Very low	(0.2 , 0.2)
Low	(0.2 , 0.2)
Medium	(0.2 , 0.2)
High	(0.2 , 0.2)
Very High	(0.2 , 0.2)
	(,)

Watch

1.00
0.75
0.50
0.25
0.00

Very low Low Medium High Very High

Cancel **Save**

Working area: Discrete attribute. Component utilities

Attribute values	Component utilities
Very low	(0.05 , 0.15)
Low	(0.2 , 0.25)
Medium	(0.35 , 0.45)
High	(0.55 , 0.75)
Very High	(0.85 , 0.9)
	(,)

Watch

1.00
0.75
0.50
0.25
0.00

Very low Low Medium High Very High

Cancel **Save**

5.1. Quantifying preferences. Component utility assessment

Component utility assessment in the WEB-MAUT-DSS

Node Information: Dose Crit. Ind.

Node | Attributes | Component utilities | **Utility assessment** | Local weights

Weight elicitation | Alternatives | Ranking | SA-Weight stability intervals

Continuous attribute

Discrete attribute

Assess

☒ Direct assessment
☐ Lottery-based assessment

Working area: Direct assignment. Component utilities

Attribute range (0.76 , 2.47) **Watch**

Most preferred: ☒ ☐

Attributes values	Component utilities
	(,)
	(,)
	(,)
	(,)
	(,)

Cancel Save

0.76 mSv 2.47

Working area: Direct assignment. Component utilities

Attribute range (0.76 , 2.47) **Watch**

Most preferred: ☒ ☐

Attributes values	Component utilities
1.2	(0.7 , 0.8)
1.61	(0.45 , 0.55)
2.045	(0.2 , 0.3)
	(,)
	(,)

Cancel Save

0.76 mSv 2.47

5.1. Quantifying preferences. Component utility assessment

Component utility assessment in the WEB-MAUT-DSS

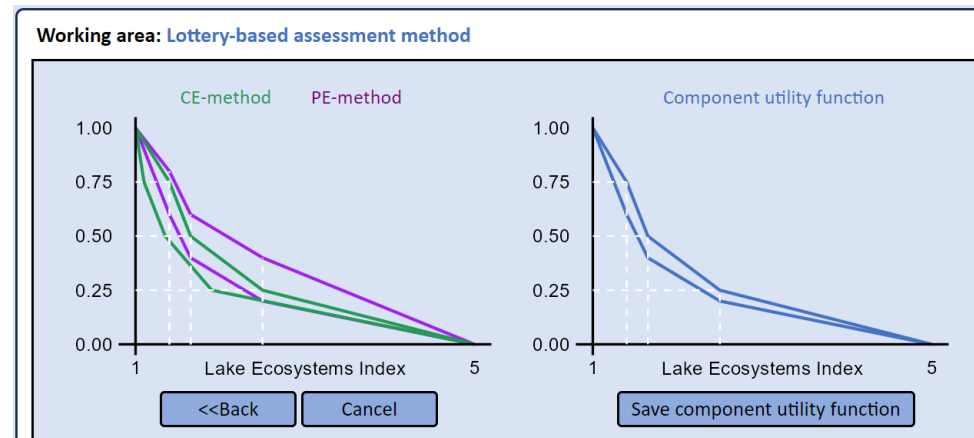
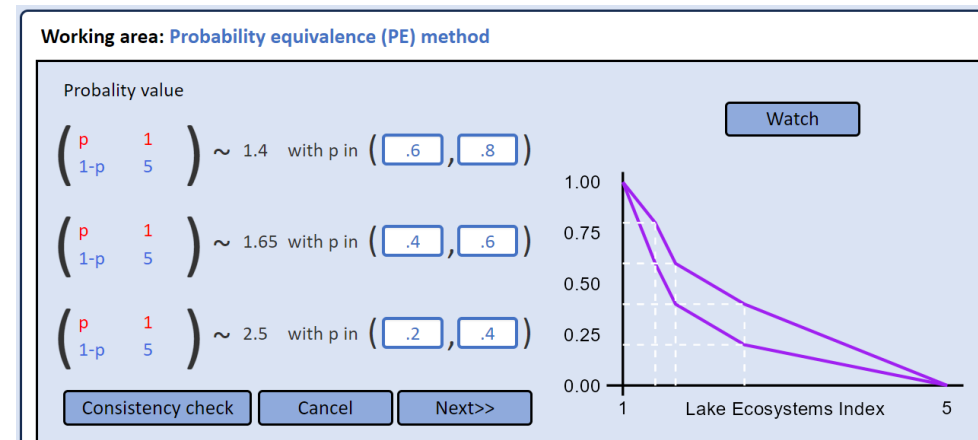
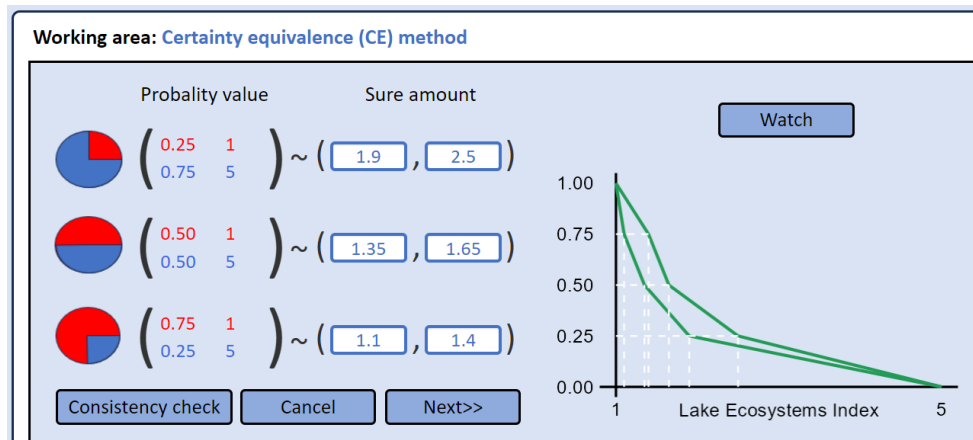
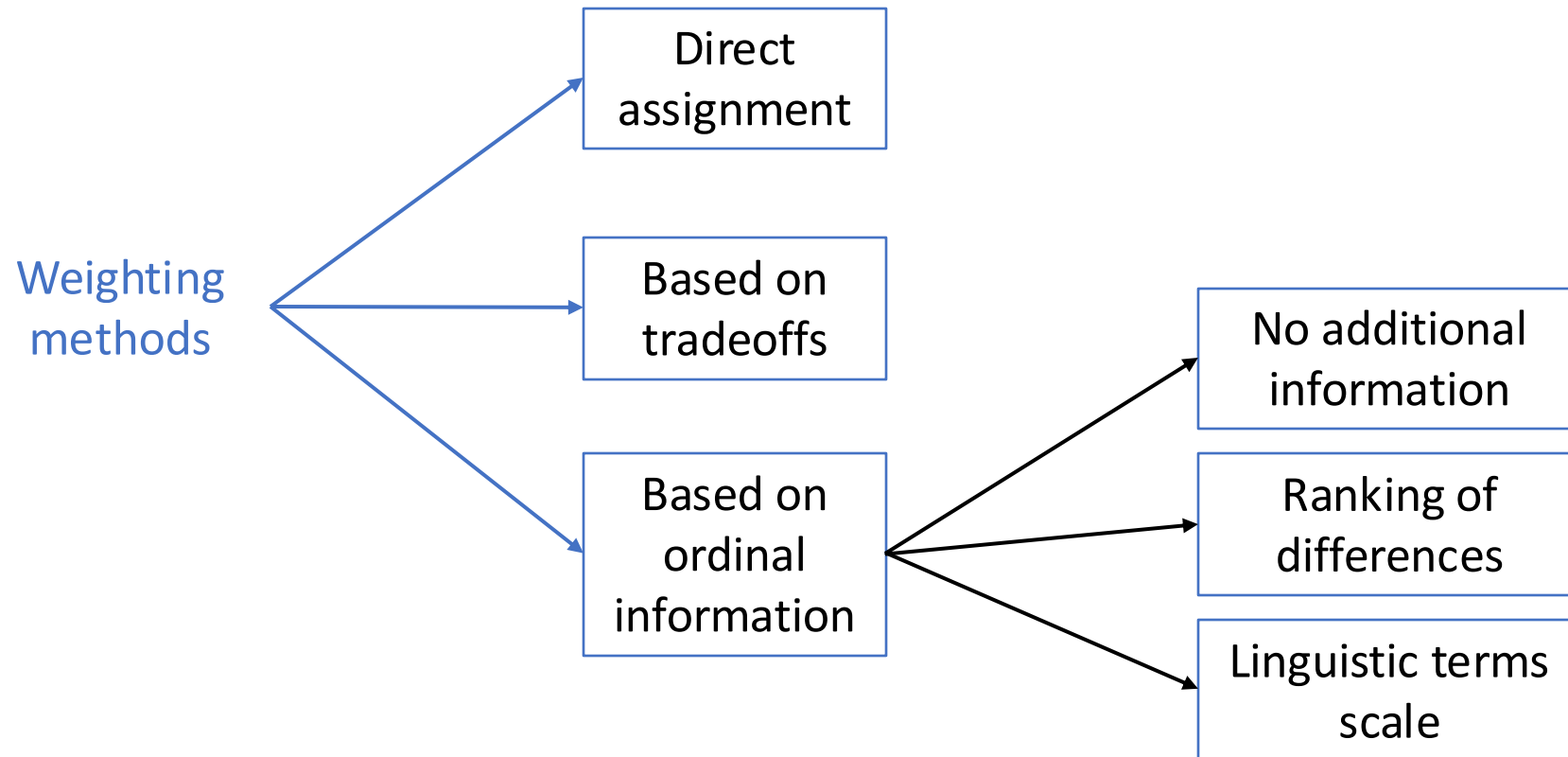


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5.2. Quantifying preferences. **Weight elicitation**

Weight elicitation in the WEB-MAUT-DSS



5.2. Quantifying preferences. Weight elicitation

Weight elicitation in the WEB-MAUT-DSS

Working area: **Weight elicitation based on ordinal information**

Objective list:

Objective ranking

Drag & drop

Social Imp.
Economic Imp.
Environ. Imp.

Most important
Least important

Information of the strength of the differences between the weights of the consecutive objectives in the ranking.

- ☐ No additional information
- ☐ Ranking of differences
- ☒ Linguistic terms

Cancel Next>>

Working area: **Linguistic term scale**

Objective ranking

Most important
Least important

Social Imp.
Economic Imp.
Environ. Imp.

drop-down list

- Equally important
- Slightly more important
- More important
- Much more important

<<Back Elicit weights Cancel

$$w_2 (\text{Social}) > w_3 (\text{Economic}) > w_1 (\text{Environmental})$$

w_2 slightly more important than w_3

w_3 more important than w_1

Cardinal sum reciprocal method

Danielson & Ekenberg (2017)

Working area: **Linguistic term scale**

Objective ranking

Most important
Least important

Social Imp.
Economic Imp.
Environ. Imp.

Slightly more important
More important

<<Back Elicit weights Cancel

5.2. Quantifying preferences. Weight elicitation

Hierarchically eliciting weights:

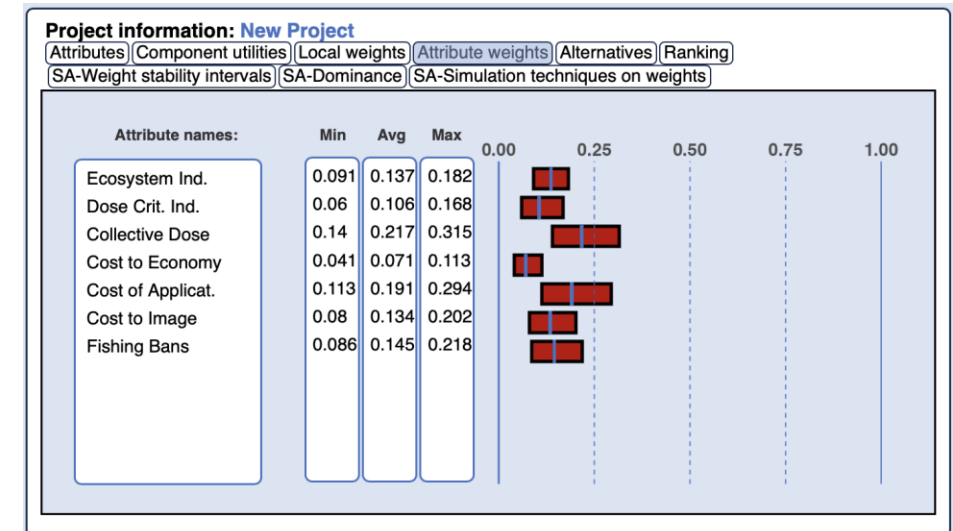
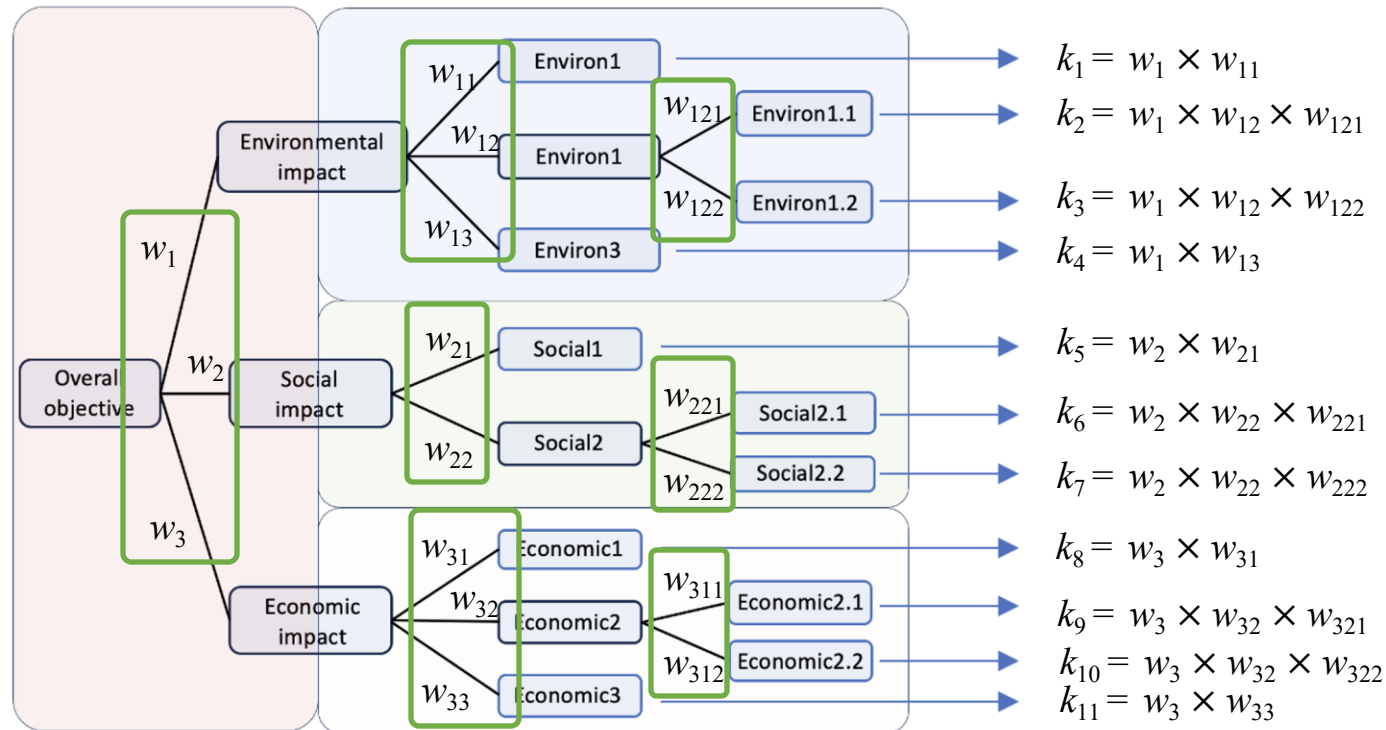
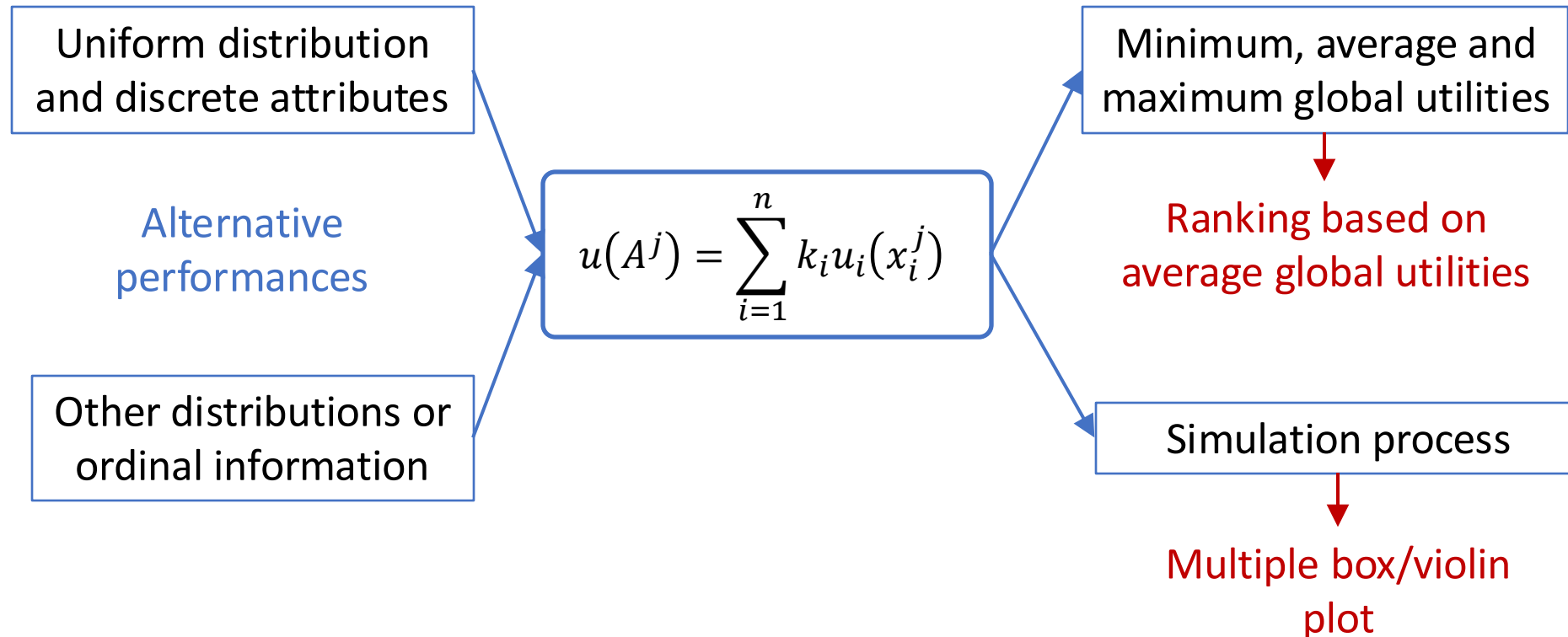


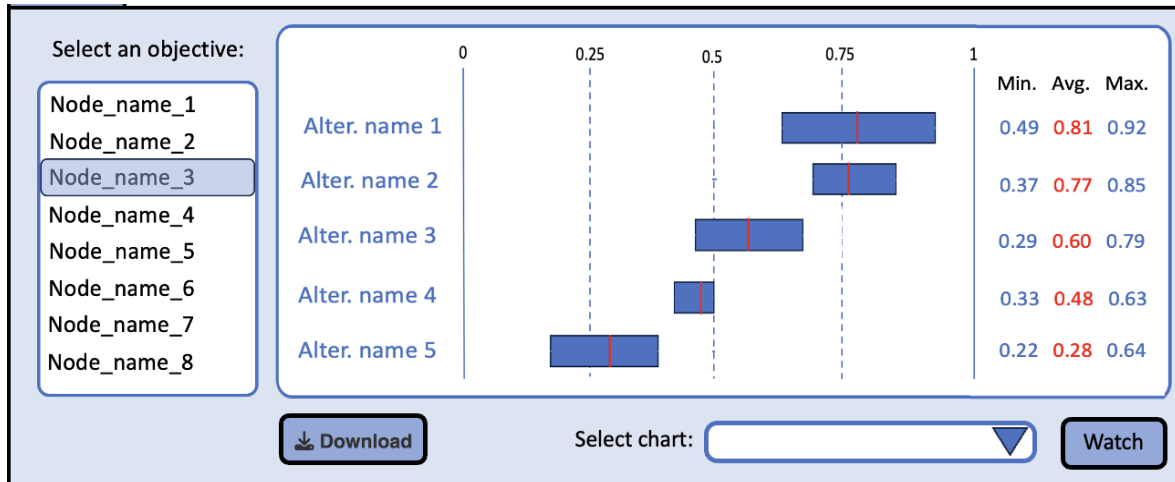
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6. Evaluating alternatives

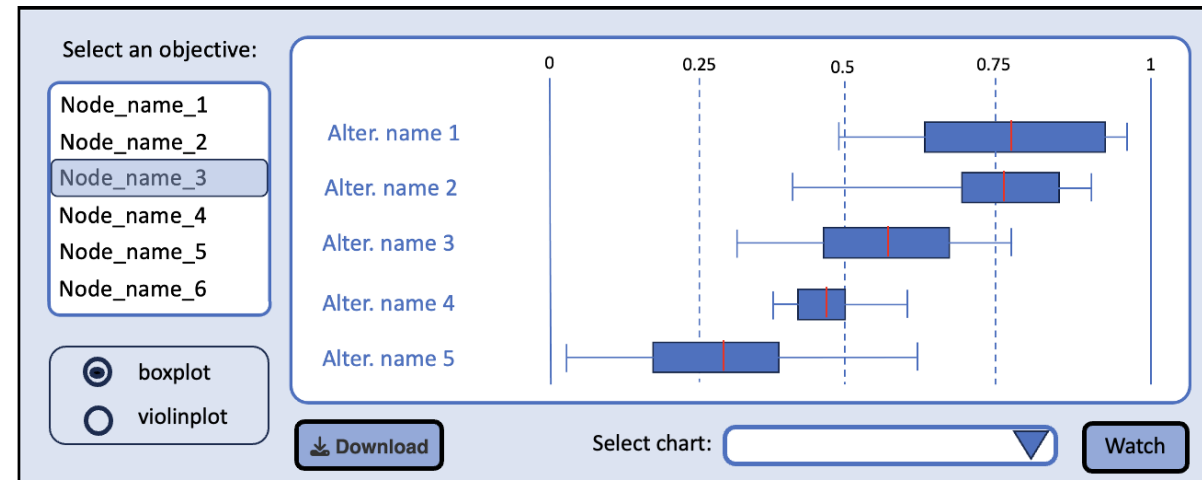


6. Evaluating alternatives

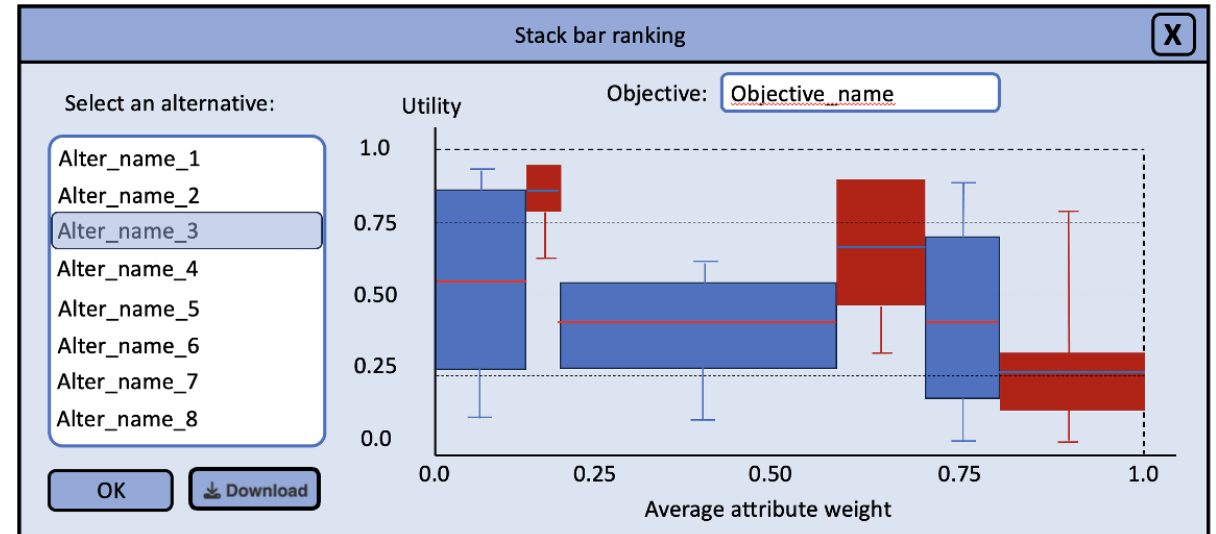
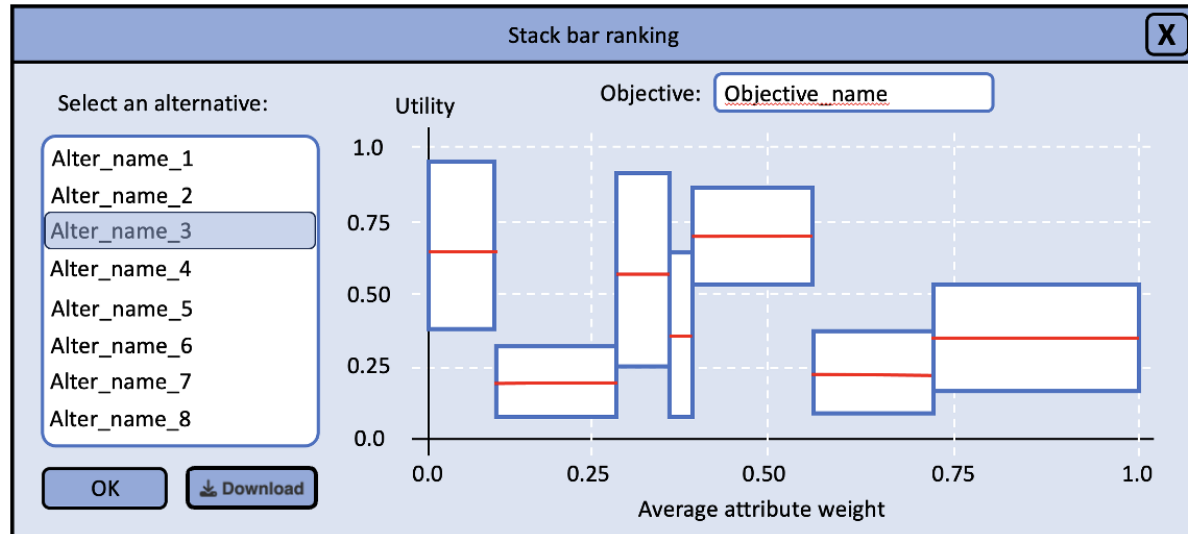


Ranking based on
average global utilities

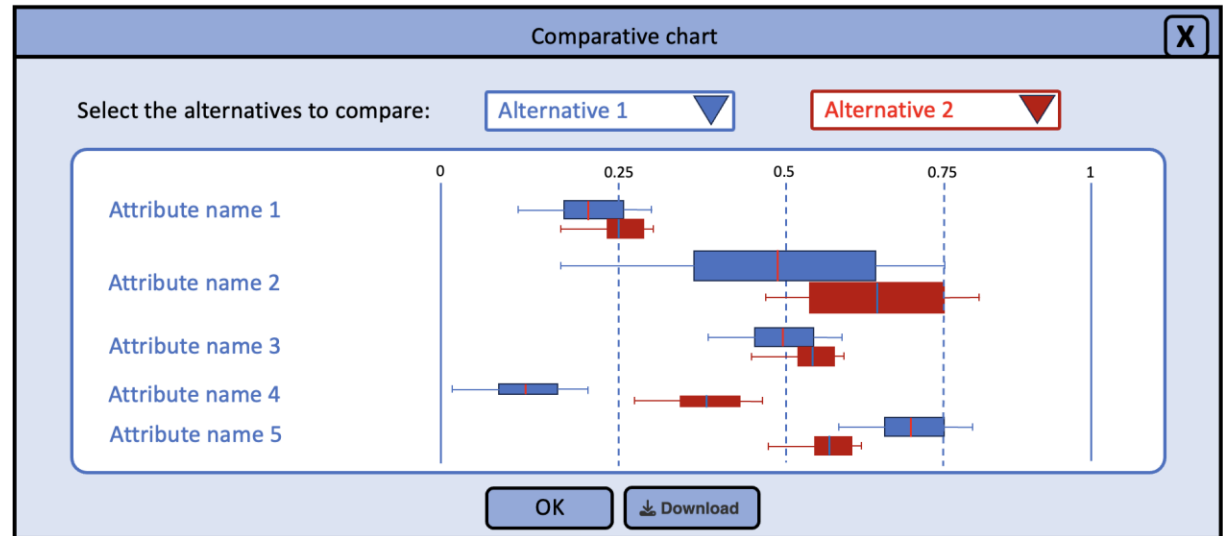
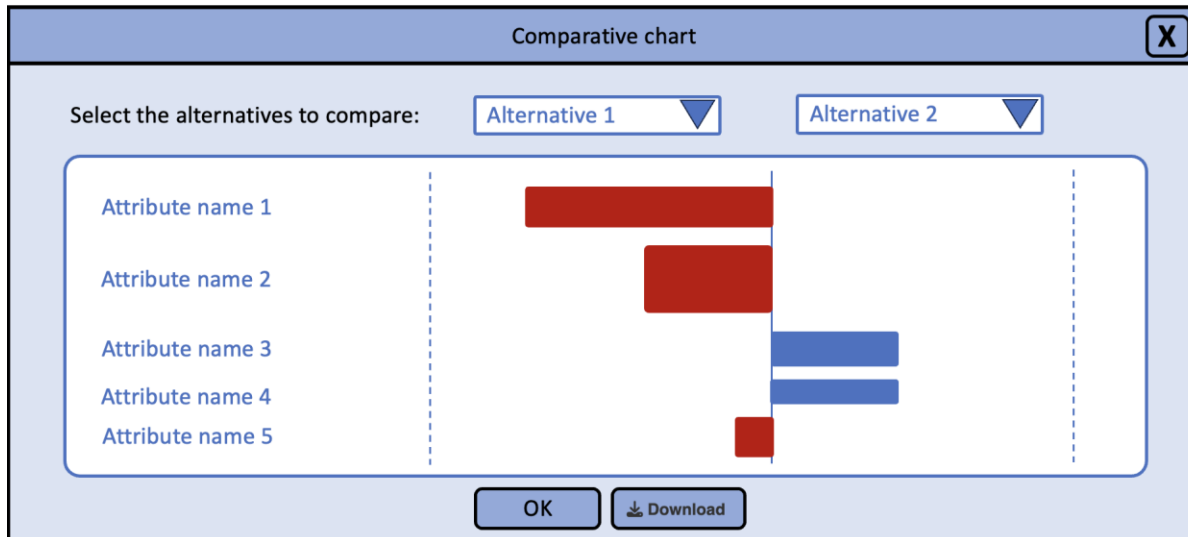
Simulation process



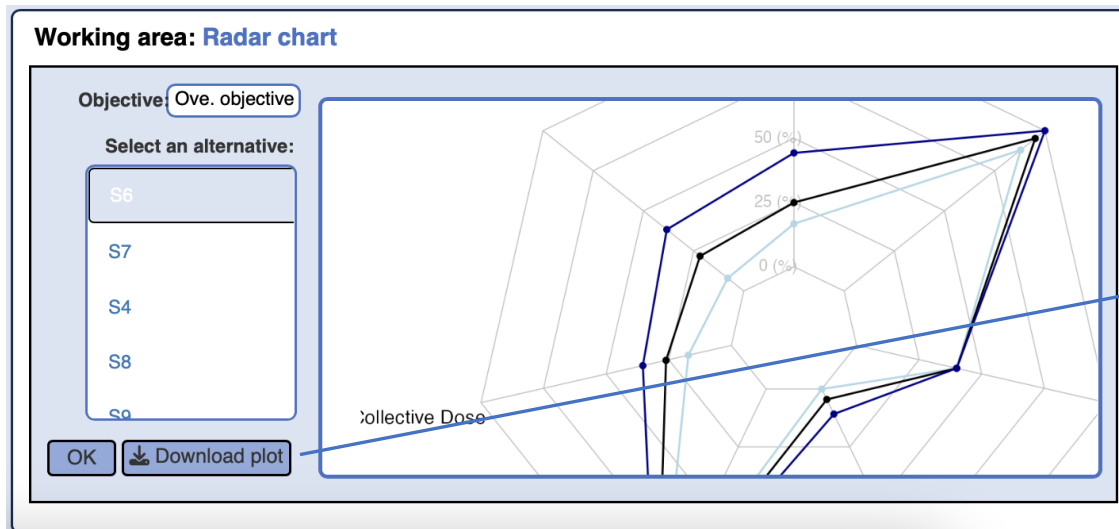
6. Evaluating alternatives



6. Evaluating alternatives



6. Evaluating alternatives



Node: Ove. objective - Alternative: S6



6. Evaluating alternatives

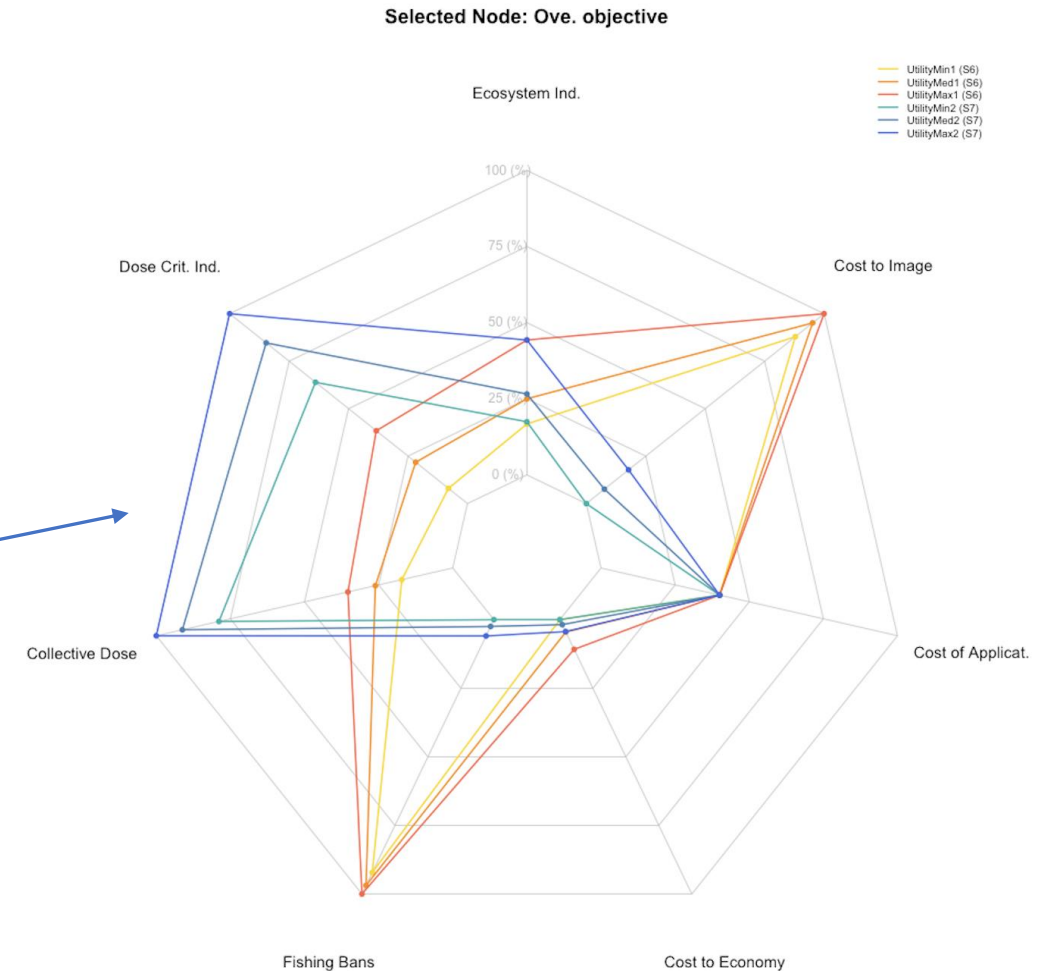
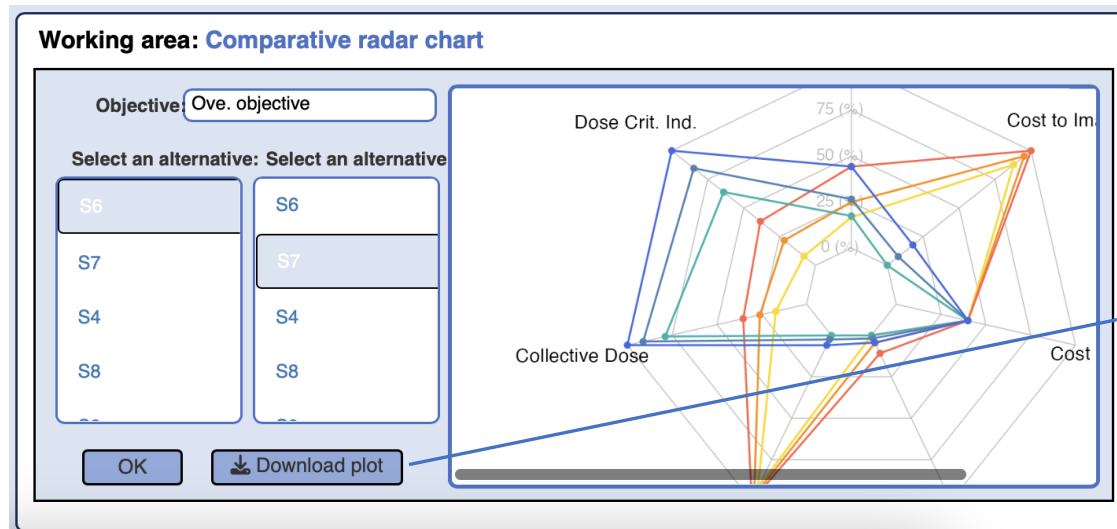


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7.1. Sensitivity analysis. Non-dominated and potentially optimal alternatives

Project information: New Project

Attributes Component utilities Local weights Attribute weights Alternatives Ranking SA-Weight stability intervals

SA-Dominance SA-Simulation techniques on weights

Non-dominated alternatives

S1
S2
S3
S4
S5
S8
S9

Potentially optimal alternatives

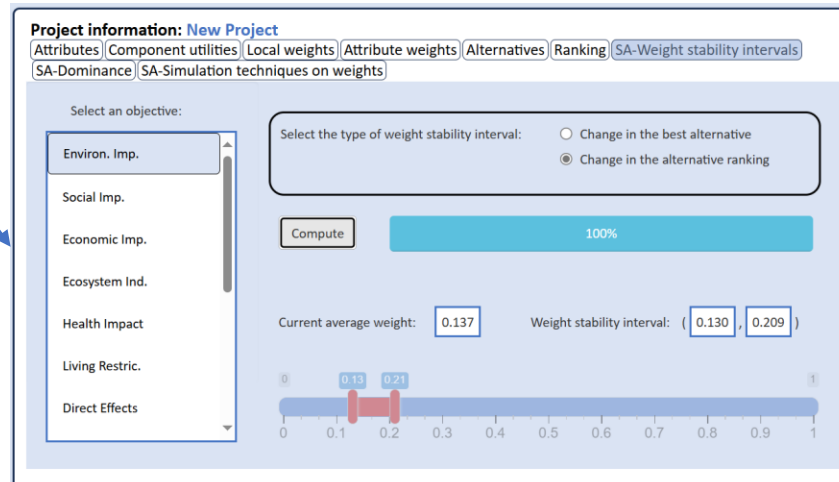
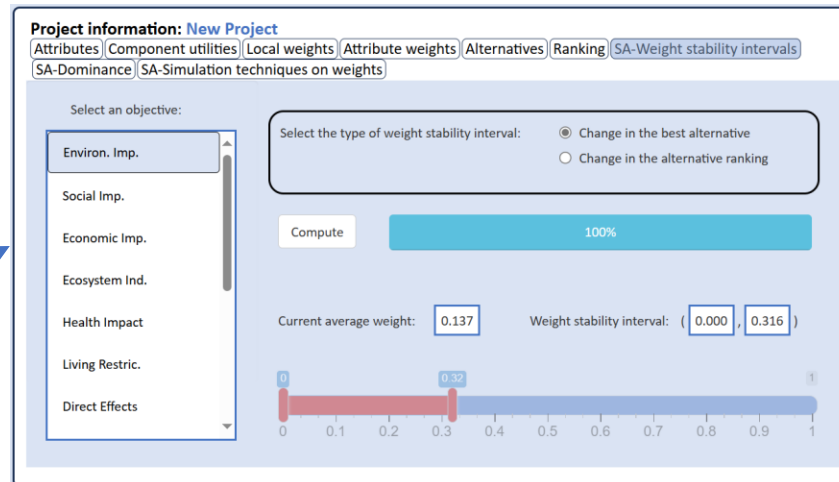
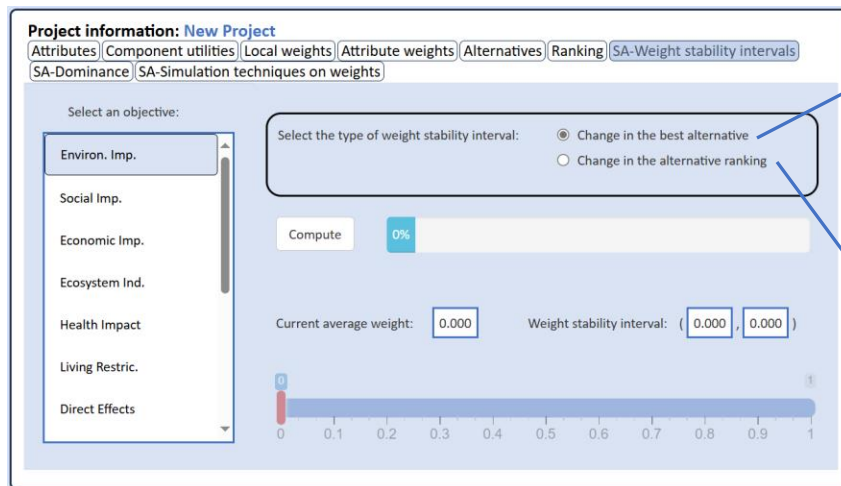
S1
S2
S3
S4
S5
S8
S9

Pairwise dominance values

	S1	S2	S3	S4	S5
S1	X	-0.14	-0.173	-0.07	-0.0
S2	-0.105	X	-0.197	-0.094	-0.0
S3	-0.066	-0.126	X	-0.055	-0.0
S4	-0.212	-0.271	-0.304	X	-0.0
S5	-0.173	-0.233	-0.265	-0.162	X
S6	-0.285	-0.345	-0.377	-0.274	-0.0
S7	-0.3	-0.36	-0.393	-0.29	-0.0
S8	-0.192	-0.252	-0.285	-0.182	-0.0

Assess 100%

7.2. Sensitivity analysis. Weight stability intervals



7.3. Sensitivity analysis. Monte Carlo simulation techniques on weights

Project information: New Project

Attributes | Component utilities | Local weights | Attribute weights | Alternatives | Ranking | SA-Weight stability intervals | SA-Dominance | **SA-Simulation techniques on weights**

Select an option:

- ☒ Random weights
- ☐ Ordinal information on weights
- ☐ Local weights

Perform simulation

0%

Attribute list:

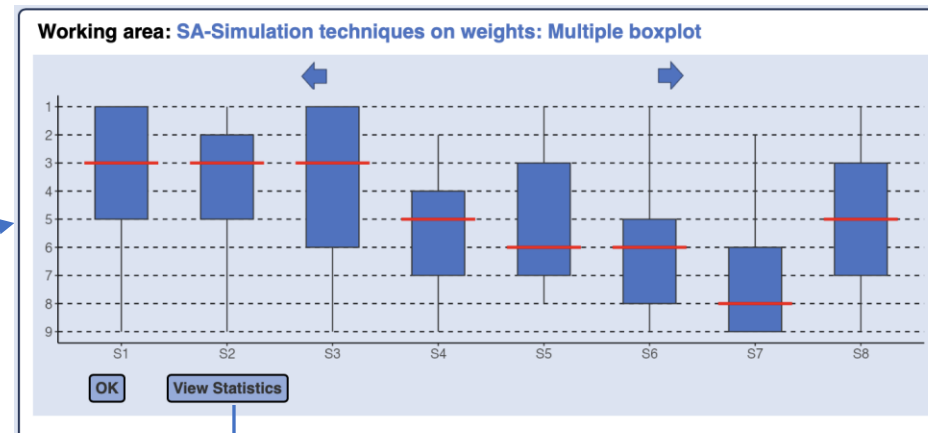
- Ecosystem Ind.
- Dose Crit. Ind.
- Collective Dose
- Cost to Economy
- Cost of Applcat.
- Cost to Image
- Fishing Bans

Drag & drop

Attribute ranking:

Most important

Least important



Working area: SA-Simulation techniques on weights: Statistics

	Mode	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Std. Deviation
S1	1.00	1.00	1.00	3.00	3.48	5.00	9.00	2.48
S2	2.00	1.00	2.00	3.00	3.33	5.00	9.00	1.75
S3	1.00	1.00	1.00	3.00	3.48	6.00	9.00	2.37
S4	4.00	2.00	4.00	5.00	5.30	7.00	9.00	1.97
S5	7.00	1.00	3.00	6.00	5.10	7.00	8.00	2.04
S6	8.00	1.00	5.00	6.00	6.13	8.00	9.00	2.13
S7	9.00	2.00	6.00	8.00	7.30	9.00	9.00	2.05
S8	1.00	1.00	3.00	5.00	5.01	7.00	9.00	2.66

OK

7.3. Sensitivity analysis. Monte Carlo simulation techniques on weights

Project information: New Project

Attributes | Component utilities | Local weights | Attribute weights | Alternatives | Ranking | SA-Weight stability intervals | SA-Dominance | SA-Simulation techniques on weights

Select an option:

☐ Random weights

☒ Ordinal information on weights

☐ Local weights

Perform simulation

100%

Attribute list:

Attribute ranking:

Collective Dose

Cost of Applicat.

Fishing Bans

Ecosystem Ind.

Cost to Image

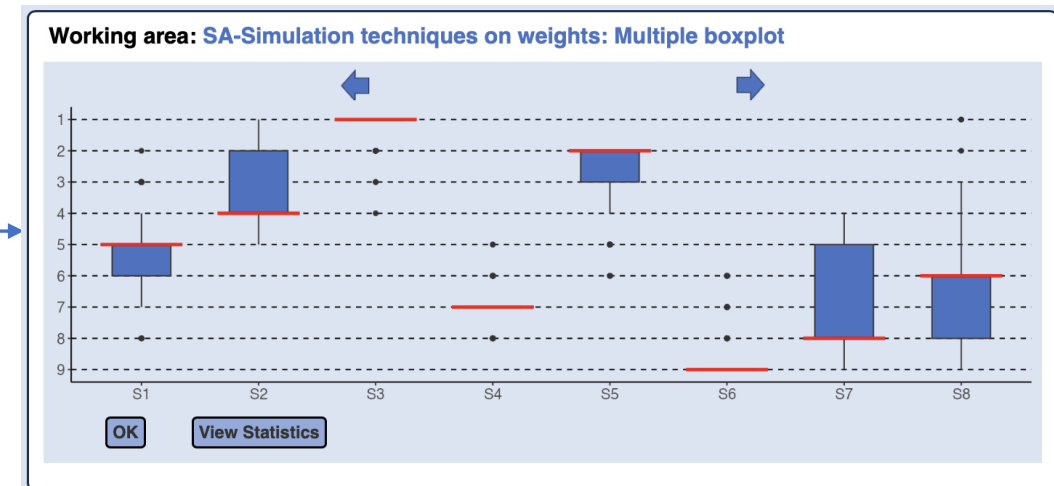
Dose Crit. Ind.

Cost to Economy

Drag & drop

Most important

Least important



7.3. Sensitivity analysis. Monte Carlo simulation techniques on weights

Project information: New Project

Attributes | Component utilities | Local weights | Attribute weights | Alternatives | Ranking | SA-Weight stability intervals | SA-Dominance | SA-Simulation techniques on weights

Select an option:

☒ Random weights

☐ Ordinal information on weights

☐ Local weights

Perform simulation

0%

Attribute list:

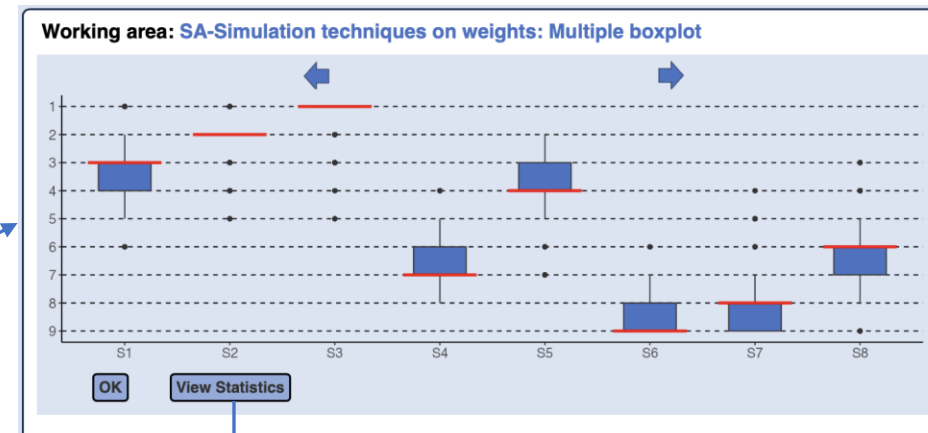
- Ecosystem Ind.
- Dose Crit. Ind.
- Collective Dose
- Cost to Economy
- Cost of Applicat.
- Cost to Image
- Fishing Bans

Attribute ranking:

Drag & drop

Most important

Least important



Project information: New Project

Attributes | Component utilities | Local weights | Attribute weights | Alternatives | Ranking | SA-Weight stability intervals | SA-Dominance | SA-Simulation techniques on weights

Attribute names:

	Min	Avg	Max
Ecosystem Ind.	0.091	0.137	0.182
Dose Crit. Ind.	0.06	0.106	0.168
Collective Dose	0.14	0.217	0.315
Cost to Economy	0.041	0.071	0.113
Cost of Applicat.	0.113	0.191	0.294
Cost to Image	0.08	0.134	0.202
Fishing Bans	0.086	0.145	0.218

Working area: SA-Simulation techniques on weights: Statistics

	Mode	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	Std. Deviation
S1	3.00	1.00	3.00	3.00	3.43	4.00	6.00	1.00
S2	2.00	1.00	2.00	2.00	2.11	2.00	5.00	0.78
S3	1.00	1.00	1.00	1.00	1.28	1.00	5.00	0.67
S4	7.00	4.00	6.00	7.00	6.34	7.00	8.00	0.94
S5	4.00	2.00	3.00	4.00	3.78	4.00	7.00	1.10
S6	9.00	6.00	8.00	9.00	8.53	9.00	9.00	0.57
S7	9.00	4.00	8.00	8.00	8.08	9.00	9.00	1.06
S8	6.00	3.00	6.00	6.00	6.30	7.00	9.00	1.12

OK