COST BENEFIT ANALYSIS

INTRODUCTION

The idea of this guide is to provide the basics steps to conduct a Cost Benefit Analysis (CBA) or to modify an existing one. It is assumed that the user is familiar with the terms described here.

IDEAL WORKFLOW

In the following figure we describe an ideal workflow to use the SDSS, and in this guide we will describe the basic steps to conduct cost-benefit analysis (CBA) and the required data and preconditions from other modules in order to use the CBA module correctly.



Figure 1 workflow in the SDSS

MANAGING CBA FOR A GIVEN STUDY AREA AND PROJECT

From the menu, press "Conduct Cost Benefit analysis" and the following screen will be displayed:

tudy Area:	demo	*		
roject:	alternative and scenario	*		
CBA N	ame	Edit	Delete	Visualize
1 CBA0	234test	۵	0	۲
2 CBAD	emo00001	\$	0	3
3 CBA0	5	۵	0	3
4 CB00	METRICS	۵	0	3
5 CBAO	00XXX	0	0	3

Figure 2 list of CBA calculations

There are two comboxes, the first one allows you to choose the study area and then the second one a project within the selected study area. First, the user has to select the study area and the project for which a CBA should be conducted or edited.

Once you select these two items, the list will be populated with the currently existing CBA records conducted before for the combination of Study Area/Project. Then you can open an existing one by clicking on the "*Edit*" icon:

tudy	Area:	demo	*			
roje	ect:	alternative and scenario	~	*		
	CBA Name	•	Edit	Delete	Visualize	
1	CBA00234	test	0	٢	3	
2	CBADemo	00001	0	0	3	
3	CBA005		() ()	9	3	
4	CB000MET	TRICS	0	9	۲	
5	CBA0000X	xx	0	0	3	

Figure 3 edit existing CBA calculations

You can also delete previously created CBA records by clicking on the delete icon displayed on the record.

Working with the CBA module is an iterative process, because we can have several alternatives plus several scenarios of change, so is better to asses one by one at time and progressively store the results.

DEFINING ALTERNATIVES – GENERAL CONSIDERATIONS

Some information defined in the selected Alternative will be used in while conducting a Cost & Benefit analysis and is important to define it correctly. These are described as follows:

e:		singing	oning solutions	5							
vord	d:	Damn	basin								
ripti	tion:	Constr	uction of new	the noche	ra area						
ad P	PDF File:	Select	a file		Browse						
ad S	Shape File:	Select	a file		Browse						
nati	tive Type:	Struct	irəl	×		8					
		In the second second									
: Yea ime: n he	ear: e: venefits	015 0	-								
: Yea ime: n be ; v inc rren	ear: e: eenefits ncremental b ent situation:	015 0 Denefit c	luring investme	ent period:							
Yea ime: n be inc irren Co	ear: enefits incremental b ent situation: ost Informatic Add Cost	015 0 enefit c	luring investme	ent period:							
Yea ime: n be inc irren Co	ear: e: henefits hcremental b ent situation: ost Informatic Add Cost Item	015 0 e lefit c	Sub Type	ent period:	Start Yea	End Year	Recurren	Qty	Cost/Unit	Total Cost	Delete
: Yea ime: n be ; v inc irren Co A 2 4	ear: e: encremental b ent situation: ost Informatic Add Cost Item Constructior	n 015	Luring investme	ent period:	Start Year	End Year 3	Recurren	Qty 1	Cost/Unit 40000.0	Total Cost 400000	Delete
: Yea ime: n be ; v inc nrren Co A	ear: e: encremental b ent situation: ost Informatic Add Cost Item Construction	n n	Sub Type Building & Wor	ent period: k Force costs	Start Yea	End Year 3	Recurren R	Qty 1	Cost/Unit 400000.0	Total Cost 400000	Delete
: Yea ime: n be : v inc irren) Co 2 4 1 1 1 2 2 4 3 4 4 3 4 4 3 4 4	ear: exemptifies accommental b ent situation: ost Informatic Add Cost Item Construction dditional Benn Add Addition	n n n n n n n n n n n n n n n n n n n	Sub Type Building & Wor	ent period: k Force costs	Start Yea	End Year 3	Recurren R	Qty 1	Cost/Unit 400000.0	Total Cost 400000	Delete
: Yea ime: n be : v inc irren Co A A d	ear: e: exemptifies incremental b int situation: ost Information Add Cost Item Construction dditional Ben Add Addition	n nal Benefit	Sub Type Building & Wor	nt period:	Start Yea	End Year 3	Recurren R	Qty 1	Cost/Unit 400000.0	Total Cost 400000	Delete

Figure 4 information from the Alternative used for CBA

The costs are defined in the alternative and these are loaded in the CBA matrix. Typically the costs refer to the cost of build/implement the alternative and other direct and indirect costs such as construction and maintenance. Also the user can define other costs, which are an indirect consequence of the implementation of the measure like reduction of the tax income, law suits against the government among other side impacts in case of a relocation alternative for example.

For each alternative of mitigation the following information should be entered in order to be properly loaded in the CBA module:

- a) Start year: the start year of the construction or implementation of the alternative.
- b) Lifetime: the time span in which the risk reduction alternative is effective.
- c) When the benefits start: From which year we can start to accrue the full benefits of the measure, in general this is when the measure is in place.
- d) Allow have incremental benefits: With this option the user can specify an incremental amount of the expected risk reduction to be accrued, even if the measure is not completed or fully implemented.
- e) **If the alternative is the current situation**: in that case all above described fields are omitted because there is not risk mitigation.

	mo Map Comparison Alte	ernative - engineering solutions	18							
Name:	engineering solutions									
Keyword:	Damn basin									
Description:	Construction of new basin/	/dam in the noceera area								
Upload PDF File:	Select a file	Browse								
Upload Shape File:	Select a file	Browse								
Alternative Type:	Structural									
Start Year:	2015									
Lifetime:	10 🗘									
When benefits	2 0									
Allow incremental b	benefit during investment pe	riod:								
Is current situation	10 E									
2.000										
🗳 Add Cost										
Add Cost		Sub Type	Start Yi	sar End Year	Recurrent	Qty	Cost/Unit		Total Cost	Delete
Add Cost Item 1 Construction	on	Sub Type Building & Work Porce costs	Start Yi 1	ear End Year 3	Recurrent	Qty 1	Cost/Unit 400000.0		Total Cost 400000	Delete
Add Cost Item 1 Construction	on .	Sub Type Building & Work Porce costs	Start Yr	End Year 3	Recurrent R	Qty 1	Cost/Unit 400000.0		Total Cost 400000	Delete
Add Cost Rem Construction Additional Ben Additional Ben Additional Construction	on nefts	Sub Type Building & Work Porce costs	Start Yr 1	cer End Year 3	Recurrent R	Q8y 1	Cost/Unit 400000.0		Total Cost 400000	Delete G
Add Cost Item 1 Constructio Add Addition Desc	on nefta mai Benefit	Sub Type Building & Work Force costs	Start Y	er End Year 3	Recurrent R Recu	Qty 1	Cost/Unit 400000.0 Yearl	y benefit	Total Cost 400000	Delete
Add Cost Item 1 Constructio • Additional Ben 0 Add Addition Desc 1 Increase in	on	Sub Type Building & Work Parce costs	Start Yr 1 Start Year 73	end Year 3 10	Recurrent R Recu Recu	Qty 1	Cost/Unit 400000.0 Year	y benefit	Total Cost 400000	Delete Gester Gester
Add Cost Rem Constructio Add Additional Ben Add Additional Ben Add Addition Desc Increase in Hazard Update Hazard Update	on	Sub Type Building & Work Porce costs	Start Yr 1 Start Year 3	end Year 3 end Year 10	Recurrent R Recur	Qty 1	Cost/Unit 400000.0 Year	y benefit	Total Cost 400000	Delete Delete
Add Cost Zem Constructio Add Add Dost Add Addition Desc Increase in Hazard Updat eliment at Ris	on netta nati Benefit A Agriculture 60	Sub Type Building & Work Porce costs	Start Year 3	end Year 3 end Year 10	Recurrent R Recu Recu	Qty 1 urrent	Cost/Unit 400000.0 Yeard 2300	y benefit	Total Cost 400000	Delete @ Delete @
Add Cost Rem Constructio Add Storal Ben Add Addstor Desc Tacrease in Hatand Update Cheneed at Rs Othersbilly, U	on netra nal Benefit e Agriculture 66 eak Update Update	Sub Type Building & Work Porce costs	Start Yr 1 Start Year 7	end Year 3 end Year 10	Recurrent R Recu Recu	Qty 1	Cost/Unit 400000.0 Yeard 2300	y benefit	Total Cost 400000	Delete G

Figure 5 defining cost and benifit items

Then for each cost item, the user has to define the following:

- a) Item: The main description of the item in question (i.e. Dam. dike, basin, etc.)
- b) **SubType**: A sub-classification is possible, the user can indicate a subtype (i.e. : Labor, Materials, Expropriations of land, etc.)
- c) Start Year: Start year in which the cost is accrued.
- d) End Year: End year or end of the period of the cost.
- e) **Recurrent**: This indicates whether the cost is seen as a whole investment amount for the specified period and then is divided by the number of years of the defined period or if it is a recurrent amount per year for the period of validity of the cost.
- f) **Quantity**: The number of the same elements to be taken into account.
- g) Unit cost: the unitary cost per item
- h) Total Cost: is auto-calculated by taking the unit cost and the quantity.

With this same idea the user can define additional benefits which are the consequence of the implementation of the risk reduction alternative.

CREATING/EDITING A CBA ANALYSIS

The precondition of the module is to have some risk analysis already done for the study area an project selected in the previous step, for both the situation as business as usual (a.k.a. current situation) and the situation with risk mitigation (an alternative to reduce the risk in place). Otherwise you cannot conduct the CBA completely if there is no data.

Once the user has chosen whether to edit or create a new CBA Analysis, the following screen will be displayed in the working area of the application:

Demo Map	Den	no Map	Compa	rison	Alternative	- engineering	solu	rtions 🗵	Cost Benefit A	nalysis - CBA0000XXX	(🗵				
Start Year:		2015		Numb	er of Years:	60									
Select Risk Analy	sis:	test3					~								
Risk Reduction	ſ	relocati	on				~	3							
Scenario:		enginee	ring so	lutions				Load Cos	t/Risk data						
-	Description ecologic		al solu	solutions				5						1.000	
Description	Description relocatio		ion				/	2018	2019	2020	2021	2022	2023	2024	
∃ Benefits															
AAL (current situ	uation)	0	0.00	0.00)	0.0	D	698560.06	698560.06	698560.06	698560.06	698560.06	698560.06	698560.06
AAL (Alternative	.)		0	0.00	0.00)	0.0	D	942702.23	942702.23	942702.23	942702.23	942702.23	942702.23	942702.23
Risk Reduction			O	0.00	0.00		0.0	0	0.00	0.00	-244142.17	-244142.17	-244142.17	-244142.17	-244142.17
Costs															
Maintenance			0	0.00	0.00)	0.0	D	-12000.00	-12000.00	-12000.00	-12000.00	-12000.00	0.00	0.00
Construction			•	368994.0	0 -368	8994.00	-36	8994.00	-368994.00	-368994.00	-368994.00	-368994.00	0.00	0.00	0.00
Incremental Ben	hefits		10	368994.0	0 -368	3994.00	-36	8994.00	-380994.00	-380994.00	-625136.17	-625136.17	-256142.17	-244142.17	-244142.17
4															

Figure 6 the CBA analysis screen

Description of the controls of the above screen:

- **Start Year:** Defines the start year of the analysis
- Number of years: Defines the duration of the analysis.
- **Risk analysis Combo:** Displays the available risk analyses done for the combination of Study Area and Project.
- **Risk reduction alternative combo:** based on the selected risk analysis, only the alternatives for which the risk has been calculated are loaded.
- **Scenario Combo:** based on the selected risk analysis, only the scenarios that were used for calculating the risk are loaded.
- **Load Cost/Risk data:** Loads the data from the risk module for the selected combination of risk analysis, Scenario and alternative.
- **Visualize alternative:** when pressed it displays a popup window with the data of the alternative, the user can add additional costs and additional benefits.

The idea of the workflow is to start working with a given risk analysis and for each alternative and scenario load the risk values into the CBA matrix and add all the relevant additional or collateral costs & benefits:

Start Year:	2016	Number of	Years: 40							
Select Risk Analysis:	test3			~						
Risk Reduction	ecologica	solutions	itions							
Scenario:	Most real	stic		✓ Load Cost	t/Risk data					
Description		2016	2017	2018	2019	2020	2021	2022	2023	2024
Benefits										
AAL (current situatio	in) 🌾	0.00	0.00	0.00	0.00	0.00	0.00	666549.16	666549.16	666549,16
AAL (Alternative)	6	0.00	0.00	0.00	0.00	0.00	0.00	254631.02	254631.02	254631.02
Risk Reduction	6	0.00	0.00	0.00	0.00	0.00	0.00	411918.14	411918.14	411918.14
E Costs										
Maintenance	6	0.00	0.00	0.00	-291352.00	-291352.00	0.00	0.00	0.00	0.00
Construction	6	-538644.00	-538644.00	-538644.00	-538644,00	-538644.00	-538644,00	-538644.00	-538644.00	-538644.00
Incremental Benefits	5	-538644.00	-538644.00	-538644.00	-829996.00	-829996.00	-538644.00	-126725.86	-126725.86	-126725.86

Figure 7 the CBA matrix

In the green upper part of the matrix the benefits are listed. In the bottom red part the costs are listed. And for each time we change the scenario and the selected alternative, the matrix will be filtered, and we can edit and modify the values like a spreadsheet. You can also add additional costs, additional benefits whether in the alternative definition and also by pressing the add item button at the bottom:

Add Cost/Benefit		×
Select item type:	Cost	*
Description:	Maintenance dam	
Amount:	23000	EUR
Apply item for a	determined period	
Select Start year:		~
Select End Year:		~
	Save	Cancel

Figure 8 adding additional costs & benefits

You can decide to add the specific Cost or Benefit for a defined time span by checking the option *"Apply item for a determined period"*

	×
Cost	*
Maintenance dam	
23000	EUR
determined period	
2020	*
2025	*
Save	Cancel
9	Cost Maintenance dam 23000 a determined period 2020 2025

Figure 9) applying	item for	a defined	time span
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Start Year:	2016	Number	of Years: 40						
Select Risk Analysis:	test3		112	~					
Risk Reduction alternative:	ecological s	olutions		*	۲				
Scenario:	Most realist	ic		*	Load Cost/Risk data				
Description		2027	2028	2029		2030	2031	2032	
Benefits									
AAL (current situatio	on) 🥥	566549.16	666549.16	66654	19.16	814884.88	814884.88	814884.88	
AAL (Alternative)	0	254631.02	254631.02	25463	31.02	440336.85	440336.85	440336.85	
Risk Reduction	0	111918.14	411918.14	4119:	18.14	374548.03	374548.03	374548.03	
🗉 Costs									
Maintenance	9	0.00	0.00	0.00		0.00	0.00	0.00	
Construction	0	0.00	0.00	0.00		0.00	0.00	0.00	
		And the second s		18 14 41 19	18.14 374		374548.03	374548.03	

Figure 10 the CBA matrix

When the risk values change in the future, the new values will be displayed with a different colour. The same happens with the custom items added to the matrix.

Saving the results

The user can see the intermediate results by clicking the button named "*Results & Calculation*". Here the user can choose an economic metric to see the behaviour of all alternatives trough the different defined scenarios:

lame of the analysis:	CBA005	Interest	Rate: 1.45		
Calculation & Results		~			
Alternative	No scenario	Business as usual	Risk informed pla	nr Most realistic	
engineering solutions					
ecological solutions					
relocation					

Figure 11 saving a CBA analysis

The user chooses one option from the combo named "Economic Metric" and then the system conducts the calculation of such metric:

Save Cost Benefit Analy	sis				×		
Name of the analysis: Calculation & Results	CBA005	Interest I	Interest Rate: 1.45				
Alternative	No scenario	Business as usual	Risk informed plan	ed planr Most realistic			
engineering solutions	9577051.43	20127783.40	0	11926420.08			
ecological solutions	4030358.23	0	0	11130347.74			
relocation	-9207787.07	-9185351.88	0	-9004812.59			
				Confirm Cano	el		

Figure 12 applying the economic metric

Then from here the user can save the Analysis either as a new one or an existing one.

CBA AND MCDM

Each time you save the CBA the values of the calculated metrics these are exported to the MCDM. All the metrics can be used as an economic indicator in the MCDM. The CBA module basically saves them in the Indicator table.

APPENDIX 1 – CBA METRICS

The current supported economic metrics are the following:

- 1. Net Present Value (NPV)
- 2. Benefit-Cost Ratio (BCR)
- 3. Internal Rate of Return (IRR)

And these are defined as follows:

$$BCR = \frac{\sum_{t=0}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{t=n} \frac{C_t}{(1+i)^t}}$$
$$NPV = \sum_{t=0}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$
$$IRR = \mathbf{0} = \sum_{t=0}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

Where:

t = year ,
i = discount rate,
n = threshold,
B = benefit,
C = cost

In the matrix we show the values without applying discounting; we only apply discounting on the calculation of these metrics.