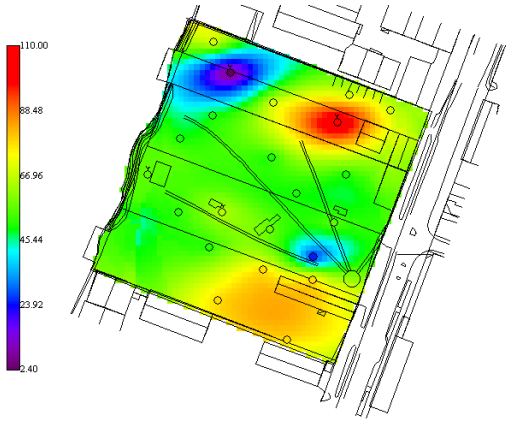
Cost-Benefit Analysis for Comparing Remedial Actions at Contaminated Sites



Lars Rosén[1,3], Tore Söderqvist[4], Pär-Erik Back[1,2], Patrik Brodd[2], Lars Grahn[3], Åsa Soutukorva[4],

[1]FRIST, Chalmers University of Technology, Göteborg, Sweden [2]SWECO, Stockholm, Sweden
[3]SWECO, Göteborg, Sweden
[4]Enveco Miljöekonomi, Skärholmen, Sweden

The problem in Sweden

- 80 000 potentially contaminated sites (2008).
- The 1500 most contaminated sites is expected to cost 60 billion SEK (€7 billion) to remediate.

- Can we afford it? Prioritisation between actions and sites needed.
- How much should we remediate? Ensure acceptable risk levels for humans and the environment and a sound use of available resources

Projects in the Sustainable Remediation Programme (Swedish EPA)

- Participants:
  - FRIST, Chalmers: Lars Rosén, Pär-Erik Back
  - Enveco Miljöekonomi: Tore Söderqvist, Åsa Soutukorva
  - SWECO VIAK: Lars Grahn, Patrik Brodd

- Three projects:
  - 2004-2005: Valuation of risks in selection of remedial strategies
  - 2005-2007: Cost-benefit analysis (CBA) as a tool for prioritising remedial actions
  - 2007-2008: Multi-criteria analysis (MCA) for sustainable remediation (*In prep*).

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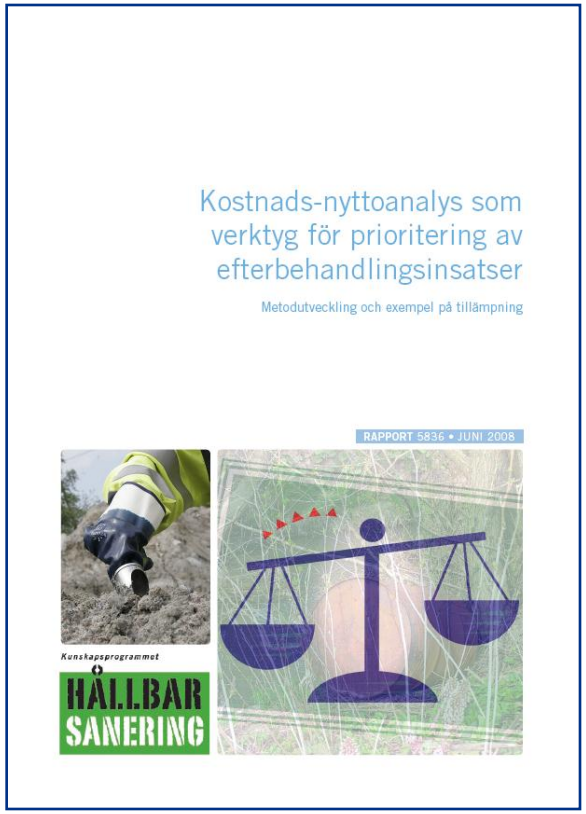

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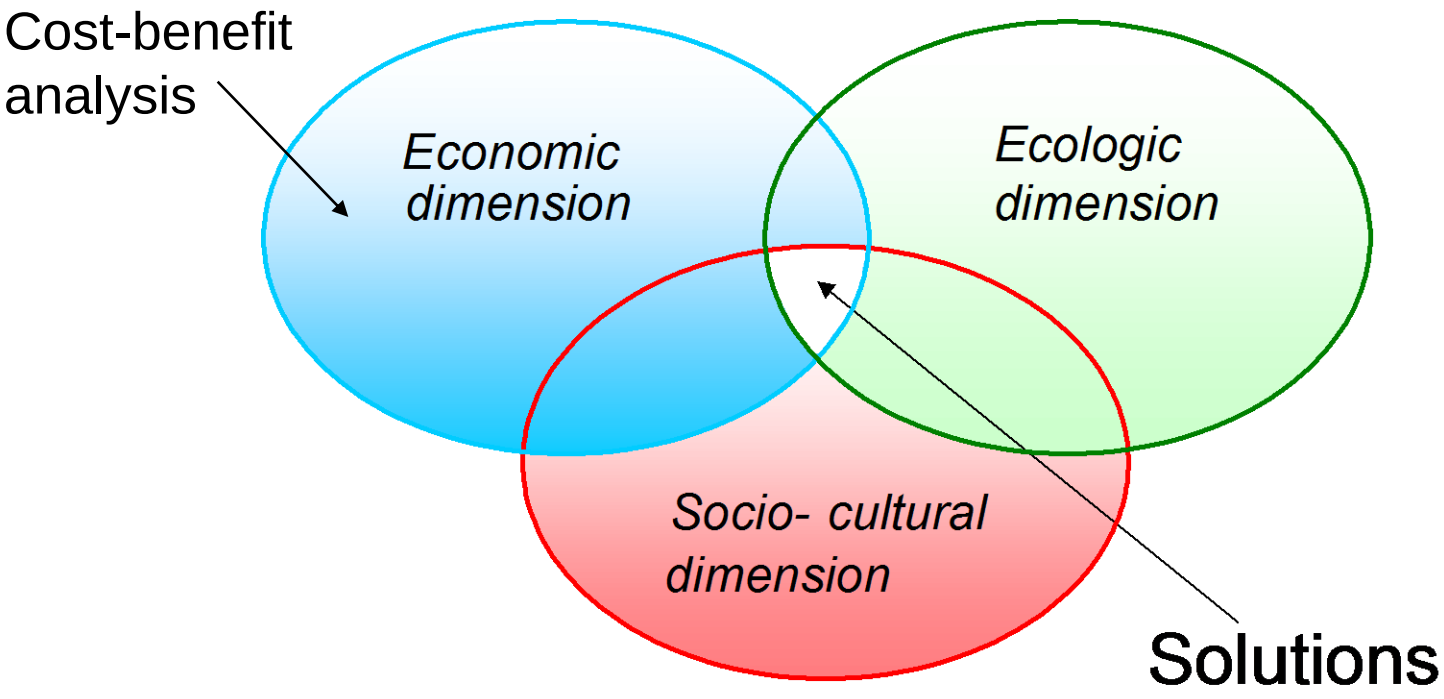
Sustainable development



” Development that ensures that the use of resources and the environment today does not restrict their use by future generations.”

After Söderqvist et al (2004) and Brundtland Commission (1987)

What is cost-benefit analysis?

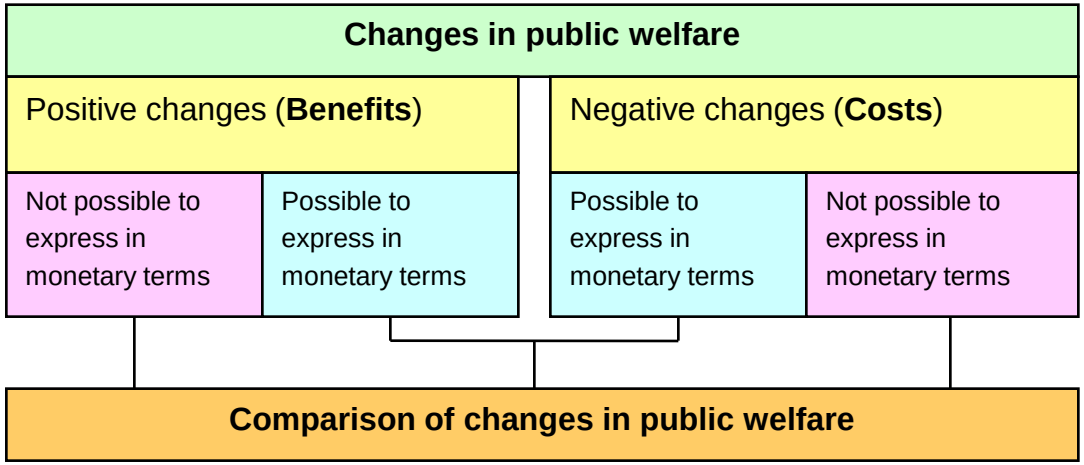
- Performed on the societal level.
- Purpose: to estimate changes in public welfare.
- Basic criterion: Is the sum of all benefits for all companies and individuals larger than the sum of all costs for all companies and individuals?
- Analysis of distributional effects necessary.

Mathematical description

Target function: $$\Phi_i = \sum_{t=1}^{T} \frac{1}{(1+r)^t} \{B_{it} - C_{it}\}$$

B_i = benefits of alternative *i*
C_i = costs of alternative *i*
T = time horizon
r = discount rate

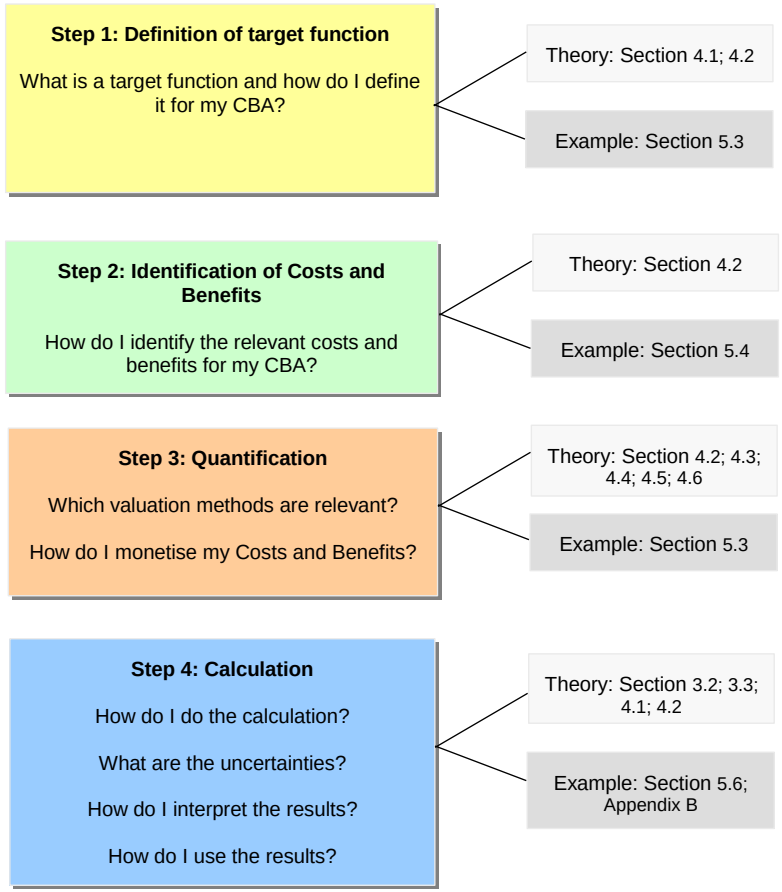
How to express changes in public welfare?



- The positive and negative changes are expressed as far as possible in quantitative monetary terms.
- Some changes, especially those related to the environmental impacts on society, may be difficult to monetise.
- It is important that all changes are expressed at least in qualitative terms and included in the CBA.

A four-step procedure

- *Step 1:* Definition of the basic CBA model and its target function.
- *Step 2*: Identification of the specific costs and benefits, evaluation of the importance of each factor, and valuation in qualitative terms (+/-).
- *Step 3:* Quantification of each cost and benefit, starting with the factors assessed to be the most important in the precedent step. If monetary values are inaccessible within reasonable effort, the qualitative valuation from *Step 2* is maintained.
- *Step 4:* Summation of all costs and benefits over specified time horizon and interpretation of whether the total effect on public welfare is positive or negative.
  - Uncertainty analysis
  - Distributional analysis.



Costs of a remediation project

Costs included in the proposed model are:

C1. Contract costs.

C2. The negative effects on human health from remedial actions.

C3. The negative effects on ecosystem products and services

Examples on changes in risks:

Economic project risks (e.g. delays).

Increased health risks on and off site.

Increased environmental risks on and off site.

Benefits of a remediation project

Benefits included in the proposed model are :

B1. Increased land value.

B2. Net effects on market goods and services associated with the site.

B3. Net effects on health and ecosystem goods and services.

Warning – risks of double accounting!!

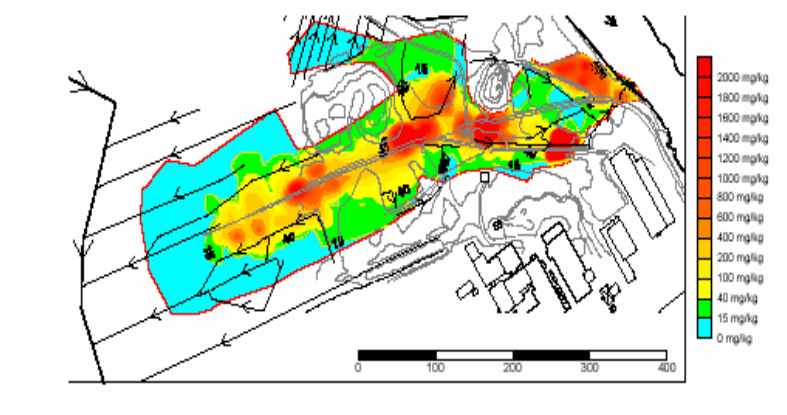
Examples on changes in risks:

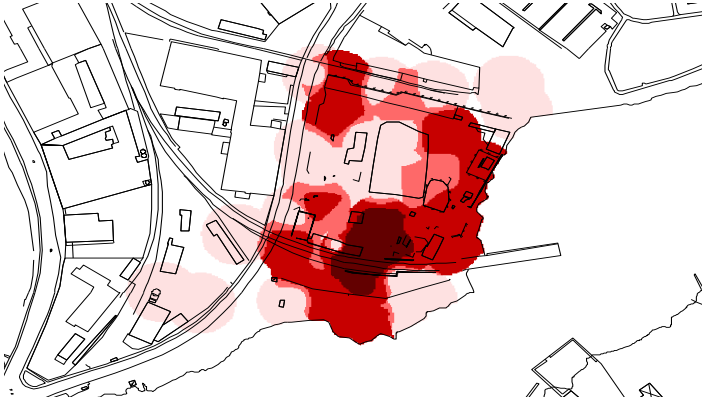
Decreased health risks on and off site.

Decreased environmental risks on and off site.

Two examples

- Case 1: Wood preservation facility, north Sweden
  - Located near the central section a small town in northern Sweden
  - Severe arsenic contamination in soil
  - Also lead, copper and chromium contamination
  - Expected to be a locally important recreational area
- Case 2: Former industrial area, Stockholm:
  - Adjacent to a lake and residential areas
  - PAH, aliphates, BTEX, phenols, copper, free-phase creosote
  - Contamination in soil, groundwater (also in fractured rock and lake sediments)
  - Potential future residential, business and recreational area





Results Case 1 (wood preservation site)

Monetised benefits (B), MSEK		Monetised costs (C), MSEK	
B1a	1,8	C1	55,1
B3aa	0,03	C2a	0,10
B3ab	0,01	C3b	0,15
Total	*1,84*	*Total*	*55,35*
Net benefit (B-C): 1,84-55,35 ≈ -54 M SEK			
Not monetised benefits (B)		**Not monetised costs (C)**	
B3ba	>0	C2b	>0
B3bb	>0		

Interpretation:

- Monetised costs 31 times higher than the monetised benefits.
- Most benefits due to increased land value.
- Very limited benefits due to decreased risks for humans.
- Benefits from increased ecosystem goods and services (e.g. recreation) not expected to compensate for the large discrepancy between monetised benefits and costs.

Results Case 2 (industrial site, Stockholm)

Monetised benefits (B), MSEK		Monetised costs (C), MSEK	
B1a	120	C1	126
B3ab	0,002	C3a	7,8
		C3b	0,07
Total	*120,002*	*Total*	*133,87*
Net benefit (B-C): 120,002-133,87 ≈ -14 M SEK			
Not monetised benefits (B)		**Not monetised costs (C)**	
B3ba	>0	C2b	>0
B3bb	>0		
B3bc	>0		

Interpretation:

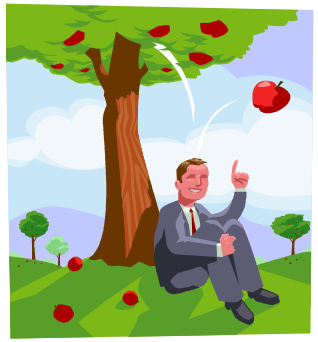
- Monetised costs 12 % higher than the monetised benefits, given future residential land use.
- Most benefits due to increased land value.
- Very limited benefits due to decreased risks for human health.
- Benefits from increased ecosystem goods and services (e.g. recreation) may make the total outcome positive.

Conclusions case studies

- The value of the health risk reductions were remarkably small (in both case studies), and insignificant in a public welfare perspective.
- The potential property value was the most important factor in a public welfare perspective.
- Analysis of distributional effects showed that the property owners were the main beneficiaries, while the tax payers paid the costs.
- Sensitivity analysis showed, in both cases, that changes in time horizons and interest rates had insignificant effects on the total outcome of the analysis.

Conclusions CBA method

- CBA part of a sustainability evaluation of remediation projects.
- CBA provides:
  - Structure
  - Transparency
  - Helps to identify and put focus on factors that may otherwise be ignored.
- The data demand for a complete CBA is extensive - a complete CBA is only reasonable in large projects.
- However, the structure and at least qualitative estimations should be a part of all remediation projects



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