The steps of cost-benefit analysis with emphasis on local level actors in water protection

CITYWATER Seminar
Finding benefits in local water protection –
How much clean water worth and where to put your money?
Helsinki 20.3.2013

Marko Nurminen
Coordinator of Sustainable Development
Technical and Environment Services Office
Lahti Region Environmental Services

marko.nurminen@lahti.fi

The content of this presentation

First, a quick run-through about the basic features of cost-benefit analysis (CBA)

An illustrative example of the use of the CBA framework in a sea flood case study

Some take-home messages

Cost-benefit analysis (CBA)

Cost-benefit analysis is a normative tool for rational decision making helping to investigate the profitability of a project to society.

Benefits mean increases in the welfare of the people.

Costs mean decreases in the welfare of the people.

The project is worthwhile if net social benefit is positive, that is, its benefits to society are larger than its costs.

Time is taken into account in the analysis by discounting. The benefits and costs are converted into present values.

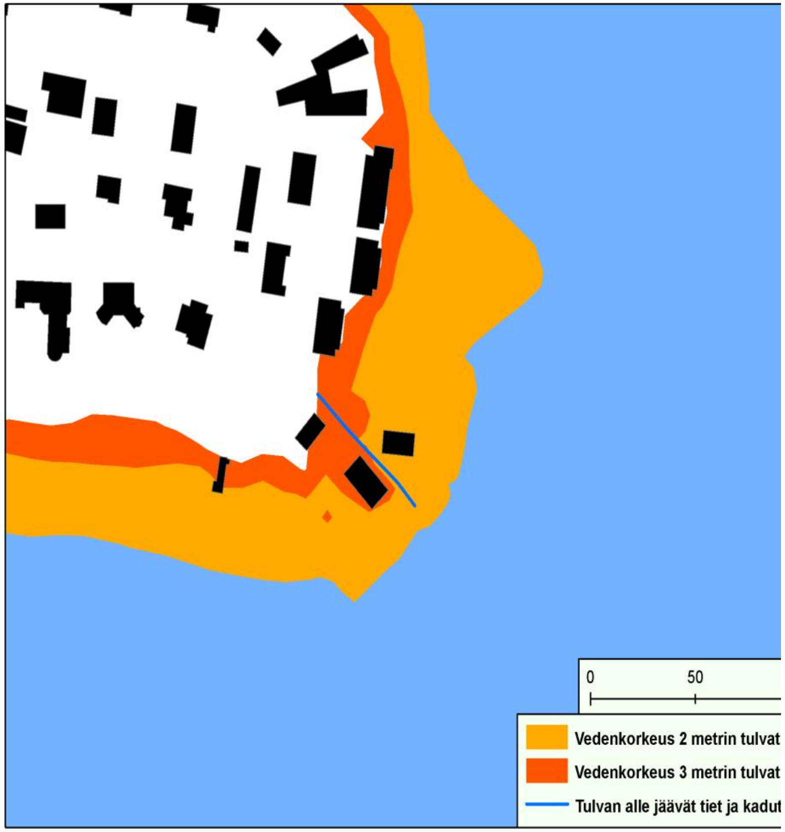
The basic steps of CBA

1. Specify the set of alternatives.
2. Decide whose benefits and costs are counted.
3. Identify the impact categories.
4. Predict the impacts quantitatively over the life of the project.
5. Monetise all impacts, i.e.,express them in money terms.
6. Discount the benefits and costs to obtain present values
7. Compute the net present value of each alternatives
8. Perform sensitivity analysis.
9. Report the results and make the recommendations.

Source: Boardman, Greenberg, Vining and Weimer (2011) Cost-Benefit Analysis.

Case: Ramboll's CBA study of flood two protection cases in Helsinki region

- Ramboll Finland studied two geographically defined sea flood risk cases in Helsinki region
- Different flood protection schemes were analysed by using cost-benefit framework
- The flood heights were set to 2 and 3 meters (flood frequency 1/100a and 1/250a)
- This wasn't full-scale and in-depth CBA! Calculations merely utilise the CBA framework.



Source: Nurminen, Rantanen and Heikkola (2012). Pääkaupunkiseudun ilmastonmuutokseen sopeutumisen strategia. Tapaustutkimus kustannuksista kahdella alueella. HSY and Ramboll Finland Oy.

Step 1: Flood protection alternatives of existing coastal built areas

Area A

- a dike for +2 m sea flood covering the whole coast line
- a dike for +3 m sea flood covering the whole coast line
- a temporary barrier made from big bags for +2 m sea flood covering the coast line
- a temporary barrier made from big bags for +3 m sea flood covering the coast line
- a dike for +2 m sea flood covering the area only partially
- no dikes or temporary barriers for +2 m sea flood
- no dikes or temporary barriers for +3 m sea flood

Area B

- a dike for +2 m sea flood covering the whole coast line
- a dike for +3 m sea flood covering the whole coast line
- a temporary barrier made from big bags for +2 m sea flood covering the coast line
- a temporary barrier made from big bags for +3 m sea flood covering the coast line
- no dikes or temporary barriers for +2 m sea flood
- no dikes or temporary barriers for +3 m sea flood

Step 1: Basic information about the case areas

	Area A	Area B
Population	130–230 inhabitants	480–740 inhabitants
Residential buildings	Small-houses from 40s to 00s	New apartment buildings
Floor area	8 900–18 600 m^2	22 800–46 000 m^2
Business structure	No commercial services nor industries, only micro-sized enterprises	Shopping mall and production facilities close to the flood area
Public buildings	None	A school and day-care centre
Streets and walkways	1,1–3,1 km and 0,1–1,4 km	0,6–2,2 km and 4,7–2,2 km
The length of dike	0,5 km or 2,3 km	1,9 km
Construction costs of dike	0,7 MEUR and 3,1–4,6 MEUR	2,6–4,6 MEUR
Costs of temporary flood protection system	0,3–0,4 MEUR	0,2–0,3 MEUR

Step 2: Whose benefits and costs was dealt with in the flood case?

The question is who has standing, i.e., whose benefits and cost are included in the analysis

In the case study, the main target was in the local level effects

One issue are the effects on people who live, work, or travel in the flooded areas.

The other issue are the effects on the local companies and public services a like.

The macro-level effects are small for example on regional gross national product or on employment.

Step 3:The impact categories

Humans

- possible death incidents
- injuries
- illness
- stress and other effects on people's mental well-being
- temporary housing arrangements

(Natural) Environment

- dirt and rubbish contamination and pollution related by flooded water

Buildings

- cleaning and drying buildings and structures
- repairing of the damages

Personal property

- damaged personal property
- vehicles and boats

Infrastructure

- streets, infrastructure, underground spaces, substations, sewages etc.
- interruptions and breaks related to traffic, electricity, heat and telecommunication

Economy

- business interruptions
- effects on the values of properties
- effects on the insurance premiums
- regional economical effects related to cleaning and repairing

Step 4: Predicting the impacts quantitatively over the life of the alternatives

The chosen time horizon was from 2012 to 2100.

This impacts predicting step is a vital part for a successful CBA.

The fixed investments were quite easy to estimate in the project.

Still in practice, predicting impacts is difficult job to do.

Long time horizon, uniqueness of the project and complex relationship with different level direct and indirect impacts make predictions difficult.

Step 4:Some of the key data sources that made the flood CBA case study possible

- The base data acquired by analysing flood maps with GIS
- A quite large number of different Finnish flood studies
- The large material produced projects such as TOLERATE and IRTORISKI
- The principle was that the CBA calculations and parameter estimations are based on publicly available data

Step 5: Monetising the impacts

Impacts must be valued in money terms.

In the flood CBA, the goal was to monetise every recognised impact in the case study even though in some impact categories the justifications of the monetisation were more or less vague.

We tried to avoid to reinvent wheel and used as much as possible research results and other authoritative sources.

Step 5: Examples of monetising the impacts in the flood case study

Suorat vaikutukset	***2 874 000***	
Ihmiset	***65 000***	
Tulvasta suoraan aiheutuvat kuolemantapaukset	0	
Oletetaan, että ihmisten henkeen suoraan kohdistuvat vaikutukset ovat todennäköisesti erittäin pienet. Suhteellisen hitaasti nousevat Suomenlahden meritulvat antavat mahdollisuuden ihmisten evakuoinnille kohdealueelta.		*Tiehallinto on määritellyt vuonna 2005 verottoma vamma 711 311 (, vaikea tilapäinen vamma 217 7 128 634) ja vammautunut keskimäärin 187 082 (*
Tulvasta suoraan aiheutuvat loukkaantumiset ja sairastumiset	60 000	*Asukkaiden lukumäärä [kpl]*
Arvioitavissa sairastumisen kustannusten kautta (hoito ja toipumisen vaihtoehtoiskustannukset)	60 000	*Lievästi loukkaantuneita [% asukkaista]*
Tulvasta suoraan aiheutuva henkinen kärsimys	5 000	
Arvioitavissa sairastumisen kustannusten kautta (hoito ja toipumisen vaihtoehtoiskustannukset)	5 000	*Kyse on tulvan jälkeisestä post-traumaattisista stressioireista (PTSD) kärsivien osuudesta [% alueen asukkaista]*
Luonnonympäristö	***20 000***	
Tulvan tavanomaisesta (luonnollisesta) poikkeavat suorat vaikutukset luonnon ympäristöön	20 000	*Mahdollinen tulvaveden aiheuttama roskaantum alueiden puhdistukseen menee 5 henkilötyöku*
Rakennukset	***1 590 000***	
Oletuksia		
Tulva-alueen rakennusten kokonaiskerrosala [k-m2]	10 425	*Paikkatietoaineistoanalyysi*
Asuntojen lukumäärä [kpl]	55	*Paikkatietoaineistoanalyysi*
Maanpäällisten kerrosten lukumäärän keskiarvo [krs/kpl]	1,4	*Paikkatietoaineistoanalyysi*
Tulva-alueella lähinnä omakoti- ja paritaloja [krs/kpl]	2	*Alueen rakennuskannan silmämääräinen tarkas*
Rakennusten maapinta-ala [m2]	9 988	*Paikkatietoaineistoanalyysi*
Kerrosten laskennallinen lukumäärä [krs/kpl]	1,04	
Tulva-alueella kastuvan kerrosalan määrä [k-m2]	5 300	*Pyöristetty arvio kerrosalan ja talojen kerrosten p*
Rakennustyypit		*Rakennustyyppierottelulla ei ole merkitystä raker 2010, taulukko 5.3)*
Yhden asunnon talot [kpl]	28	*Paikkatietoaineistoanalyysi*
Talousrakennukset [kpl]	13	*Paikkatietoaineistoanalyysi*

Step 6: Discounting

Future benefits and costs are discounted relative to present benefits and costs. The result is the present values (PV).

The problem is to choose the right social discount rate *s*

$$PV(\text{Benefits}) = \sum_{t=0}^{n} \frac{B_t}{(1+s)^t} \qquad PV(\text{Costs}) = \sum_{t=0}^{n} \frac{C_t}{(1+s)^t}$$

We use in the flood case we used an time-declining inter-generational discounting factor introduced by Sumaila and Walters (on average 1,5 % annual discount rate during the period)

Step 7: Computing the NPVs

The net benefit value (NPV) of an alternative is the PV of the benefits minus the PV of the costs.

The rule of the thumb is that adopt the alternative if its NPV is positive, i.e., benefits exceed its costs.

This is basically the “easy” part of the CBA. Yet, the uncertainty about the benefits and costs make the calculations a bit more difficult.6

Step 7: Dealing with uncertainty

Uncertainty is an inherent part of every CBA.

In the flood case, NPVs were calculated by using the expected values of the net benefits and costs

$$E[NPV] = \sum_{t=1}^{n} p_t (B_t - C_t)$$

The probabilities (*p*) based on the assumed frequencies of the two flood cases.

Step 8: Sensitivity analysis

The impacts and their monetary valuation may contain considerable amount of uncertainty

Sensitivity analysis deals with these kind of uncertainty issues.

Every assumption in a CBA study can be varied. In practice, it is focused in the most important assumptions.

There are different tools for the sensitivity analysis.

We used partial sensitivity analysis (alternative assumptions about key parameters)

Step 8: Example of the results of a sensitivity analysis (area A)

Protection	Base-line	Disc. factor 1 %	Disc. factor 7 %	A death case	Buildings –60 %	Buildings +100 %	Protection +50 %	Personal property +100 %	Personal property –50 %
Dike, 2 m	-3,4	-2,8	-3,8	-2,6	-4,1	-2,3	-4,9	-3,0	-3,6
Dike, 3 m	-5,3	-4,9	-5,5	-5,0	-5,8	-4,6	-7,6	-5,0	-5,5
Temporary, 2 m	+1,0	+1,4	+0,2	+1,8	+0,3	+2,1	+0,7	+1,4	0,8
Temporary, 3 m	+0,2	+0,3	-0,2	+0,5	-0,2	+0,6	+0,1	+0,5	+0,0
Short, 2 m	+0,5	+0,9	-0,4	+1,3	-0,1	+1,4	+0,5	+0,8	+0,0
No protection, 2m	-1,7	-2,3	-0,6	-2,5	-1,0	-2,8	-1,7	-2,1	-1,5
No protection, 3 m	-1,3	-1,7	-0,4	-1,6	-0,7	-2,0	-1,2	-1,6	-1,1

Step 9: A recommendations with NPVs for the flood cases with error margin ±0,5 MEUR

Area A	Dike +2 m	-3, 4 MEUR
	Dike 3 m	-5,3 MEUR
	Temporary protection +2 m	+1,0 MEUR
	Temporary protection +3 m	+0,2 MEUR
	Smaller dike +2 m	+0,5 MEUR
	No protection +2 m	-1,7 MEUR
	No protection +3 m	-1,3 MEUR
Area B	Dike +2 m	-4,6 MEUR
	Dike +3 m	-6,4 MEUR
	Temporary protection +2 m	-0,3 MEUR
	Temporary protection + 3 m	-0,4 MEUR
	No protection +2 m	-0,4MEUR
	No protection +3 m	-0,2 MEUR

Some take-home messages

Even in a quite straight forward and geographically well-defined cases CBA can turn to be a tedious method.

Do categorisations, quantifications, monetising and as transparent as you can.

Don’t reinvent wheel. Use as much as possible existing material and results, and copy good ideas and methods.

Use peer networks and do your CBAs together.