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TESTING A FLOOD PROTECTION CASE BY MEANS OF A GROUP DECISION SUPPORT SYSTEM

Riitta Molarius[1]
Adriaan Perrels[2]
Markus Porthin[3]
Tony Rosqvist[4]

Valtion taloudellinen tutkimuskeskus
Government Institute for Economic Research
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[1, 3, 4] VTT Technical Research Centre of Finland, FI-02044 VTT
[2] VATT Government Institute for Economic Research, FI-00100 Helsinki

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Valtion taloudellinen tutkimuskeskus

Government Institute for Economic Research

Arkadiankatu 7, 00100 Helsinki, Finland

Email: adriaan.perrels@vatt.fi

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Abstract: The report discusses an experimental decision-making simulation session applied to a flood protection case study against the backdrop of flood risks reinforced by climate change. A diverse set of interest groups was represented in the session that was facilitated by risk analysts using groupware. The purpose of the session was to test the decision analytic process, to learn about stakeholders' tendencies towards types of solutions and their possible underlying explanations. Therefore quantitative ratings have limited value in this case. The exercise is part of a larger study (TOLERATE) concerning socio-economic impacts of climate change enhanced extreme weather conditions.

Key words: climate change, climate change adaptation, extreme event, flood, Group Decision Support System

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Tiivistelmä: Raportissa esitellään tuloksia kokeiluluontoisesta päätöksentekoprosessista liittyen tulvasuojeluun. Tulvasuojelu on muuttunut entistä ajankohtaisemmaksi ilmastomuutoksen myötä. Laaja sidosryhmäjoukko osallistui ryhmäohjelmalla toteutettuun asiantuntijaistuntoon tavoitteena keskustella tulvasuojelun vaihtoehdoista sekä arvottamaan näitä eri päätöskriteerien suhteen. Kokeilun tavoitteena oli arvioida päätösanalyyttistä päätöksentekoprosessia – raportissa esitetyt määrälliset arviot eivät ole sellaisinaan käyttökelpoisia todellisista tulvasuojeluratkaisuista päätettäessä. Kokeilu kuuluu osana laajempaan tutkimukseen (TOLERATE), jossa arvioidaan ilmastomuutokseen liittyvien ääri-ilmiöiden sosiotaloudellisia vaikutuksia.

Asiasanat: ilmastonmuutos, ilmastonmuutokseen sopeutuminen, äärimäinen sääilmiö, tulva, tietokoneavusteinen ryhmätyö

Summary

The TOLERATE project attempts to assess costs of weather disasters, notably river floods, of which the frequency and severity can be aggravated due to climate change. In addition to assessing costs the project also attempts to assess approaches that can alleviate the cost of disasters, either by reducing the probability that a certain disaster occurs or by making areas more robust in sustaining extreme events such as floods,

A decision-making simulation session was organised in which alternative packages of flood protection solutions were considered in the context of the flood risks of Pori, a city near the West-coast of Finland situated on both sides of the Kokemäki river. Various categories of flood protection were considered and evaluated in conjunction with alternative solution packages for flood protection. The participants were from public authorities with responsibilities regarding water management, local and national spatial planning, rescue and disaster management, public finance, and road infrastructure planning and maintenance. In addition various representatives from private sector interest groups participated, such as the insurance sector, the Finnish business association (EK) and the Association of home owners.

The session was indeed '*only*' a facilitated group decision-making *test*. The quantitative results should be only understood in terms of indicating probable priority orderings. The quantitative results as such are even not particularly important, but the structured evaluation provides a clear basis to discuss tendencies towards types of solutions and their possible underlying explanations.

As was expected the decision-making simulation exercise did not provide strong guidelines regarding preferred options. Nevertheless the results indicate that in a real world exercise there would most probably be broad support for a significant improvement of the protection level. However, the extent of the improvement and the preferred type of solution would need a more elaborate assessment in which the participants would be involved in an earlier stage and would be better informed (over time). Among others participants should have a say in the definition of evaluation criteria and the identification of solution alternatives to be included in the comparison.

The exercise also indicated that there are some risks for societal disputes about preferable solutions. In first instance it seems that costs are not necessarily problematic, but the impacts of different solutions on the living environment can be a source of misunderstanding and dispute. Consequently these impacts should be assessed thoroughly for all alternative solutions. Another risk related to the interpretation of the effects on the living environment is that of choosing the zero-alternative as a kind of deadlock compromise.

Even though participants had rather varying opinions on how such a decision-making exercise should be carried out, a majority was of the opinion that this is a useful and all in all a quite effective (compact) way to engage a larger collection of interest groups in the evaluation and decision making regarding significant public projects.

In the preparatory phase of the TOLERATE study was hypothesized that in principle the assessment of the risks of floods, including the reinforcement effects of climate change as well as possible flood protection measures, could be understood as an optimal control problem. Already in that phase it was indicated that most probably such an optimal control approach would not be feasible in a strict sense, but rather works as a metaphor and helps to systemise the comparison of alternative strategies. The decision making simulation exercise discussed here exemplifies this point. Not only is there uncertainty regarding a part of the information, but there is also uncertainty about the way different interest groups conjecture the overall problem. A part of the latter uncertainty can be somewhat relieved by providing better and more accessible information. However, partly the uncertainty may be fundamental, because the stakeholders are facing limitations in their capacity to evaluate all information. Furthermore, the choices ahead may involve trade-offs that are very hard to monetise if at all, whereas the stakeholders may even change opinion several times. Obviously, this is does not mean that a cost-benefit assessment loses its significance, as stakeholders still want to know what are the economic consequences of stressing as such non-monetised features,

Contents

1. Introduction

The TOLERATE project attempts to assess costs of weather disasters, notably river floods, of which the frequency and severity can be aggravated due to climate change (TOLERATE team, 2007; Perrels et al. 2008). However in addition to assessing costs the project also attempts to assess approaches that can alleviate the cost of disasters, either by reducing the probability that a certain disaster occurs or by making areas more robust in sustaining extreme events such as floods.

Even though in first instance the extent of a flood is expressed in terms of the number of affected buildings and the flooded floor area, and the amount of direct damage incurred, eventually, the judgement of a certain level of flood risk is based on a much broader basis than direct and total macro-economic costs of (prevented) disasters only. The broader welfare effect of better flood control includes notions of security, potential value changes of real estate, changes in the living environment, and environmental effects. It should be noted that improved flood control[1] may also entail measures that have negative effects on the latter three aspects. These aspects consist of factors that are hard to monetise straightaway. At best, when considering the trade-offs between alternative packages of solutions, implied willingness to pay could be revealed by eliciting preferences of the various stakeholders. To this end multi-criteria analysis is needed. The exercise will however illustrate that the idea of conjecturing the overall flood control problem as an optimal control problem is mainly useful as metaphor.

A decision-making simulation session was organised in which alternative packages of flood protection solutions were considered in the context of the flood risks of Pori, a city near the West-coast of Finland situated on both sides of the Kokemäki river. Various categories of flood protection were considered and evaluated in conjunction with alternative solution packages for flood protection. The participants were from public authorities with responsibilities regarding water management, local and national spatial planning, rescue and disaster management, public finance, and road infrastructure planning and maintenance. In addition various representatives from private sector interest groups participated, such as the insurance sector, the Finnish business association (EK) and the Association of home owners.

The session was indeed '*only*' a facilitated group decision-making *test*. The quantitative results should be only understood in terms of indicating probable priority orderings. The quantitative results as such are even not particularly im-

[1]. In this report the term 'flood control' is used when referring to the overall policy area of forecasting, monitoring, and preventing floods, as well as attenuating impacts of floods. The term 'flood protection' refers to physical and regulatory measures that reduce the probability that a flood occurs. So, flood protection constitutes a subset of flood control.

portant, but the structured evaluation provides a clear basis to discuss tendencies towards types of solutions and their possible underlying explanations.

The information about alternatives was kept simple, whereas also the representation of non-monetary impacts was crude and compound. The test produced useful insights concerning the way participants associated various features with each other and it provides information about how interest groups digest this kind of decision making processes. Also feedback regarding the amount and quality of information for conducting such a decision process was valuable.

In chapter 2 there is a brief overview regarding the state of the art in flood risk assessment in Finland. Chapter 3 gives a concise presentation of the flood risk case in Pori. Chapter 4 goes through the actual decision-making session, while chapter 5 gives an interpretation of the results. To this end also the ratings are presented, but this is mainly done to make the procedure and effects understandable for the reader, *not* because we attach application value to the ratings as such. We do think however that some of the findings in the evaluation are indeed representative, but these are mostly at a very generic level. Chapter 6 draws conclusions and ponders about lessons learned.

2. State of art on impact assessment of floods and of flood control in Finland

2.1 Categorising floods

Floods occur in Finland due to the following causes:

- river flooding may appear:
    - due to prolonged periods of above average precipitation (ice dams and high sea water levels in the river mouth can aggravate the situation);
    - as so-called spring floods due to rapid snow melt
    - due to ice dams in rivers during spring (in combination with snow melt effects)
- coastal flooding can occur due to storm surge
- very local floods in urban areas can appear after a cloud burst.

Even though spring floods are a frequently occurring event in various river systems (e.g. downstream the Kemi river) the damage of these floods is usually quite limited due to the very low population densities in the concerned areas. As a consequence river flood control received fairly little attention in the past decades, with the exception of Pori. Pori is the only larger urban settlement in Finland with significant river flooding risks. Similarly, combination of land uplift and the absence of tides prevent storm surge in coastal areas from getting a significant issue. Climate change is, however, changing this view.

2.2 The effect of climate change amidst other factors

Climate change is expected to raise seawater levels (IPCC, 2007), whereas also the occurrence of storm weather is expected to increase. At the same time expansion of the urban area along the sea side in the greater Helsinki area has continued, sometimes without much recourse to flooding risks. Indeed it is a rather common outcome of flood risk assessments that the augmentation of flood risks, when expressed in economic terms (costs), can in the first place be attributed to the expansion of the building and infrastructure stock in areas that are prone to floods. In addition, also the general increase in productivity and wealth per unit of building stock (e.g. m^2) contributes to rising costs estimates for floods. Climate change comes in as a third factor, due to higher flood probabilities in a certain area and due to the increase of the average flood size. The way the risks develop over time should always be assessed in the local context. By way of exception, the contribution of climate change to the cost of floods can sometimes be more important than the economic development. Conversely, in other cases climate change may also result in a reduction in flood probability.

In recent years the upsurge in climate change related studies has resulted in a rising awareness about flood risks and their possible augmentation due to climate change. In EXTREMES I[2] (2003–2005) and EXTREMES II[3] (2006–2008) the goal is to find out possible changes in the return time of selected extreme weather related events in the future in Finland. The aim of the project "Climate change in urban planning" (2006–2008) is to promote adaptation to and mitigation of climate change in urban planning and thereby i.e. to reduce damages caused by floods and storms, as well as to reduce greenhouse gas emissions[4]. The most comprehensive of the recent projects was FINADAPT. Its aim was to assess the adaptive capacity of the Finnish environment and society under a changing climate[5] and to identify needs for further research. The project was running from 2004–2007. The project addressed for example the following topics in the context of climate change: biological diversity, forestry, agriculture, water resources, human health, transport, the built environment, energy infrastructure, tourism and recreation, urban planning, and economic development.[6]

As regards hydrological features of Finnish water systems in the future, many studies have been made. A project called EXTREFLOOD I (Flood hazards in Finland: modelling and mapping of extreme floods, producing flood scenarios and delivering flood information to stake holders) was carried out in the period 2003–2005[7]. Its follow-up project EXTREFLOOD II aims to develop methods which enable more extensive and more effective ways to control floods[8]. The project has three goals, being:

- further development of flood risk mapping methods
- the study of conflicts between land use planning and flood protection
- scenario simulations of future floods in case study areas.

The Nordic co-operation project -"Climate and Energy Systems; Risks, Potential and Adaptation- CES"- addresses to the impacts of global warming on renewable energy production. The project takes place in the period 2007–2010. In this pro-

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[2] http://www.ymparisto.fi/default.asp?contentid=136501&lan=EN, poimittu 21.4.2008.

[3] http://www.ymparisto.fi/default.asp?contentid=189842&lan=EN, poimittu 21.4.2008.

[4] http://www.ymparisto.fi/default.asp?contentid=191611&lan=EN, poimittu 21.4.2008.

[5] FE1/2007 Assessing the adaptive capacity of the Finnish environment and society under a changing climate (2007): FINADAPT. Ed. Carter T.R. Finnish Environment 1/2007, Environmental Protection, 76 p., URN:ISBN:9789521125430, ISBN: 978-952-11-2543-0 (PDF), ISBN: 978-952-11-2542-3 (pbk.).

[6] http://www.ymparisto.fi/default.asp?contentid=227544&lan=EN, poimittu 21.4.2008

[7] http://www.ymparisto.fi/default.asp?contentid=107906&lan=EN, poimittu 21.4.2008

[8] http://extreflood.utu.fi/ , poimittu 21.4.2008.

ject the main interest in Finland is in the future hydro power production and dam safety both of which need to have a closer examination on floods.

A systematic treatment of flood protection alternatives is, however, appreciably less well developed. Only recently, in conjunction with the EXTREFLOOD I and II projects, flood risk maps have been constructed for river systems and coastal areas (www.ymparisto.tulvakartat).

In general, flood protection is, by default, not a part of the regular hydrological and water quality and quality management, which makes comprehensive assessments of river system management often incomplete. Similarly, maintenance of existing means of protection, and the required funding and attribution of responsibilities are not necessarily always clearly arranged.

This report discusses the evaluation of flood protection alternatives based on a given set of *flood probabilities by category* (1/50 and 1/250 years) for a certain area, in this case illustrated on the basis of information about the Pori area. The decision-making simulation exercise is meant as an illustration of how groupware-based decision analysis may be utilised in the evaluation of quantitative and qualitative aspects related to flood protection investment appraisal and flood control in general.

3. The flood protection case considered

Essentially the decision making exercise is meant to shed light on the possibilities to mix pecuniary and non-pecuniary information, on the abilities of various types of stakeholders to obtain an appreciation of the decision-making framework and, on the different preferences with respect to various dimensions of the decision-problem considered.

Even though the exercise was more a learning event and produced at best indications with respect to some prioritisation matters and trade-offs, it was nevertheless built on a simplified representation of a real flood risk case, being the city of Pori, where significant river flooding risks are acknowledged (see §2.1). The municipality of Pori is running a project in which flood risks and flood protection alternatives are assessed extensively (http://www.pori.fi/tpk/porin_tulvat/). The process also involves public hearing possibilities, as part of the legislation concerning environmental impact assessment.

Point of departure is that the current flood protection level is expected to fail even in case of a river flow level associated with a return time of 50 years. To this can be added that in the case of the Kokemäki river, climate change is expected to aggravate the risks as the future river flow level associated with a return time of 50 years is comparable to what would currently be the flow associated with a 70 years return time.

The considered alternatives are in the first place categorised according to the exceptionality of the water level in terms of return time (R). The options are:

0. current protection level: R < 50;
1. new protection level, capable up to flow level events of R = 50;
2. new protection level, capable up to flow level events of R = 250.

There are simulations available of the incurred cost to buildings, costs of production interruptions, and of temporary accommodation for floods associated with return times of 50 and 250 years, both for current and future climate (for details see Perrels et al, 2008). Prior to the expert session, concise summary information was provided about return times, protection categories, total expected damage costs per return time level, and the costs of control alternatives (see appendix 1 for pre-session information). Later these discussed return times are marked as R50 and R250 in this text. The considered time span is 2005–2050.

The costs of flood for different return levels, as shown during the expert session, are reproduced in table 1. The costs are based on the building stock situation of 2007. No effects of economic growth (e.g. in terms of value/m^2) are taken into account. It should be stressed that since then data updates and additional information have resulted in an upward correction of the earlier simulated costs.

Table 1. The number of affected buildings and the total attributed costs for several return times (R =) in current (N_I) and future (T-I) climate respectively, M refers to the sea level rise due to low pressure / storm surge*

buildings affected	R = 50 > > > > > >		R = 250 ; M1 > > >		R = 250 ; M2 > > >	
	N_I	T_I	N_I	T_I	N_I	T_I
homes	1274	1365	2335	2547	3129	3202
appartments	1295	1400	1918	1918	2001	2022
shops, offices	30	32	54	56	68	71
industrial buidlings	29	32	90	101	135	138
other buildings	452	492	872	948	1121	1142
TOTAL	3080	3321	5269	5570	6454	6575

Costs in mln. €	**R = 50 > > > > > >**		**R = 250 ; M1 > > >**		**R = 250 ; M2 > > >**	
	N_I	**T_I**	**N_I**	**T_I**	**N_I**	**T_I**
households	82	93	173	195	277	290
services	4	5	19	21	36	38
others	2	2	8	11	27	29
TOTAL	89	100	200	227	341	357

*) See the proviso at the end of the previous page. The figures above were based on the than available results. New data on unit-costs of building damage and effects of duration led to some increase in the cost estimates.

The considered flood protection alternatives in terms of types of solutions were the following:

0. Current protection level (some repair of current low embankment)
1. (Mainly) Stronger embankments
   1.a. protection level up to R50
   1.b. protection level up to R250
2. (Mainly) Dredging
   2.a. protection level up to R50
   2.b. protection level up to R250
3. New river arm
4. Building or building block specific flood protection measures.

Table 2 summarises costs and other impacts, mainly on the living environment that are related to the *implementation and maintenance* of the alternatives. These impacts are permanent and can be likened to the premium of an insurance against hazards.

Table 2. The summary of implementation and maintenance costs, and other (non-monetary) effects per flood protection alternative

	Estimated cost (million €)	Other effects
0 – alternative	2 ~ 4	few; perhaps limitations in land use (zoning)
1.a. stronger embank-ment R = 50	15 ~17	landscape effects, with possible spin-off on real estate values
1.b. stronger embank-ment R = 250	25 ~ 28	more outspoken land-scape effects, with possi-ble spin-off on real estate values
2.a. dredging R = 50	14 ~ 16	environmental effects for the river ecology
2.b. dredging R = 250	19 ~ 22	even more extensive en-vironmental effects for the river ecology
3. new river arm	35 ~ 50	comprehensive implica-tions for land use in Pori; landscape effects; envi-ronmental effects for the river ecology
4. building specific measures	20 ~ 30	no large effects; possible effects on the outside looks of buildings

The information on non-monetary effects was kept rather simple. On the one had the information at this point is still relatively scant, while on the other hand the qualitative character of the information makes is hard to summarise within the confines of a simplified decision making simulation. In a real world decision making process the description of the effects should be done carefully, but also as much as possible in a harmonised manner, whereas indeed information over-load is one of the threats in complex multi-stakeholder decision making proc-esses.

4. The expert session

4.1 The preparatory phase

The decision context, as summarised in chapter 3, was largely defined prior to the session and without consultation of the participants. Yet, during the expert session participants got the opportunity, albeit limited, to amend the definitions of the flood protection alternatives.

In real world decision-making situations, the definitions of the points of departure and the decision-making framework are important and should be subject to some degree of interaction with the involved interest groups. Agenda setting, which is exclusively done by a limited number of bureaucrats or technocrats or for which only a subset of interest groups is consulted, may lead to exclusion of relevant alternatives and/or to erosion of the credibility of the decision-making process among the public.

Another essential task is the identification of the relevant stakeholder groups. Since this exercise concerned only a test, diversity in opinions was needed, but it was not necessary to insist on complete representation. There were even simple technical reasons, such as workable size of the group, which did put some tentative upper limit on the number of participants. The eventual set of participants turned out to be sufficiently diverse (see Appendix 2 for the participant list).

The advance information sent to the participants consisted of an invitation (also explaining the context of the exercise), an agenda for the day, and a compact collection of overhead material of state of the art knowledge and the basic solutions to be discussed. The expert session started with a rehearsal of the basic information and procedures of the day.

4.2 The expert session proper

It should be noted that there was not any mandate for actual decision making in the test session. Some stages of the decision-making simulation where predefined to the extent that a one-day session would suffice. In a real decision context two days or a set of recurrent sessions would be a more realistic schedule for the expert decision making. The agenda for the expert session is found in Appendix 3. The actual decision process started after the introductory remarks and the presentation of the current knowledge of flooding risks in the example area.

The aim of the session was to consider different flood protection strategies and different stakeholders' opinions about their pros and cons. Multiple Criteria Decision Analysis (MCDA) and a value tree presentation (Keeney and Raiffa, 1993;

Keeney, 1992) was used to structure the opinions. The principal idea in MCDA is to present the different *decision criteria* in a tree structure to aid the decision process. The set of criteria should reflect which features the decision makers find important when making the decisions. First the *decision alternatives* to be considered are chosen. Then all decision alternatives are assessed with regard of every criterion separately, one at a time. Every alternative receives thus a *value* with regard of each criterion. Next the criteria are weighed against each other according to their relative importance. Finally the *aggregate value* of each alternative is calculated as the weighed sum of its values with respect to the criteria. If the decision maker has given all preference statements according to his true values, which is not a trivial task, the decision maker prefers the alternative that receives the highest aggregate value.

A computer system was used to facilitate the session. In order to collect the opinions of all participants in an efficient way, the participants had laptop computers connected via the Internet to their disposal. Using a Group Decision Support System software called GroupSystems ThinkTank, the participants were able to give both numerical and verbal input throughout the process. Web-HIPRE, a dedicated MCDA software, was used for the MCDA presentation and calculation.

The most significant framing of the decision problem was made by pre-defining the *decision criteria and their sub-criteria*, shown in the form of a value tree in Figure 2. The value tree was developed on the basis of the influence diagram in Figure 1. The latter figure outlines a simplified relationship between flood and consequences for households, business sectors and infrastructure. These were identified as the main stakeholder groups affected by the event (and are the main agents for planning of protection). For a more detailed account on the consequences related to a flood, the reader is referred to the flood mind map in Appendix 1.

Basic influences of a flood on infrastructure, business and households:

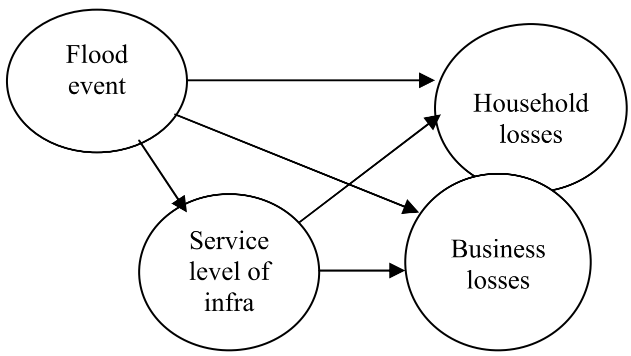

Figure 1. An influence diagram indicating the main consequences of a flood.

The value tree comprises of five decision criteria broadly representing protection and use of resources. The red colouring is associated with the three protection-criteria, whereas blue with the two resource-criteria. The protection is measured in terms of the capability to mitigate the adverse consequences of a flood event for the stakeholders can be alleviated (see Figure 1).

The outcome of the decision on the investment-criteria (use of resources) is deterministic: the investments incurred by selecting a protection level entail the use resources that have a, more or less, fixed net present value for the investment period considered, i.e. 45 years. Also the impacts on the built environment are deterministic – some impacts having a positive sign, e.g. providing opportunities for innovative land use.

The decision outcomes with respect to the protection-criteria are uncertain: the benefits of flood control will materialise only with the occurrence of the flood. Thus, all protection benefits are anticipatory at the moment of decision-making. It should be noted that in the decision-making simulation the damage levels per return time category (R50 and R250) were not discounted nor weighted by the different probabilities of occurrence of R50 and R250 events in the considered time span (2005-2050).

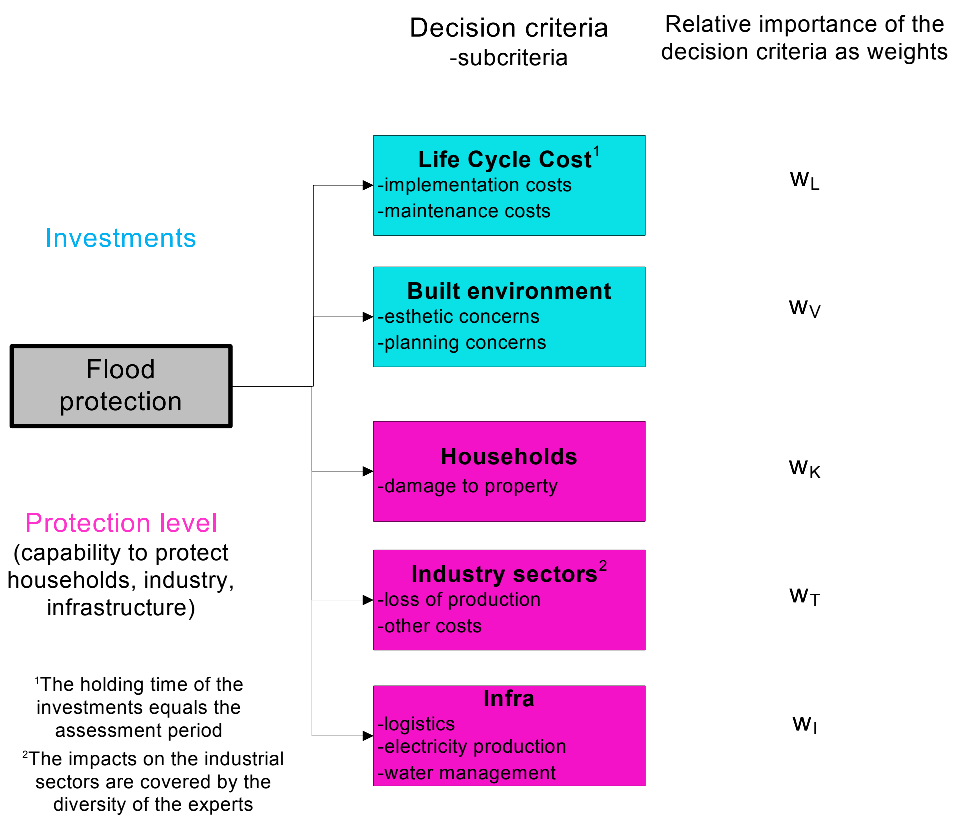

Figure 2. The value tree and weights denoting the relative importance of the decision criteria. The sub criteria in the boxes are the main dimension used in defining the respective scales.

Figure 3 shows the value tree defined for the expert session together with an indication of the analysis phases. The analysis phases were:

1. Review of the flood protection alternatives (decision alternatives)
2. Assessment of the value of the alternatives with regard to each decision criterion
3. Weighing of the criteria according to their relative importance

The value tree was input to the Web-Hipre tool (www.hipre.hut.fi).

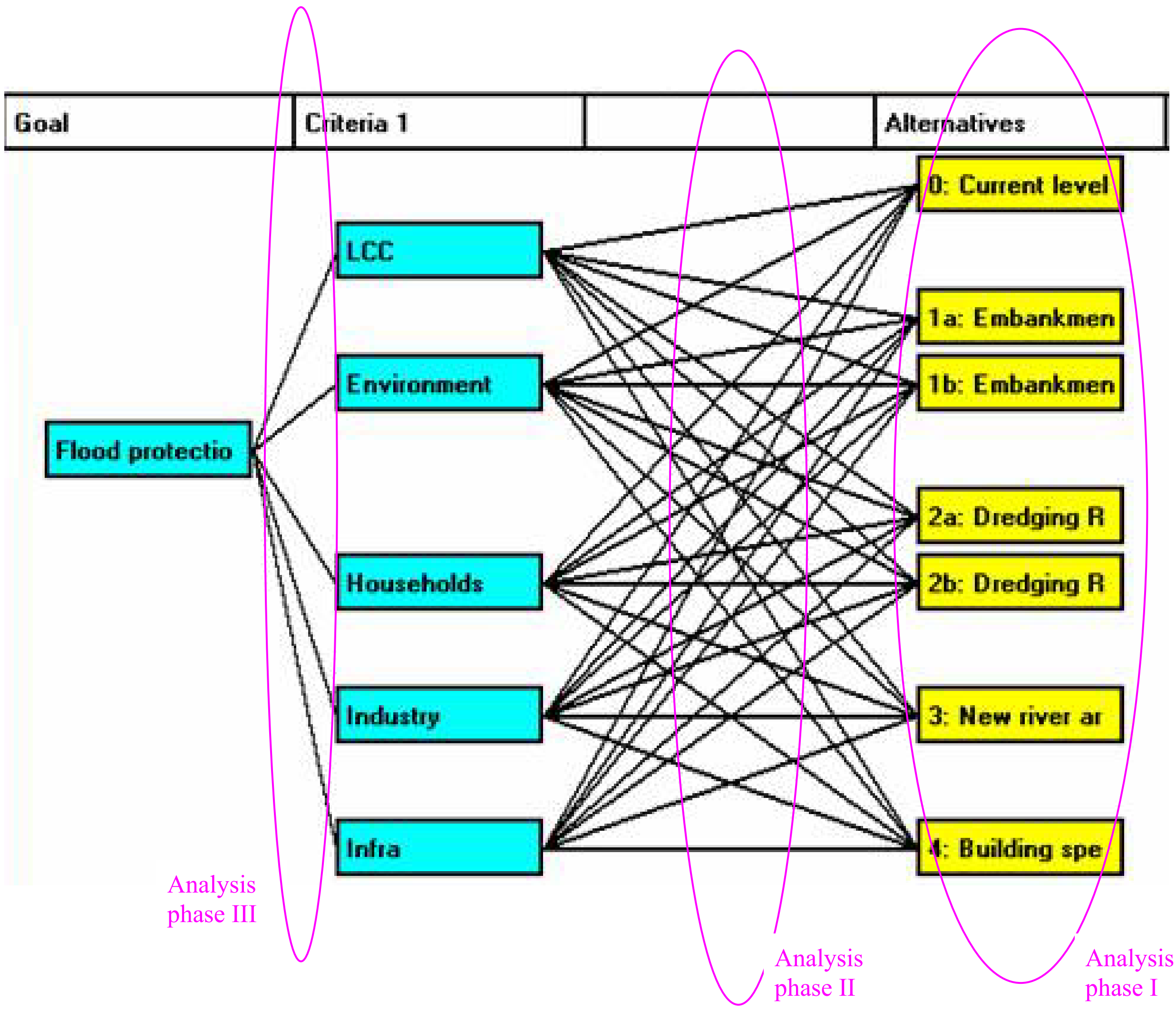

Figure 3. Decision model of the Tolerate Extra expert session with analysis phases indicated.

Analysis Phase I

The protection solutions where discussed based on pre-defined description that were fitted to the situation in Pori, and are reproduced below from section 3:

0. Current protection level (some repair of current low embankment)
1. (Mainly) Stronger embankments
    1.a. protection level up to R 50
    1.b. protection level up to R250
2. (Mainly) Dredging
    2.a. protection level up to R50
    2.b. protection level up to R 250
3. New river arm
4. Building or building block specific protection.

The predefined solution based on embankment (option 1) and dredging (option 2) where design to meet *specific protection levels*: protection against the R50 and R250 flood. The new channel (option 3) was defined such that it would be good enough for the R250 flood. The real estate protection (option 4) was defined such that its main protection aim was against R50 floods. These were compared to the 'zero-option' which reflected the current protection level (policy).

The experts felt quite happy with the pre-defined solutions which also could have been developed in a separate task in a two-day session.

Analysis Phase II

In this phase each protection alternative is scored against each decision criterion. The participants were asked to give scores from 1 to 10 where 10 is given for best performance, 1 for worst. The scores were then scaled to a 0-to-1 scale, which is the standard format in a MCDA process. The mean values between the participants were used to represent the group opinion. After the numerical assessments, the participants were asked to write down the rationale behind their assessments. Basically, scoring cannot be performed unless the experts reviews the performances of the alternatives jointly and decides their relative performance. In the study, the performance has been discretized into four pre-defined protection levels. These performance levels are 'Full protection against R50 and R250 floods', 'Full protection against R50 floods', 'Improved protection for selected buildings', and 'Current control level'.

Obviously, a flood control alternative that provides full protection of infrastructure against the considered flood scenarios will receive full scores for the particular criterion 'Infrastructure'. By the same token, an alternative that provides full protection for 'Households' and 'Industry sectors' against the flood scenarios, will receive maximum scores possible related to the protection-criteria (marked with red in Figure 2). An alternative that performs well on the protection-criteria usually performs poorly on the investment-criteria. Trade-offing is unavoidable, and the basic decision problem is to find a flood protection alternative that provides the best overall performance over all the decision criteria.

According to decision analysis the best alternative receives the most aggregated scoring where aggregation is a weighted arithmetic average of the criterion-specific scores. The scoring is subjective, reflecting the experts' valuation of the alternative's performance on the performance scale associated with the criterion considered. The templates related to the scoring are shown below: first those related to the cost-criteria in Table 3, then those related with the protection-criteria in Table 4.

Table 3. Valuation of flood protection alternatives with respect to cost-criteria LCC and Built Environment (scores 1- 10; 1= 'worst', 10= 'best' for each criterion)

Protection alternative	**LCC [score]**	**Built Environment [score]**
0	**10**	?
1a	?	?
1b	?	?
2a	?	?
2b	?	?
3	**1**	?
4	?	?

The monetary consequences for LCC and the descriptive consequences for Built Environment, for each protection alternative, are presented in Table 2 and are not reproduced here. The worst and best performances on LCC are unambiguously identified from Table 2 and represented by alternatives 3 and 0, respectively. Interestingly, the extreme scores are not unambiguous for Built Environment; e.g. the significant changes related to the new river arm (alternative 3) may by some stakeholders be the source for new innovative opportunities for land use planning, and therefore be given high scoring, whereas for some stakeholders the changes may be viewed as notably harmful with low scoring for the alternative in question.

The consequences related to pre-defined levels of flood protection are described for the criteria ‘Household’, ‘Business sector’ and ‘Infrastructure’ in Table 4. Experts give scores for the flood protection levels related to each criterion. The protection alternatives are linked to the protection levels as shown in Table 5.

Table 4. Valuation of flood protection alternatives with respect to benefit-criteria Households, Business sectors and Infrastructure (scores 1- 10; 1= 'worst', 10= 'best' for each criterion)

Protection level	**Households**			**Business sectors**			**Infrastructure**		
	consequence R50	**consequence R250**	**score**	**consequence R50**	**consequence R250**	**score**	**consequence R50**	**consequence R250**	**score**
Full protection against R50 and R250 floods	no damage	no damage	**10**	no damage	no damage	**10**	no damage	no damage	**10**
Full protection against R50 floods	no damage	same as for current solution	?	no damage	same as for current solution	?	no damage	same as for current solution	?
Improved protection for selected physical assets including households	25-50% of threatened houses protected	10-25% of threatened houses protected	?	25-50% of threatened companies protected	10-25% of threatened companies protected	?	critical infra protected	some critical infra protected	?
Current protection level	900-2000 of houses damaged, cost average 10-60 k€ / house	1500-4000 of houses damaged, cost average 20-90 k€ / house	**1**	30-70 companies affected, cost average 50-150 k€ / house	50-200 companies affected, cost average 120-400 k€ / house	**1**	sewage disruptions, local logistic disruptions	sewage network failure, wide logistic disruptions, electricity and telecom disruptions	**1**

Table 5. Linkage between decision alternatives and flood protection levels

Protection level	Decision alternative
Full protection against R50 and R250 floods	1b,2b,3
Full protection against R50 floods	1a,2a
Improved protection for selected physical assets including households	4
Current protection level	0

Analysis Phase III

In this phase the relative importance of the five criteria is defined (see Figure 2) and the overall score of each alternative is computed. The participants were asked to assess the relative importance of the criteria by distributing 100 points according to their opinion. The question asked is: how many points would you distribute to the changes from worst to best on the criteria, the points reflecting the relative importance of the changes? Again, the participants were asked to give the rationale behind the scores directly after the assessments. The weights were then normalised to sum up to one and mean values of the weights were calculated to represent the group opinion. In fact, by specifying the weights w_L, w_V, w_K, w_T, w_I, the performances of alternatives on the different decision criteria are made commensurable: the weights (normalised weights w_i) adjust the criterion-specific scores of an alternative ($s_i(a)$) such that they can be summed up to a single value $V(a)$ score depicting the overall goodness or value of the alternative a as given by

$$V(a) = \sum_{i=1}^{5} w_i s_i(a) \quad w_i \in [0,1], \sum_{i=1}^{5} w_i = 1,\ s_i(a) \in [0,1] \forall a$$

The additive form for the value function entails that the decision-maker / expert shows mutual preferential independence: the preference of one alternative over another on any criterion does not depend on the levels of performances shown by the alternatives on any other criteria.

It is expected that the scorings, weightings, and therefore the values of the experts will vary a lot depending on the expert's inclination to be optimistic or pessimistic as to the occurrence of a flooding, and to the extent he/she is involved in the consequences of the flood. It should be kept in mind that the probabilities of experiencing a 1/50 or a 1/250 flooding are 0.16 and 0.58, respectively, during the planning horizon of 45 years.

4.3 Feedback from the expert session participants

At the end of the session an overall evaluation was requested. To this end several issues were suggested to consider, being:

- General feedback on the process
- Possible similar sessions in the future?
- Which stakeholders were missing, but should be present in the analysis process?
- Any wishes regarding the reporting of the session?
- Negative comments?
- Recommendations?
- Other comments?

To apply MCDA in a one day group decision session with a group previously unfamiliar with the methodology was a challenging task and this was also seen in the feedback. In general, the participants found the decision making process interesting, but a little bit difficult to understand. Some of the participants found the situation somewhat confusing and would have wished more information beforehand or a more elaborate example exercise at the beginning of the day. Some felt also that the purpose of the process was not well-defined. On the other hand, other participants noticed that the process itself was more important than the results. The computerized system, which enabled efficient collecting and processing of both numeric and verbal inputs, was considered both useful and fun. Many of the participants saw the benefits of structuring a decision context with MCDA and it was suggested that a similar approach could be used in different political decision.

The participants were also asked which stakeholders were missing, but should have been present in the decision making session. The participants felt that for example the experts from Finnish Meteorological Institute and Flood experts from Finnish Environmental Centre could have been present. Also the Army, rescue services, nature conservation organisations, land use planners and last but not least local and national politicians were mentioned. On the other hand, one participant felt that the method was suitable only for small groups.

The participants gave some interesting recommendations how to develop the method or where to use the method subsequently. For example, it was suggested that in future versions the participants would also be enabled to comment each others answers. Another suggestion was to engage in a flood risk assessment of the whole country. Another interesting suggestion was to arrange citizen panels in or across flood risk areas. One participant hinted at the possibilities of internet as a means to draw in more people and more diversity

The attendees agreed that one of the best advantages of the method was that it captured everyone's opinion in the group. This was very important especially for the members of the group without significant prior knowledge of flood protection matters nor experience in this kind of computer assisted group decision making processes. .

5. Interpretation of the results

5.1 Introduction

Prior to discussing possible interpretations of the results it is good to reiterate the limitations of the exercise. For a start it was announced as an experimentation / learning exercise. This may have influenced the attitudes of some participants. During the session also some participants indicated that they wondered in what role they were participating, as a citizen, a specialist or as the representative of an organisation or societal group[9]. The representation of choices and impacts was also simplified, notably non-monetary impacts were treated rather superficially. The number of participants was modest in comparison to actual public decision-making situations and the coverage of relevant interest groups was incomplete.

The following implicit factors affect the evaluations (ratings) which participants were asked to make:

- the willingness to pay for improvement of current levels of flood protection (status quo or an alternative)
- the extent to which the incremental willingness to pay is responding to incremental protection levels (i.e. prevented losses)
- the extent to which the preference for a flood protection alternative depends on effects on other (non-monetary) resource use and quality in the living environment (with the proviso that this dimension was represented superficially)
- the extent to which the preference for a flood protection alternative depends on the societal distribution of effects, i.e. what is damaged and who is affected, given a certain overall cost level.

In the next sections the results of the group ratings are presented. We reiterate that the explanations on why particular tendencies in ratings occurred are much more important than the ratings as such. In fact, even if an adequate level of information provision (ex ante and on the spot) would have been achieved, conclusions about priority rankings and trade-offs of stakeholders can still be flawed. For example, the sequence in which choices are provided, as well as the extent to which they are partitioned can affect results significantly. This notion is referred to as 'choice bracketing' (e.g. Camerer and Loewenstein, 2004, page 18).

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[9] The participants were invited via their workplace e-mail addresses. The invitation and the participant list were also alluding to their professional background.

5.2 Ratings of resource use and protection performance

In the first step participants rated the flood protection alternatives with respect to the life cycle costs and other effects of their realisation. In the next step participants rated the flood protection alternatives with respect to their performance to reduce damage for the sectors households, business, and infrastructure respectively. Finally, the participants were providing weights (shares) for the five criteria used (with a total of 1). After this step an overall assessment was made of the group rating of the alternatives and the implications for trade-offs between the criteria. Participants could comment to the results of this last step, but not alter it as it was implied by the inputs in the previous steps in the process.

Even though most participants considered life cycle costs levels separate from the notion ‘value for money’ (that would be handled later), some apparently mixed in other considerations. Possibly also the idea that very cheap options are suspicious may have played a role. Tables 5 and 6 only provide the group scores, while the distribution of individual ratings shows is shown in Appendix 4. By and large the participants show a fairly consistent pattern in the judgement of this criterion, meaning that the higher the life cycle cost are, the lower the ratings tend to be. Yet, the sensitivity of the rating for cost rises varies over the participants. With respect to judging life cycle cost for dredging and dikes there is remarkable difference in step size between the current protection level and the R50 level (7.2 – 6.5) and between the R50 and R250 levels (6.5 – 3.7 (or 3.1)). One should not attach particular value to the numerical value of these differentials, but the observation does illustrate that non-linearity in the scaling of effects may occur.

The ratings for life cycle cost have lower standard deviations for all alternatives compared to those for living environment. This is consistent with the observation that the criterion living environment was less clearly described and covers more dimensions than life cycle cost. The spread in judgement of effects on the living environment relates to the supposedly varying weights that are attached to the various dimensions of the criterion living environment (amenity value of homes and residential area, landscape, river ecology). On the background looms also the general tendency to appreciate the status quo over changes that are not so easy to judge. This is probably the reason that the option ‘building specific measures’ gets the second best rating for living environment after the zero option of the current flood protection level.

*Table 5. Group level results for step 1 – rating*of life cycle costs and effects on the living environment (non-monetary resources) of flood protection alternatives*

		Criteria (and weights)**				
	Ballot Items	**Life cycle cost (0.231)**	**Living environment (0.126)**	**weighted total**	**total**	**average score**
1.	**0**. Current flood protection level	7.2	7.2	**2.6**	14.4	7.2
2.	**1A.** Dike reinforcement for R50	6.5	4.6	**2.1**	11.1	5.5
3.	**1B.** Dike reinforcement for R250	3.1	3.5	**1.2**	6.6	3.3
4.	**2A.** Dredging for R50	6.5	5.2	**2.2**	11.7	5.8
5.	**2B** Dredging for R250	3.7	3.8	**1.3**	7.5	3.7
6.	**3.** New river arm	1.6	3.6	**0.8**	5.2	2.6
7.	**4.** Building specific measures	4.0	6.0	**1.7**	10.0	5.0

*) Individual participants could give ratings from 1 (lowest/worst) to 10 (highest/best).
**) The weights of criteria were set later in step 3.

In table 6 those options are grouped together that have the same protection level, which implies they are expected to incur the same (remaining) damage per sector per flood category. When considering the step sizes between the four protection levels[10] the largest difference is between current flood protection level and any kind of improvement. Since also the absolute rating of the current flood protection level is very low, the results hint at a broadly supported view that some kind of improvement is desirable. It is worth noting that even though the weights of the different criteria vary considerably, the discriminating effect of these different sector criteria happens to be marginal in this case since the rating of the remaining damage levels is very similar for the three sectors. The ratings per sector indicate *within that sector* how different damage levels are positioned in comparison to each other. The weights of a sector indicate how damage in the considered sector is positioned in comparison to damage in other sectors.

The rating for the option 'building specific measures' with respect to infrastructure (being better than for households) is peculiar, since this option would do little to protect public infrastructure. To this may be added that no specific damage

[10] Building specific measures represent an unsure mixture, varying from R50 for some buildings down to practically current protection level for other buildings.

figures were produced with respect to infrastructure[11], but during the session various specialists presented their views on possible interruptions. In the light of the preceding remarks, it may be wondered whether the weight attached to infrastructure is possibly on the high side.

Table 6. Group level results for step 2 – rating of damage reduction performance of flood protection alternatives for three sectors*

		Criteria (and weights):					
#	**Ballot Items**	**households (0.222)**	**business sectors (0.145)**	**Infra (0.277)**	**Weighted Total**	**Total**	**Avg. Score**
1.	Solutions that ensure protection both at R50 and R250 level (options no. 1B, 2B, 3)	9.8	9.9	9.8	**6.3**	29.5	9.8
2.	Solutions that ensure protection at R50 but *not* at R250 level (options no. 1A, 2A)	7.0	6.8	6.8	**4.4**	20.6	6.9
3.	Protection reduction by building specific measures (option no. 4)	4.3	5.6	5.2	**3.2**	15.1	5.0
4.	Current protection level (0)	1.1	1.1	1.1	**0.7**	3.3	1.1

*) Individual participants could give ratings from 1 (lowest/worst) to 10 (highest/best).

According to the ratings of resource use and protection performance it seems that the most important criteria are the costs of the flood protection measures and the capability to prevent flood damages to households and public infrastructure. Both the R50 and the R250 protection levels were regarded worthwhile, and were generally regarded to be preferred over the current level of protection. Quite some participants were of the opinion that building specific measures might constitute an interesting complementary option, but this would first need more clarification.

Almost all experts were convinced that adequate protection of public infrastructure is important. However, some of them saw that there might be reasons to pay particularly attention to specific vulnerable parts of public infrastructure, such as the transformers in the electric power distribution system in flood prone areas.

[11] Experiences with flooding in Finland suggest that in the case of Pori damage cost of infrastructure are probably clearly lower than for households and business. Most important are probably interruptions in access, which could even last several weeks.

Landscape effects concern two aspects. First the more general idea of the quality of the urban landscape, i.e. the amenity value in which the river plays an important role, and second the effect of landscape effects on real estate values in residential areas with currently good river views. The experts showed rather large variations in the rating of effects on these aspects. A third aspect, river ecology, was also considered to be part of the relevant issues in the criterion living environment. Yet, this aspect seemed to be regarded of less importance than the other ones.

5.3 The overall performance and sensitivity analysis

In the overall assessment the eventual group average weights of the decision criteria at group level were as follows (total adding up to 1):

- life cycle cost (resource use): 0,231
- living environment (resource use and quality): 0,126
- households (protection): 0,222
- business sector (protection): 0,145
- infrastructure (protection): 0,277

As stated before the weight for infrastructure can be regarded as possibly on the high side, whereas the weight for business sectors seems to be on the low side, e.g. think of possible consequences for employment. A fairly widely shared opinion among the experts was that companies have better possibilities to prevent flood damages than households.

The group judgement of the performance scores per flood protection alternative can be obtained by applying the product sum of the above weights and the respective scores per criterion per protection alternative (see section 4.2). Figure 4 shows the summary scores per flood protection alternative.

The majority of the experts believes that the classical flood protection measures, like dikes and dredging, are the best alternatives (figure 4). According to the results those flood protection measures which can prevent R250 flood damages are slightly preferred over protection measures which can prevent only the damages of R50 floods. This preference results despite the fact that the measures necessary to arrive at the R250 protection level are clearly more expensive. However, when taking account the inaccuracy and imprecision of parts of the analyses both flood protection levels deserve further attention. For both protection levels dredging and dikes are the prominent alternatives, even though also the construction of a new river arm was considered as a good alternative, provided it also succeeds to prevent R250 flood damages[12].

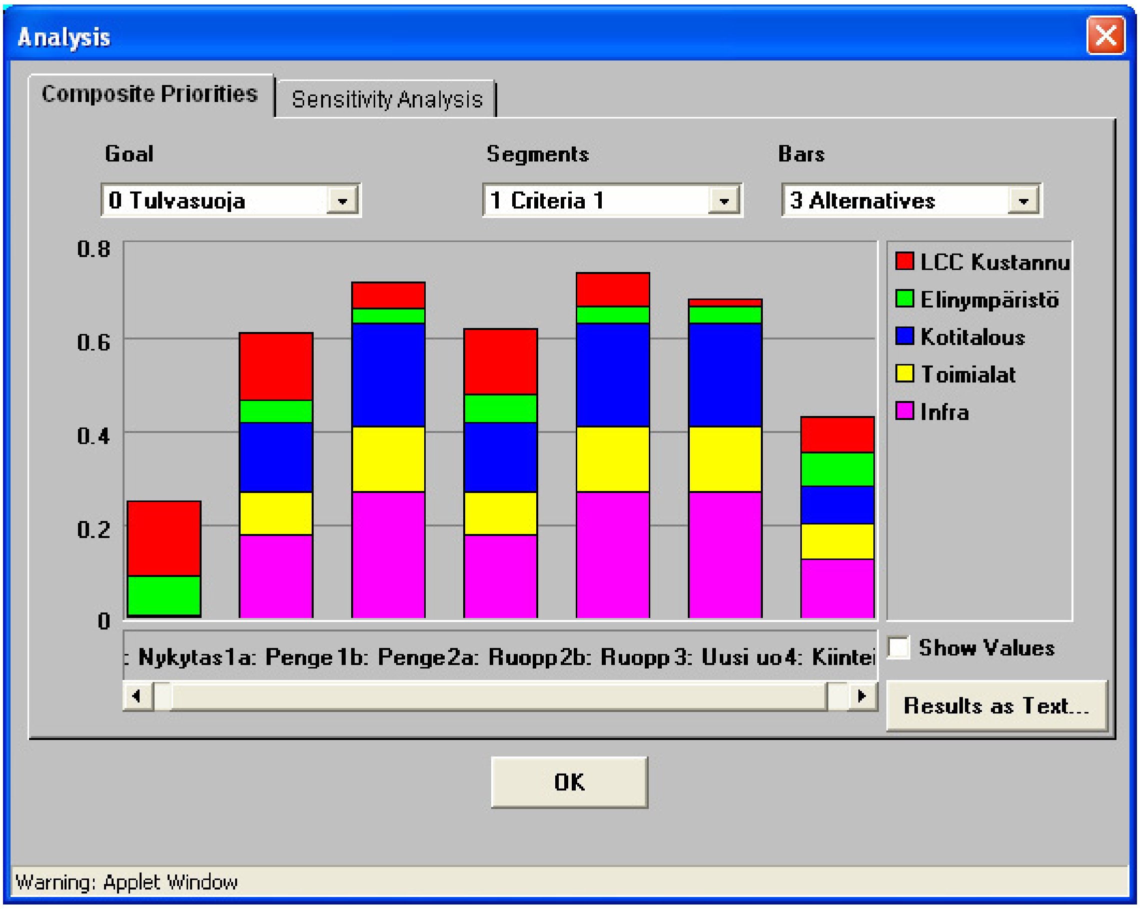

Figure 4. Normalised total group scores per flood protection alternative

By manipulating the weights per sub-criterion a sensitivity analysis can be performed. This is shown in figures 5, 6 and 7 with respect to the effects of varying the weights of lifecycle cost, living environment and, sectors respectively.

Effect of variation in the weight of life cycle cost

The zero-option may get relevant only, if people would attach an extremely high value to (own) money in the nearby future (LCC weight > 0.8). This fits well with the notion that willingness to pay for risk reduction improves when wealth levels are rising (Morone and Ozdemir, 2006). Even though we are uncertain about the representative value of the weights, it's unlikely that LCC would get more than 80% of the weight sum.

[12] Unlike the options dike reinforcement and dredging the new river arm not necessarily has only negative landscape and ecological effects. It creates all kinds of new potential.

On the other hand the resulting weight of costs in this study (0,231) is possibly low. One argument for this is that we have not been considering a portfolio of all kinds of useful public expenditures (schooling, medical care, etc.) with which this project has to compete over public budget money. In the discussion round between the subsequent decision steps this balancing of the overall public budget was mentioned however.

On the other hand we neither formally involved preferences about cost sharing between levels of government, etc.

Assuming that relevant weight scores would be between 0.2[13] and 0.7, there are 3 patches:

1. between weight 0.20 – 0.45: options 2b (and given other uncertainties) 1b are superior;
2. between weight 0.45 – 0.80: options 2a and (and given other uncertainties) 1a are superior
3. for a weight >0.80: option 0 would be preferred, but this seems to be an irrelevant range.

Assuming that other, not yet handled, dimensions (such as impact on city planning) would not greatly upset the results, the societal discussion would circle around dikes and dredging. If (current) money counts appreciably the 'A'-variant (R50 protection level) would be preferred, otherwise the 'B' variant (R250 protection level). The choice between dredging and dikes is than probably decided by other factors, or new cost estimates make the differences larger. It should be kept in mind however that the new river arm could nevertheless become a relevant option, e.g. when embedded in a wider context of city planning. Similarly, building specific measures might still be relevant, e.g. in combination with R50 dredging or dikes,

[13] A weight of 0.2 would mean that 80% of the weight (importance) is attributed to other criteria than cost. Vice versa, a weight of 0.8 would mean that the other criteria together would count for only 20%.

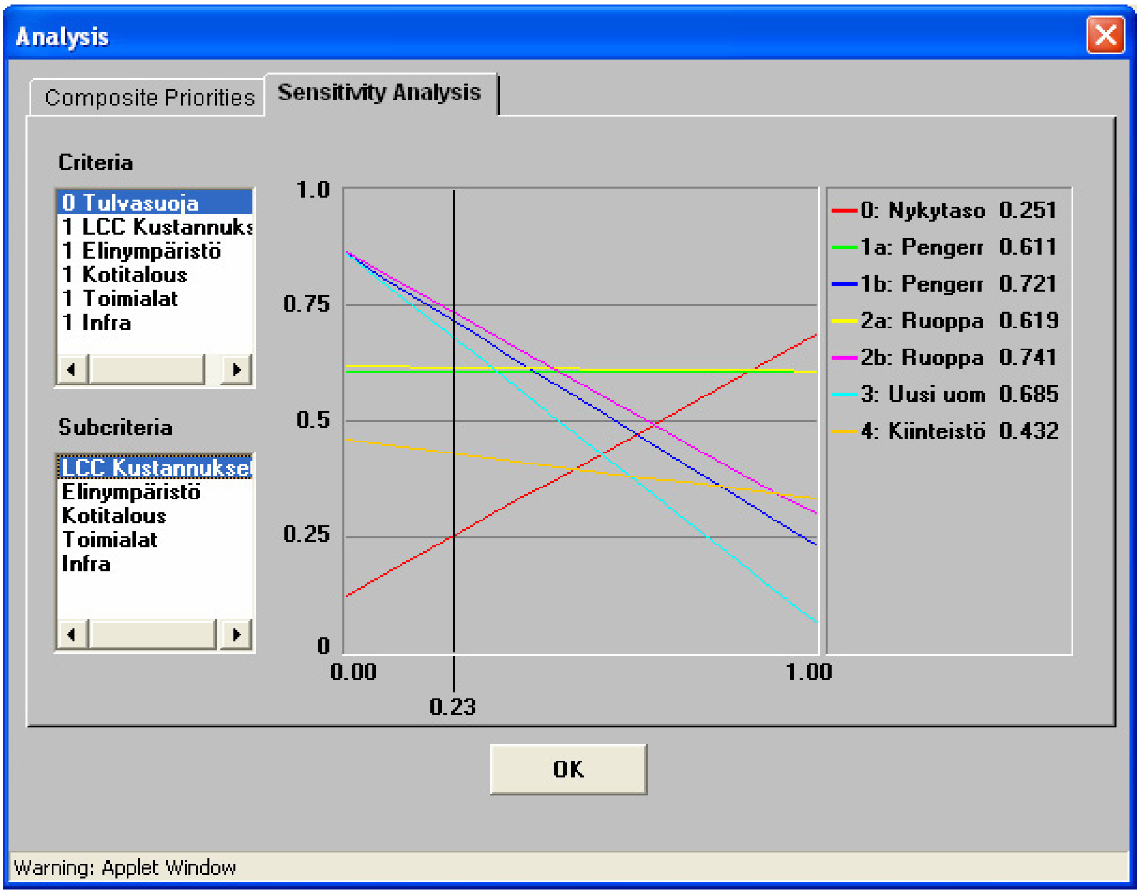

Figure 5. Implications of varying the weight of lifecycle cost for the scores of the and rankings of the flood protection solutions

Effect of variation in the weight of living environment

For the other 'resource' dimension, that is the living environment, the information was rather vague and incomplete; it also is much less clear what it exactly means when more weight is attached to this aspect. It could refer to the urge to maximise property value of residential areas but it could just as well to the wish not to disturb the fluvial ecology.

The result is anyhow a less stable (less smooth) profile, in which best options easily flip from rigorous solutions (R250 protection level) to doing nothing (zero-alternative). That looks less credible, but might also hint at possible sources of societal conflicts or risks for deadlocks on finding widely shared solutions.

At a more generic level the results still link to some notions in social-psychology. We do know that both conservatism and conservationism have some degree of elevated tendency to abstaining from intervention. On the other hand, under the proviso that they are sufficiently informed, a majority of the people has a tendency to avoid options that entail small probabilities for high impact events, even if the net present value of the damage is smaller than the net present value of the life cycle cost. This relates to loss aversion and endowment effects (Kahneman et al, 1990). However, when it comes to insuring against low probability high risk events, people will often tend to underinsure themselves, unless they are very well informed. Expected utility theory doesn't seem to be relevant in such decision situations. Instead e.g. Prospect theory provides better explanatory power. (e.g. Camerer, 2004).

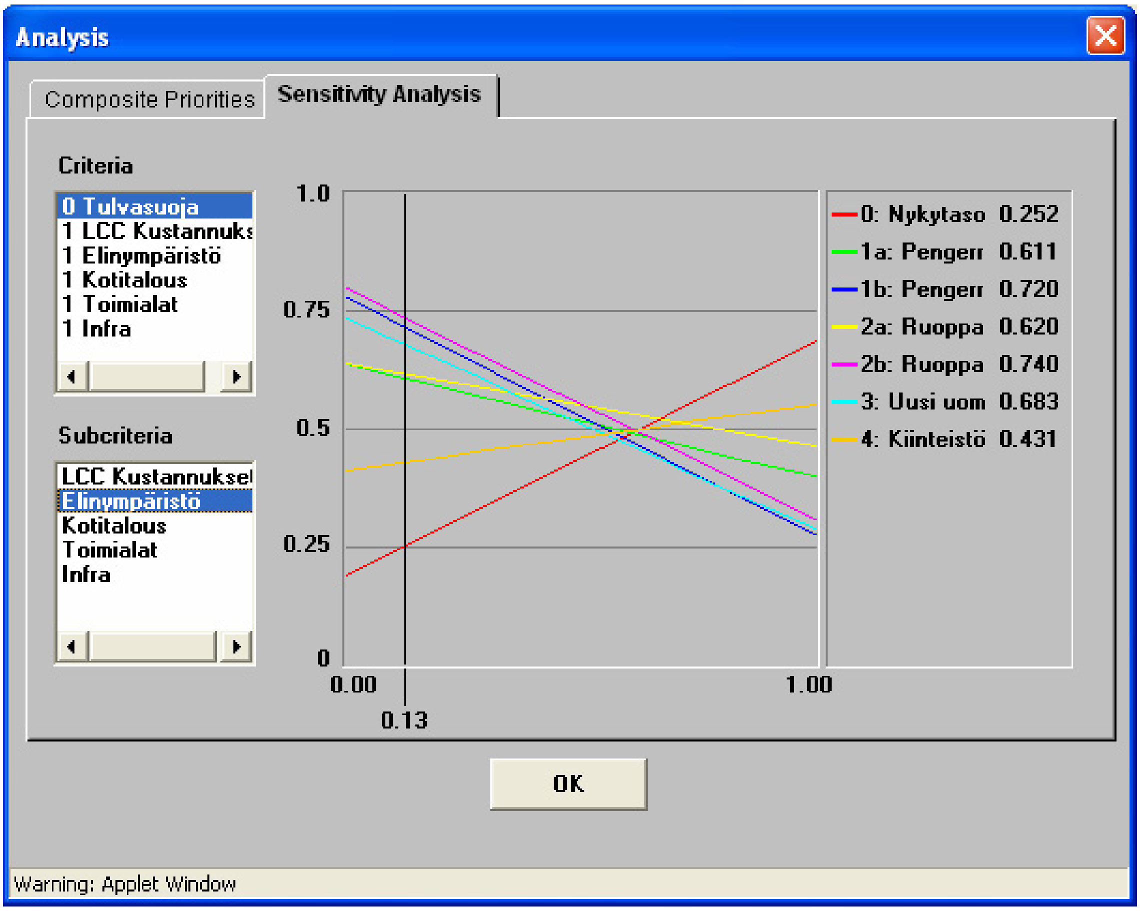

Figure 6. Implications of varying the weight of living environment for the scores of the and rankings of the flood protection solutions

Effect of variation in the weights of sector impacts

At the impact side the message is simple, better protection scores all the time better. Yet, the options 2A and 2B are so near to each other that probably other aspects are decisive on whether it will be dredging or dikes.

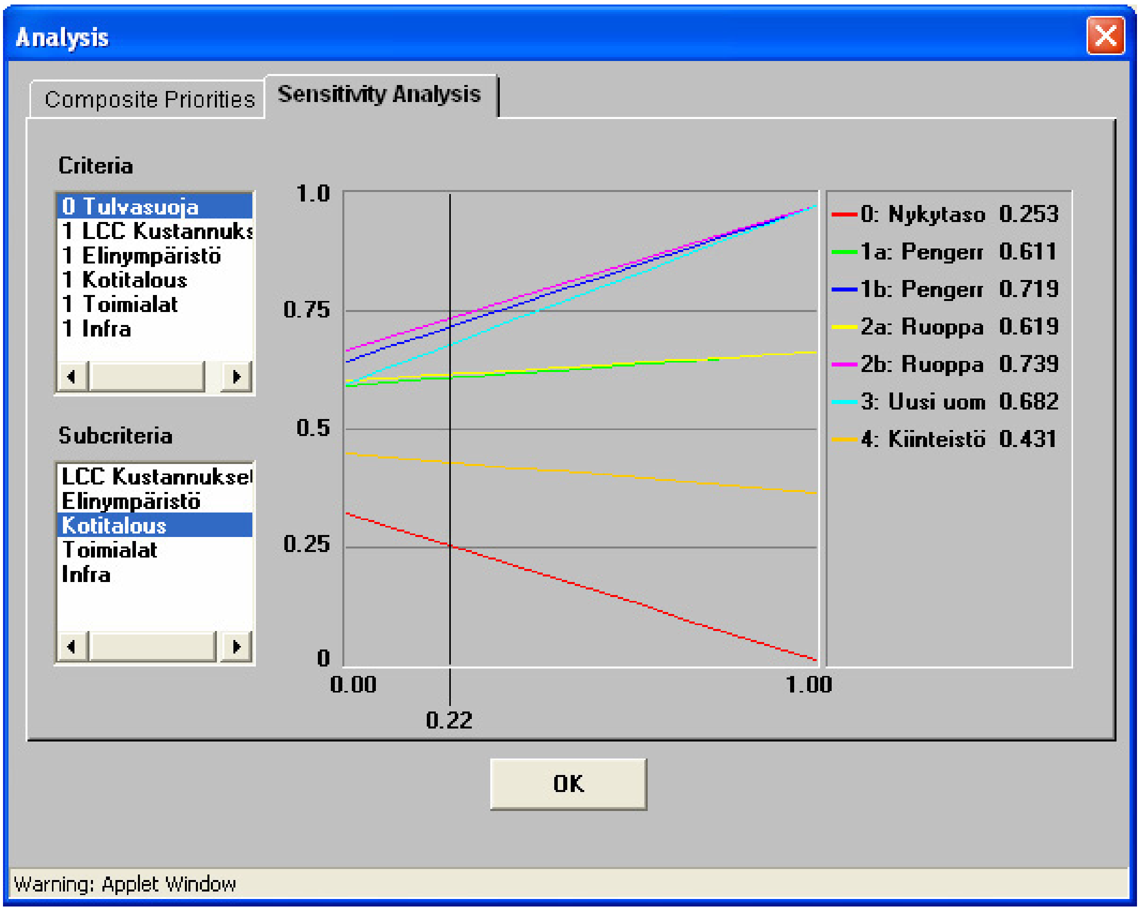

Figure 7. Implications of varying the weight of the sector households for the scores of the and rankings of the flood protection solution (for business and infrastructure the figures look very similar)

Unless it would be possible to indicate that the zero-option produces more wealth overall on average (but in that case the saved money must be extremely productive), it seems fairly robust that an improvement of the protection level is called for. Furthermore, unless costs reduce and/or effectiveness and applicability increase considerably, building specific solutions never get competitive ratings when considered as a separate principal protection option.

Given the incompleteness of info and the uncertainties of scores, it seems that the options 2A, 2B, 1A and 1B and perhaps 3 have the most societal relevance. This leaves open whether in building codes or as voluntary actions some forms of building specific actions could still be useful.

5.4 Aspects that were not included in the decision-making simulation

Apart from limitations regarding the procedures during the decision-making simulation session (see §5.1) there were also limitations regarding the effects considered. In this respect it is important between formal information that was presented by the session co-ordinators prior to each decision making step and the informal (in practice oral) information that was provided by the participants during the session. The statements of the participants consisted of facts, observations, views, and invited feedback (opinions) regarding the characteristics of the session.

The below mentioned aspects were not included in the formal information presentations (i.e. no effects specified). In many cases it was however mentioned during these presentations that these aspects are most probably of relevance in a complete evaluation. Admittedly, some of the aspects are in fact rather complex and may end up being treated superficially even in a full evaluation.

1. Aspects pertaining to the comprehensiveness of public budget evaluation

The exercise dealt with cost of flood protection measures, the cost of floods, and the cost reduction effects of flood protection measures. There are however also other public goods, such as education, health care, and transport infrastructure, that need just as well budgets for maintenance and operations. It is virtually impossible to try evaluate all these alternative purposes jointly, but it is not uncommon to check from a public finance point of view at least the overall situation of the public budget and the remaining manoeuvring space for new or extra efforts. Furthermore, given a certain manoeuvring space in the public budget it is helpful to produce a list of more or less urgent issues that probably merit (temporary) extra public expenditures.

In this decision-making simulation the reflection on the wider public budget context was left out. This may have affected the weighing of the criteria, in particular that of ‘life cycle cost’ (obviously, if one weight changes, at least one other needs to change as well).

To complicate matters even more, in this case public budget can refer to both the municipal budget and the state level budget. In final stages of the session there was some discussion on what could be a reasonable division of the costs of the improvement of flood protection between local and national authorities. There was a broad consensus that some kind of cost sharing was reasonable (i.e. not only from the local budget), but no concrete proposal or assumed value for the cost sharing was used applied during the session. Roughly spoken three levels of increasing vested interest with respect to benefiting from reduced risk of floods can be distinguished:

1. those living and having significant possessions in the flood prone area
2. those living in the same region to which the flood prone area belongs
3. the rest of the country (in which the effects of the flood are only marginal).

In most if not all flood risk cases in Finland, and also in the case of Pori, the first two groups consist of relatively small fractions of the country's total population (see also table 1). For example, if we take the Pori region (approx. 100.000 inhabitants of whom approx. 75.000 in Pori) it would constitute about 2% of the national population. In the Pori case a 50/50 sharing of the flood protection cost between local and national authorities would mean that *per capita* the citizens of the Pori region pay about 50 times more than citizens elsewhere. Obviously the local citizens also benefit much more from an improvement of the flood protection level than citizens elsewhere.

Last but not least the consideration of the larger public budget context also relates to the desirable composition of the group which participates in a decision-making process concerning large public investments.

2. Aspects pertaining to the risk governance structure

Flood control, including water management and protection measures, is by its very nature a public policy issue. Notwithstanding this point of departure it makes a lot of difference for the interest groups involved how damage can be offset and how accountability is organised. Finland is about to adopt a new compensation system based on insurances provided by the private sector (though initially within heavy regulated boundaries). Yet, up to now the compensation of damage of flooding (due to inland water systems or coastal) was based on a state scheme, which – in principle – covers 85% of the declared cost per claimant. This significantly reduces the remaining financial risk for the building owner.

Municipalities have the right to designate certain areas unfit for building or put limitations on the use (e.g. not for permanent residence). However, in many municipalities flood risk areas were not under any restrictions. Furthermore, on an individual basis exception permits can be granted. To this may be added that the construction of flood risk maps (and their public access), which are useful tools for building investors, is a very new phenomenon. This historic practice in conjunction with the abovementioned compensation scheme reduced both the motivation and the possibilities for building owners and building investors to choose a risk level that suits them.

The presented evaluation was focusing on physical flood protection measures only. As stated in the introduction flood protection is part of a more comprehensive policy area of flood control. It might be worthwhile to consider also this wider policy area. This would also mean that a much larger region (basically the entire Kokemäki river basin) needs to be involved and hence a larger collection of interest groups. It would also tie in closely with water regulation protocol for the Kokemäki river basin.

In the new regime (public flood maps and insurance system) some investors may reconsider location choices and/or may see benefits in building specific flood protection measures[14].

3. Aspects pertaining to the quality and functionality of the urban environment

In previous sections was already mentioned that the criterion living environment contained several aspects that were lumped together. Since the considered flood protection measures had varying effects on the constituent aspects of the criterion the interpretation of the (group) rating of this criterion has gotten problematic, as stated in §5.2 and §5.3.

However, in the background loom still other aspects that were not considered either (though mentioned in passing during the discussions). These other aspects can be referred to urban quality and urban functionality aspects. For example, the spatial development of a city or built up area may take a new course, if the choice for the zero-alternative would come along with a guideline to avoid additional overbuilding constructions in flood prone areas. Assuming that the flood prone area was the – in all other respects – preferred choice, it means that in other respects the functionality (including the amenity) of the city risks to be negatively affected if it is decided to refrain from new building projects in the flood prone area[15].

4. Extreme situations

The presented figures are based on R50 and R250 floods, without further complications. There are however two special cases that can turn these floods into much more serious catastrophes. The first is the onset of a heavy frost period directly after the flood occurred. Due to climate change the likelihood that the simulated floods occur in January or February is increasing substantially. As a consequence it is possible that a frost period starts soon after the flood (i.e. before most of the water has left the flooded area). The impacts would be very substantial, since the damage to buildings and constructions, in this case also public infrastructure, can increase enormously, whereas the duration of the flood situations and even more so of the recovery gets substantially prolonged. The resulting cost levels may easily triple compared to the levels reported in table 1.

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[14] . A part of the flood prone building stock in Pori is expected to experience only low water levels inside the building (i.e. <30cm). Considering local variations in elevation a nearby alternative location and/or building specific measures may save some of the buildings from flooding.

[15] . Indeed, this is not entirely sure, because there can have been lock-in processes at play.

A second type of complication would be a situation in which the river water gets polluted (e.g. due to some smaller upstream floods) just before the flood in Pori actually starts. Depending on the kind of pollutant the time for cleaning will be prolonged substantially, while also the cost of cleaning will rise. In case of hazardous pollutants residents may have to wait long before they can return to their homes or in the worst case areas may be declared unfit for residential purposes.

5. Comprehensive economic assessments of induced effects and discounting

The presented cost figures are based on the flooding of the building stock as registered in 2007. However, the considered floods can occur one or more times in the study period 2005–2050. On the one hand this implies that economic growth will add to the total damage bill (more value per m^2 and/or more surface flooded). However, in the long run there are also possibilities to reduce damage by rearranging parts of the flood prone building stock (new location; new technical features). Last but not least (distant) future damage is to be compared with present or near future investment costs[16], this would in fact require discounting of future damage. The entire calculation, or rather its results, is less easy to communicate, whereas the choice of the interest rate in case of truly long periods (i.e. over 25~30 years) is subject to debate. We therefore refrained from introducing these figures in the presentation.

Apart from the above mentioned complications with respect to future damage valuation there is also the issue that the attributed nominal damage should *by no means* be equated with (a chunk) of the regional – or for that matter national – GDP. The cost estimates as summarised in table 1 can be compared to the collection of all bills to be paid when all the repair work is carried out, against current market prices. However, not all repair work is carried out against current market prices. People will carry out some things themselves. On the other hand, in the case of a repair boom prices (incl. construction worker's wages) are likely to go up. Furthermore, a part of the repairs may be postponed to next year or later. Even more important is to realise that a significant part of the repair cost will be covered by insurances (thereby spreading the burden over the country and beyond), whereas for the remaining funding past savings and loans will be used. Probably only a small part will come from income sources. The implication is that from a macro-economic point of view the *realignment* of expenditures may be more important than lost income or extra cost. However, the latter aspects may get more important the longer the extreme situation lasts. If a significant part of production capacity remains idle or unrepaired for a couple of months (or more), it gets less likely that the economy can catch up quickly, whereas risks for permanent loss of jobs start to increase. The macro-economic evaluation of different scales of initial physical damage due to flood was not presented during the

[16] In the cost presentations life cycle cost were used, since maintenance was included as well. A substantial part of the cost concerns however upfront cost (investments).

session. In passing the difference between direct and indirect cost and possible recovery pathways were mentioned.

The considerations about the eventual macro-economic effects tie in with a broader consideration of the resilience of a region with respect to catastrophes. Next to ex ante measures, such as flood protection, also ex-post measures like rescue and recovery programmes are important to keep risks for escalation at a minimum. These issues were to some extent touched upon during the discussions, but were not explicitly handled in the formal presentations.

6. Conclusions and lessons learned

As was expected the decision-making simulation exercise did not provide strong guidelines regarding preferred options. Nevertheless the results indicate that in a real world exercise there would most probably be broad support for a significant improvement of the protection level. However, the extent of the improvement and the preferred type of solution would need a more elaborate assessment in which the participants would be involved in an earlier stage and would be better informed (over time). Among others participants should have a say in the definition of evaluation criteria and the identification of solution alternatives to be included in the comparison.

The exercise also indicated that there are some risks for societal dispute about preferable solutions. In first instance it seems that costs are not necessarily problematic, but the impacts of different solutions on the living environment can be a source of misunderstanding and dispute. Consequently these impacts should be assessed thoroughly for all alternative solutions. Another risk related to the interpretation of the effects on the living environment is that of choosing the zero-alternative as a kind of deadlock compromise.

Even though participants had rather varying opinions on how such a decision-making exercise should be carried out, a majority was of the opinion that this is a useful and all in all a quite effective (compact) way to engage a larger collection of interest groups in the evaluation and decision making regarding significant public projects

In the preparatory phase of the TOLERATE study was hypothesized that in principle the assessment of the risks of floods, including the reinforcement effects of climate change as well as possible flood protection measures, could be understood as an optimal control problem. Already in that phase it was indicated that most probably such an optimal control approach would not be feasible in a strict sense, but rather works as a metaphor and helps to systemise the comparison of alternative strategies. The decision making simulation exercise discussed here exemplifies this point. Not only is there uncertainty regarding a part of the information, but there is also uncertainty about the way different interest groups conjecture the overall problem. A part of the latter uncertainty can be somewhat relieved by providing better and more accessible information. However, partly the uncertainty may be fundamental, because the stakeholders are facing limitations in their capacity to evaluate all information. Furthermore, the choices ahead may involve trade-offs that are very hard to monetise if at all, whereas the stakeholders may even change opinion several times. Obviously, this is does not mean that a cost-benefit assessment loses its significance, as stakeholders still want to know what are the economic consequences of stressing as such non-monetised features.

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Appendix 1 – Information provided prior to the session

Tulvaskenaarioiden keskeiset ominaisuudet

i. Tarkistettiin TOLERATE-hankkeessa Kokemäenjoen virtaaman toistavuusasteet R = 50 vuotta ja R = 250 vuotta nykyisessä ja tulevassa ilmastossa. Ne voivat aiheuttaa tulvat Porin kohdalla. Miten korkeampi toistavuusaste, sitä laajempi tulva-alue on.

ii. Tulva toteutuu jos penger (tai penkereet) sortuu. Tästä syystä jokaisella toistavuusasteella sekä laajempi että pienempi tulva-alue on mahdollinen.
Seuraavat laajuudet erotellaan: eteläpenkereet sortuvat
ja/tai
pohjoispenkereet sortuvat; pohjoisella vielä kolme laajuusvaihtoehtoa

iii. Per tulvatapaus kustannukset vaihtelevat rajusti.

50v. toistavuusasteen tasolla: 45–90 miljoona per tapaus

250v. toistavuus tasolla: 130–250 miljoona per tapaus (ja yli 300 miljoona on mahdollista)

Näissä luvuissa ei ole otettu huomioon erikoisvaikutuksia, kuten saastunut jokivesi joka tulva rakennuksiin. Kokonaistaloudelliset vaikutukset aluetasolla eivät ole myöskään mukana näissä luvuissa.

iv. Ilmastonmuutos nostanee mainitut kustannukset vielä 10~15 prosentilla.

Lisäksi talouskasvu vaikuttaa kustannuksiin. Esim. rakennuskannan arvo per m^2 kasvaa ajan myöten ja myös kokonaispinta-ala tulvariskialueessa saata kasvaa.

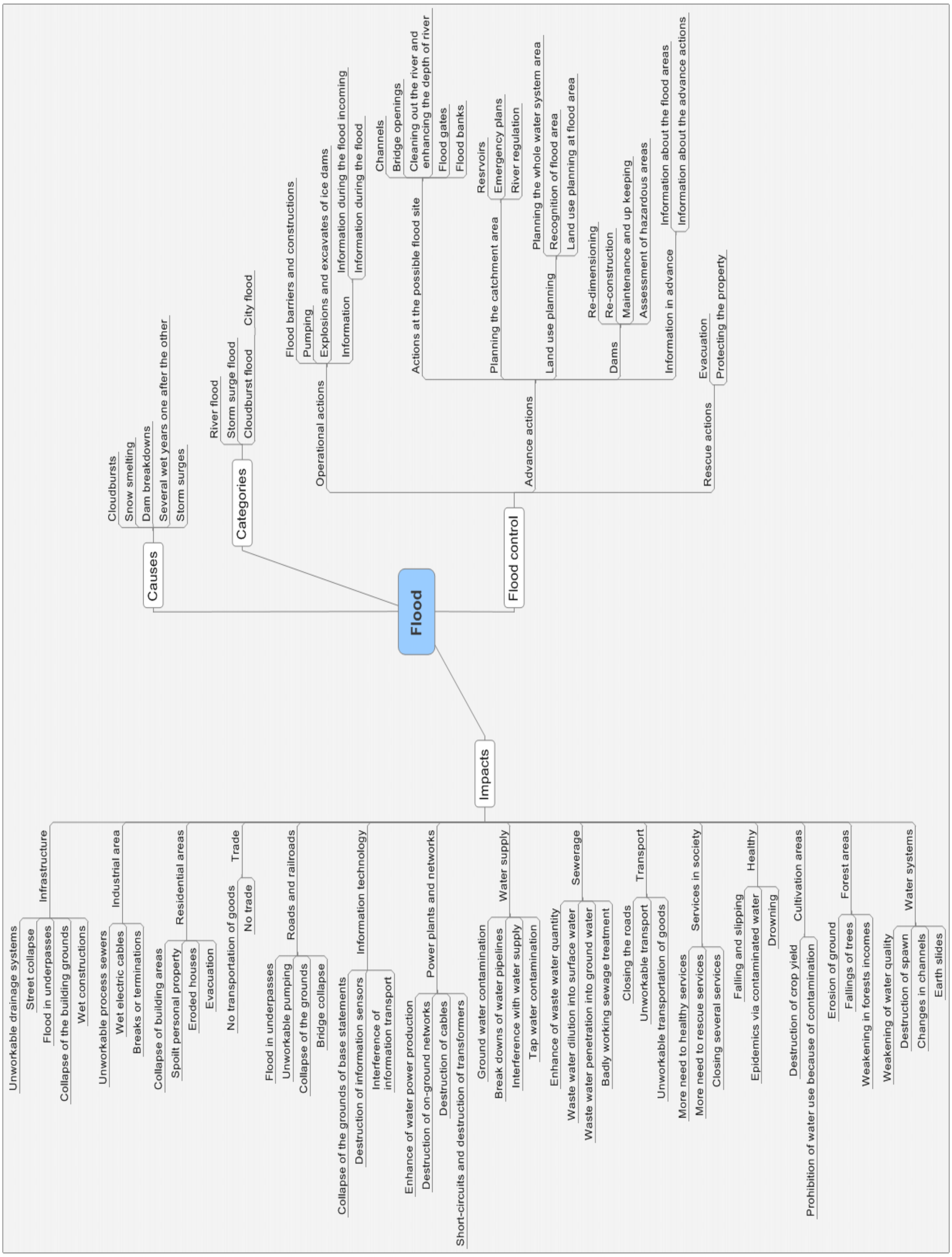
Toisaalta talouskasvu ja siihen liittyvät investoinnit antavat liikkumavaraa vastatoimenpiteiden luomiseksi.

Käsiteltävät tulvasuojaratkaisut

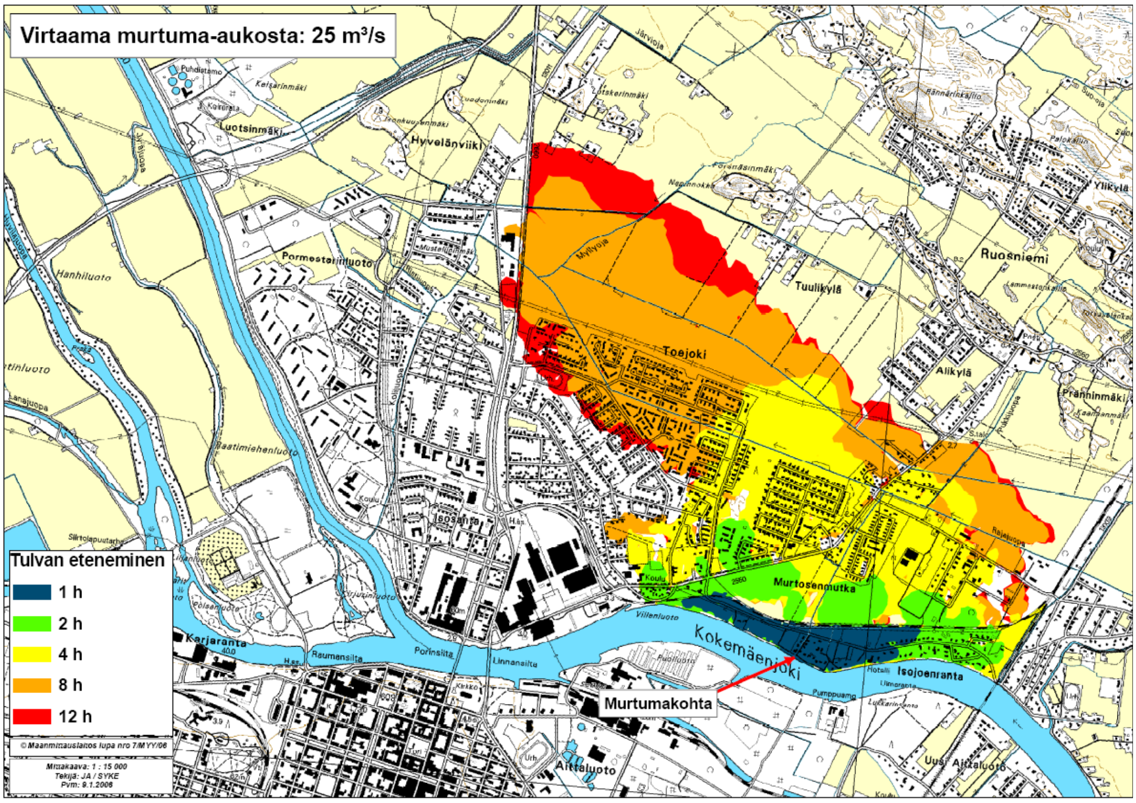
1. 0-vaihtoehto: toteutetaan vain perushuolto ja kunnossapito; runsaat tulvavahingot sekä 1/50v. että 1/250v. esiintyvässä tulvassa
2. Pengerrys
   a. Pengerrys – A: riittää estämään 1/50 v. esiintyvän tulvan vahingot
   b. Pengerrys – B: estää myös 1/250 v. esiintyvän tulvan vahingot
3. Ruoppaukset
   a. Ruoppaus – A: riittää estämään 1/50 v. esiintyvän tulvan vahingot

   b. Ruoppaus – B: estää myös 1/250 v. esiintyvän tulvan vahingot

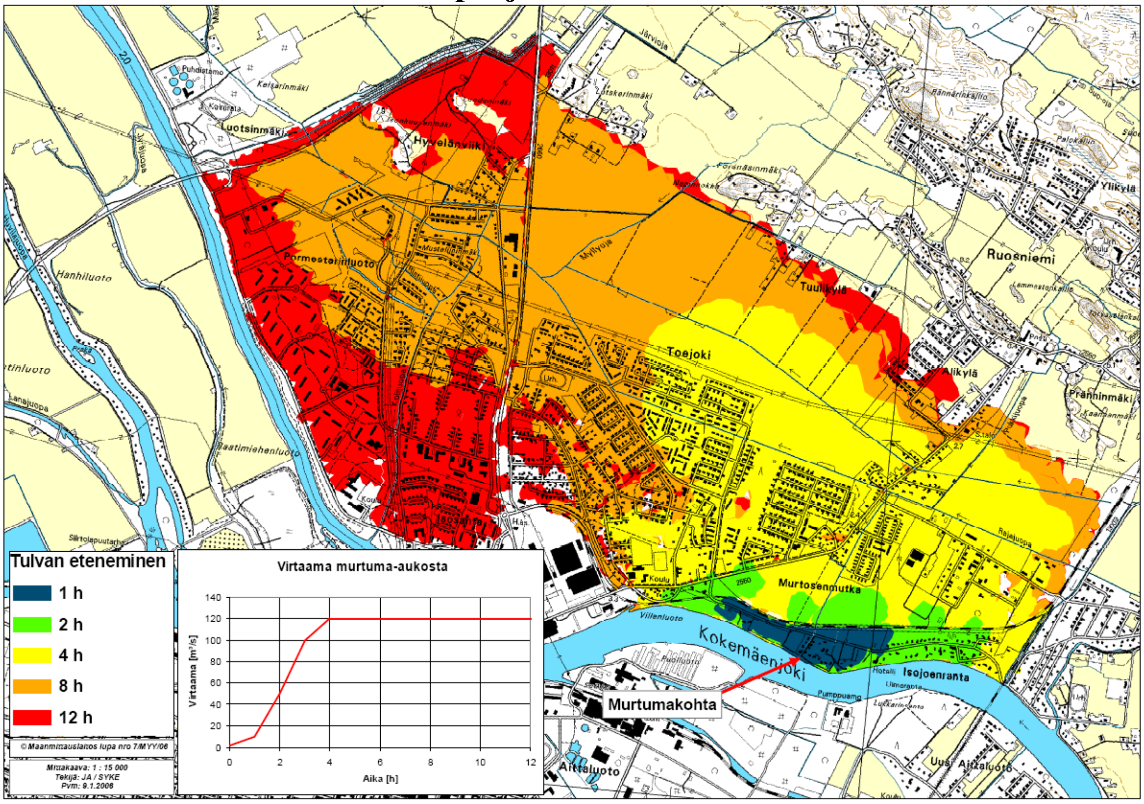
4. Uusi uoma (nykyisen lisäksi): estää sekä 1/50 v. että 1/250 v. esiintyvän tulvan vahingot
5. Kiinteistökohtainen tulvasuojelu ja maankäytön ohjaus: näillä toimenpiteillä voidaan pienentää sekä 1/50 v. että 1/250 v. esiintyvän tulvan aiheuttamia vahinkoja
6. uudet ideat (ryhmästä)?


Flood
Causes
Cloudbursts
Snow smelting
Dam breakdowns
Several wet years one after the other
Storm surges
Categories
River flood
Storm surge flood
Cloudburst flood
City flood
Flood control
Operational actions
Flood barriers and constructions
Pumping
Explosions and excavates of ice dams
Information
Information during the flood incoming
Information during the flood
Advance actions
Actions at the possible flood site
Channels
Bridge openings
Cleaning out the river and enhancing the depth of river
Flood gates
Flood banks
Planning the catchment area
Resrvoirs
Emergency plans
River regulation
Land use planning
Planning the whole water system area
Recognition of flood area
Land use planning at flood area
Dams
Re-dimensioning
Re-construction
Maintenance and up keeping
Assessment of hazardous areas
Information in advance
Information about the flood areas
Information about the advance actions
Rescue actions
Evacuation
Protecting the property
Impacts
Infrastructure
Unworkable drainage systems
Street collapse
Flood in underpasses
Collapse of the building grounds
Wet constructions
Industrial area
Unworkable process sewers
Wet electric cables
Breaks or terminations
Residential areas
Collapse of building areas
Spoilt personal property
Eroded houses
Evacuation
Trade
No transportation of goods
No trade
Roads and railroads
Flood in underpasses
Unworkable pumping
Collapse of the grounds
Bridge collapse
Information technology
Collapse of the grounds of base statements
Destruction of information sensors
Interference of information transport
Power plants and networks
Enhance of water power production
Destruction of on-ground networks
Destruction of cables
Short-circuits and destruction of transformers
Water supply
Ground water contamination
Break downs of water pipelines
Interference with water supply
Tap water contamination
Sewerage
Enhance of waste water quantity
Waste water dilution into surface water
Waste water penetration into ground water
Badly working sewage treatment
Transport
Closing the roads
Unworkable transport
Unworkable transportation of goods
Services in society
More need to healthy services
More need to rescue services
Closing several services
Healthy
Falling and slipping
Epidemics via contaminated water
Drowning
Cultivation areas
Destruction of crop yield
Prohibition of water use because of contamination
Forest areas
Erosion of ground
Fallings of trees
Weakening in forests incomes
Water systems
Weakening of water quality
Destruction of spawn
Changes in channels
Earth slides

Examples of the possible extend of the flood area



Source: SYKE – TOLERATE project



Source: SYKE – TOLERATE project

Appendix 2 – List of participants in the expert session

First name	last name	Organisation
Simo	Haanpää	Helsinki University of Technology – Land use planning training centre
Harri	Juhola	Pori city – municipal real estate
Eira	Järviluoma	Road Administration
Risto	Kekki	West-Finland county – rescue service
Ville	Keskisarja	Ministry of Agriculture and Forestry
Mirja	Koskinen	Environment Agency of West-Finland
Kalevi	Luoma	Association of Municipalities
Mika	Marttunen	Finnish Environmental Institute
Meeri	Palosaari	Finnish Business Association
Mikko	Paunio	Ministry of Public Health and Social Affairs
Juha	Saarimäki	Association of home owners
Pertti	Savijoki	Tapiola – Mutual Insurance Company
Aulis	Tynkkynen	Ministry of the Environment
Päivi	Valkama	Ministry of Finance
Tiia	Yrjölä	Ministry of Agriculture and Forestry
Riitta	Molarius	VTT
Adriaan	Perrels	VATT
Markus	Porthin	VTT
Tony	Rosqvist	VTT

Four participants appeared to have last minute obligations, preventing them to participate.

Appendix 3 – The agenda for a one-day expert session

It should be noted that in the very beginning one change in the decision process was made: the weighting of the criteria was performed *after* the scoring of the performance of the flooding solutions (decision alternatives). It is, however, important that an overall process description is made in the beginning to ensure that the experts understand how their judgements will build up the overall ratings of the solution options.

Time	Subject
9:30	Opening, context, objectives and purpose, timetable
9:40	The link with the TOLERATE project
	- the role of the session in the project and the use of this session's results
9:45	An outline of the implications of various flood scenarios
	- flood categories according to return time, their size and duration
	- hydrological simulations (Maps of R50 and R250 floods)
	- implications (direct damage, production loss, etc.)
10:30	coffee break
10:45	The steps in decision making simulation and the use of GroupSystems software
11:00	Step I – Review of protection alternatives
	- predefined options - additions and amendments
12:00	Step II – Rating the protection alternatives
	- the evaluated utility of protection alternatives in relation to the criteria - argumentation of the choices made (feedback into the computer system)
12:45	lunch
13:00	Step III – The review and weighing of the main criteria
	- presentation of the decision model - decision table and implication table - clarification and discussion of the options after which the personal weighing of the criteria in the GroupSystems software - argumentation of the choices made
13:45	Step IV – The overall results and their evaluation
14:00	coffee break
14:15	- Group evaluation results of the protection options per criterion, discussion
	- Reflection and discussion of the division of the protection cost (local/national/etc.)
15:30	Step V – Overall evaluation of the day and the process
	- feedback (guided by suggested headings 'process', 'usefulness', 'complaints', etc.)
16:00	Conclusion of the session

Appendix 4 – Detailed ratings of the decision-making session

Table A3.1 *Spread of individual rating for life cycle cost*

		Vote Distribution													
#	**Ballot Items**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Avg. Score**	**Total**	**STD**	**Votes**
1.	0: Current protection level	1	1	2	-	-	-	-	1	-	7	7.2	87.0	3.8	12
2.	1a: dikes R50	-	-	-	1	2	2	6	-	-	1	6.5	78.0	1.5	12
3.	1b: dikes R 250	1	4	3	2	1	1	-	-	-	-	3.1	37.0	1.4	12
4.	2a: dredging R 50	-	-	-	2	2	2	4	-	-	2	6.5	78.0	2.0	12
5.	2b: dredging R 250	1	3	1	3	2	2	-	-	-	-	3.7	44.0	1.7	12
6.	3: new river arm	7	3	2	-	-	-	-	-	-	-	1.6	19.0	0.8	12
7.	4: building specific solutions	1	2	3	2	-	3	-	1	-	-	4.0	48.0	2.1	12

Table A3.2 *Spread of individual ratings for living environment*

		Vote Distribution													
#	**Ballot Items**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Avg. Score**	**Total**	**STD**	**Votes**
1.	0: Current protection level	1	2	1	-	-	-	-	-	1	7	7.2	87.0	3.9	12
2.	1a: dikes R50	-	1	5	2	1	-	2	2	-	-	4.6	60.0	2.1	13
3.	1b: dikes R 250	3	4	2	-	2	-	-	-	2	-	3.5	45.0	2.8	13
4.	2a: dredging R 50	-	2	1	2	3	2	-	2	-	1	5.2	68.0	2.4	13
5.	2b: dredging R 250	2	1	4	3	1	1	-	-	-	1	3.8	49.0	2.4	13
6.	3: new river arm	3	4	1	-	1	-	2	-	-	1	3.6	43.0	3.0	12
7.	4: building specific solutions	-	2	1	-	3	1	2	1	2	1	6.0	78.0	2.6	13

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