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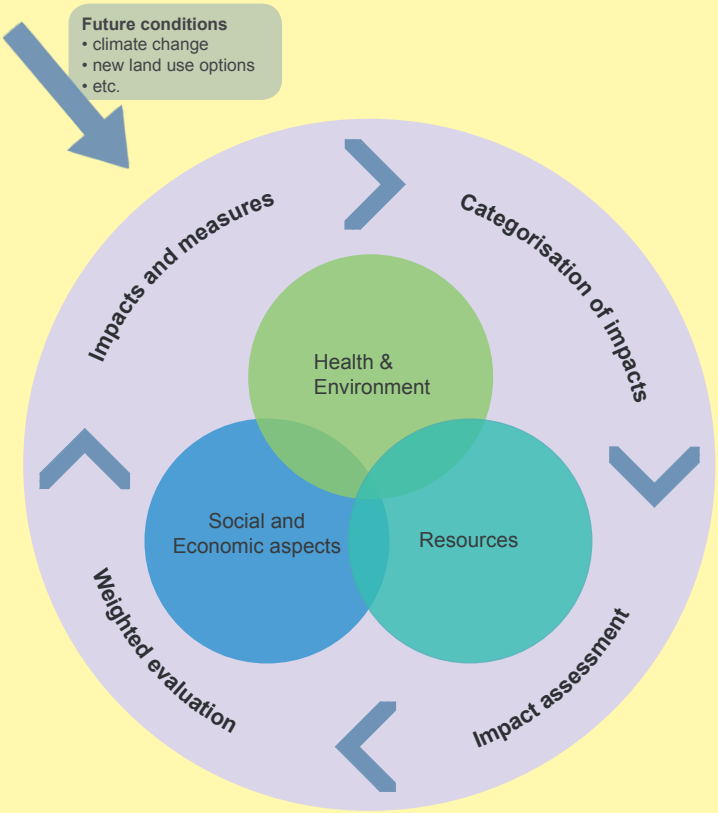

Collocation of experiences with SGI Matrix based decision support tool (MDST) within SAWA

Yvonne Andersson-Sköld

Varia 627

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Varia | Swedish Geotechnical Institute
SE-581 93 Linköping

Beställning | SGI – Information Service
Tel: +46 13 20 18 04
Fax: +46 13 20 19 09
E-mail: info@swedgeo.se
Internet: www.swedgeo.se

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Illustration on cover: The Matrix decision support tool (MDST)

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Content

1 Foreword

SAWA (*Strategic Alliance for Integrated Water Management Actions***)** is an EU Interreg IVB project with partners from the North Sea region in Norway, Sweden, UK, the Netherlands and Germany. The aim of the project is to develop a strategy which will adhere to the European Water Frame Directive (WFD) and which will also meet the requirements of the existing Flood Directive (FD) to act flexibly on challenges arising from climate change issues. This will be achieved by development and testing adaptive flood risk management plans, identify and deployment of cost-effective local scale adaptive measures, information and education and the development and application of tools to be used in the process.

In this report the results of applying a decision support tool that has been tested and developed within SAWA are presented. The tool is a stepwise process consisting of a set of matrixes for evaluation of Environmental, Social and Economic Aspects of strategies to reduce flooding, other natural hazards and general water management strategies.

2 Introduction

There is at present a growing need for tools that could be used at an early stage of land use planning or in the daily work with environmental objectives to incorporate a sustainability perspective, i.e. a holistic approach of resources, health-, environmental-, social- and economic aspects. This report presents some tests of a recently developed tool. The tool is constructed by a chain of matrices and, thus, denoted as The Matrix Decision Support Tool (MDST).

Within SAWA the tool, originally developed in the framework of the Interreg IVB project CPA (Climate Proof Areas) and the Formas funded project "Enhancing cities capacity to manage climate change", has been tested and further developed. The aim of the tool is to incorporate sustainability in a simple manner in the planning process of land use management.

It is applicable for several different purposes, for example for comparisons of different measures suggested for risk reduction of natural hazards such as flooding, erosion or landslides, mitigations of risks associated with climate change or when evaluating any other land use alternatives or measures.

The aim with the tool is to provide a checklist and a methodology that promotes discussions in order to facilitate the identification and compilation of potential measures or strategies and consequences related to land use issues. In addition, it should contribute to a more transparent decision process and increase the traceability of the reasoning behind the decisions taken.

The tool is based on classic technical risk- and vulnerability analysis, comprising all steps from risk/hazard identification to appraisal of measures. The main difference, between this risk analysis tool and many others is the allowance of comparisons of present risks and consequences of measures early in the process. In addition, the methodology repeats the risk/consequence comparison in an iterative manner during the full process until the final step (proposal for decision) has been reached. The tool is intended to be used by both experts and policy makers (or persons who will present the alternatives for the policy makers) in order to demonstrate all kinds of consequences and present them to the whole group of stakeholders (experts, policy makers, the public etc.).

The tool (MDST) is constructed by a chain of matrices and the matrices can be found in Appendix 1 of the report where the tool is described in more detail at www.swedgeo.se/upload/publikationer/Varia/pdf/SGI-V613 (Andersson-Sköld et al., 2011) or downloaded as an Excel spread sheet from: http://www.swedgeo.se/upload/publikationer/Varia/pdf/SGI-V613.xls

Within the Interrreg IVB project SAWA (Strategic Alliance for integrated Water Management Actions) the tool has been tested. The tool has been tested by SGI in municipalities i.e. Lidköping, Göteborg and Arvika in Sweden, and Melhus in Norway in cooperation with SAWA partners in Lidköping municipality, NVE (Norwegian Water Resources and Energy Directorate) and Melhus municipality in Norway. This report is a summary of the results from the test cases.

3 Background

There is at present a growing need for tools that could be used at an early stage of land use planning or in the daily work with environmental objectives to incorporate a sustainability perspective, i.e. a holistic approach of resources, health-, environmental-, social- and economic aspects (Andersson-Sköld et al., 2006; Glaas et al, 2010; Johansson, 2008; Suer et al., 2009). *Different land use alternatives* are here defined as alternatives to reduce the consequences of climate change or it can also for example comprise suggestions of measures to prevent, or reduce, the impacts of natural hazards, such as flooding and landslides, at present conditions.

There is also a need for tools that contributes to transparency, structure and discussions that will promote an efficient and more robust decision making process. The need is that the method shall be easy to use by private landowners, county administration boards or by officials at the municipal level (e.g. Roth and Eklund 2005; Suer et al., 2009).

Such, “easy to use” tool, would be of great benefit in e.g. the municipalities' efforts to:

- analyse present risks,
- identify adaptive needs of, and adaptation measures for, flooding or other land use related impacts due to current climate and in a changing climate
- evaluate different strategies for water management or risk management e.g. adaptation measures related to climate change or measures to mitigate landslide or flooding.

Previous studies indicate that the involvement of all groups of stakeholder, affected by the decision, is crucial to how well the decision is rooted, how easy it can be implemented and how sustainable it will be.

The aim with the matrix based decision support tool (MDST) recently developed at SGI is to encourage more stakeholders to take part of the process. When representatives of an organisation are working together on the tool, either as a working group or in a form of a focus group, both better acceptance and better decisions from a holistic perspective will be achieved. The work can be carried out individually and then merged into the final results, but most optimal is if it is carried out in discussion forums.

4 The Matrix decision support tool

The MDST is based on classic technical risk- and vulnerability analysis, comprising all steps from risk/hazard identification to proposal for decision on measures:

- Risk/hazard identification
- Risk assessment
- Risk analysis - acceptance of risk and need for measures
- Suggestions of measures
- Prioritising of measures
- Proposal for decision on measure

The MDST is designed to incorporate sustainability in a simple manner in a decision making or planning process. It is applicable for risk analysis of different alternatives and for comparison of different potential measures to reduce the risk of flooding, landslides and other natural hazards, to mitigate and manage the risks associated with climate change or when faced with other decisions related to land use alternatives or measures. Various aspects, such as health risks, environmental- and socio-economic conditions, can with this tool be considered in a perspicuous and transparent way at a very early stage of the analysis.

Another aim with the MDST is to allow for subsequently implementation of new knowledge gained during the work process. The aim is further to promote a discussion process. The goal is to combine experiences and knowledge to achieve the most optimal solution or strategy available for the specific conditions and context. Among the differences between this tool and other available risk analysis tools is that it supports all steps in a multi criteria analysis from definition of task to proposal of measure, but also that it takes into account:

1. The time perspective for all considered aspects

2. The consequences on different geographical scales (i.e. on local-, regional- and global scale).

3. The flexibility of the different measure alternatives.

The work using the MDST is initiated with seven preparatory steps (Figure 1). Before starting the preparatory work one can have a first look at the actual tool to get somewhat acquainted with the matrices. However, we do recommend that the preparatory steps are conducted as separate steps before any actual work with the matrices takes place. This is because the preparatory steps include actions using the brain storm technique. This technique prescribes an open and free discussion, which can be inhibited by the requirement of completing a matrix with a definite structure. The actual tool consists of four matrices as shown in Figure 1.

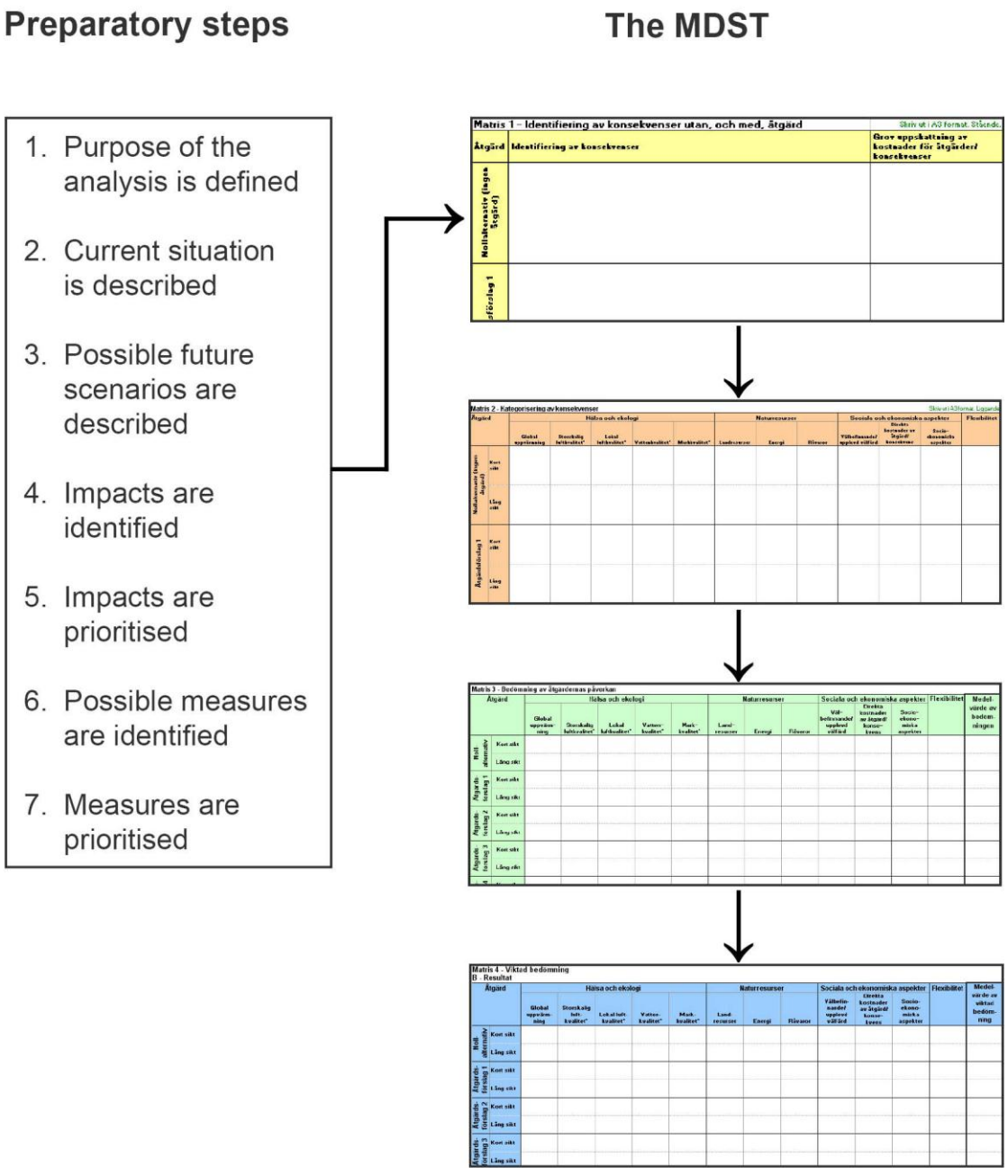

Figure 1 *The MDST and its preparatory steps (from Varia 613.*

5 Case studies

In order to test the applicability of the tool it has been tested by desk based case studies in co-operation with civil servants. It has been tested in the municipals Arvika, Göteborg and Lidköping in Sweden and Melhus in Norway. Within the framework of SAWA partners in Lidköping municipality (Sweden), NVE and Melhus municipality (Norway) have been involved. Within the framework of the Interreg project CPA, co-operation partners from Arvika have been involved, and the tool has further been tested in Göteborg municipality within the framework of the Formas funded project "Enhancing cities capacity to manage climate change".

In all case studies, the impact of flooding due to increased water levels and/or increased precipitation has been taken into concern. Climate change is expected to profoundly influence the hydrology of Sweden and northern Europe. The annual precipitation is expected to increase by 5–24% up to 2100 compared to the conditions for a reference period 1961-1990 (Andreasson et al., 2004). The river runoff flows is in general expected to be higher in winter, followed by a less pronounced snowmelt peak and lower summer flows. The changes will likely vary between different parts of Sweden (Olsson et al., 2010).

All the Swedish municipals are located by water courses of the Göta River catchment area as shown in Figure 2. There are today events of flooding, and according to climate change scenarios the risks (probability and extent) will increase during the next decades (e.g. Lawrence et al., 2011). In the sections below the case study areas and the results using the MDST for each of those are described.

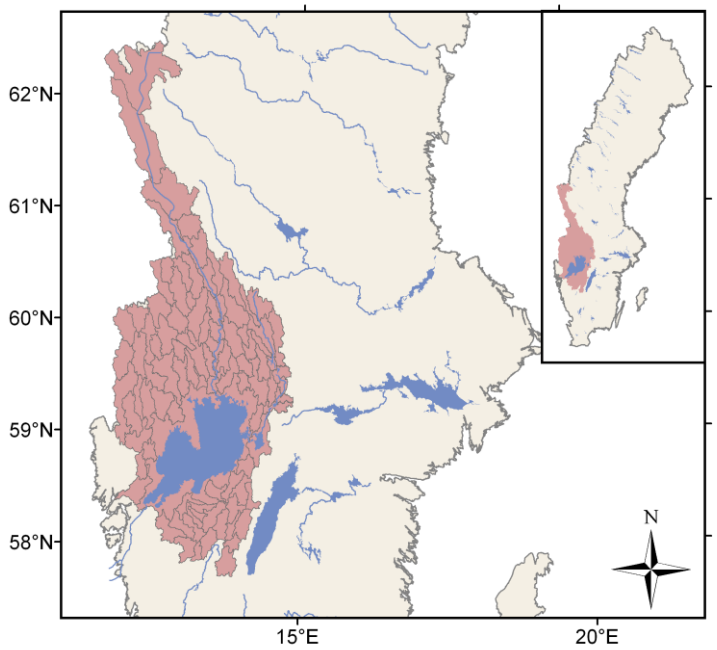

***Figure** 2 The lake Vänern and the Swedish parts of the Göta river catchment area (modified from Lawrence et al., 2011).*

5.1 Lidköping

The case study area Lidköping municipality is located in the west of Sweden by the shore line of Lake Vänern, the largest lake in Sweden and the third largest lake in Europe. Through the center of Lidköping runs the river Lidan (Figure 3). Previous studies have shown that the river Lidan does not pose any threats of flooding of the city center, neither today nor according to climate change scenarios of the area (Erdahl, 2009). The major potential threat due to climate change, are therefore consequences of flooding due to water level changes in the Lake Vänern (Hogdin et al., 2010).

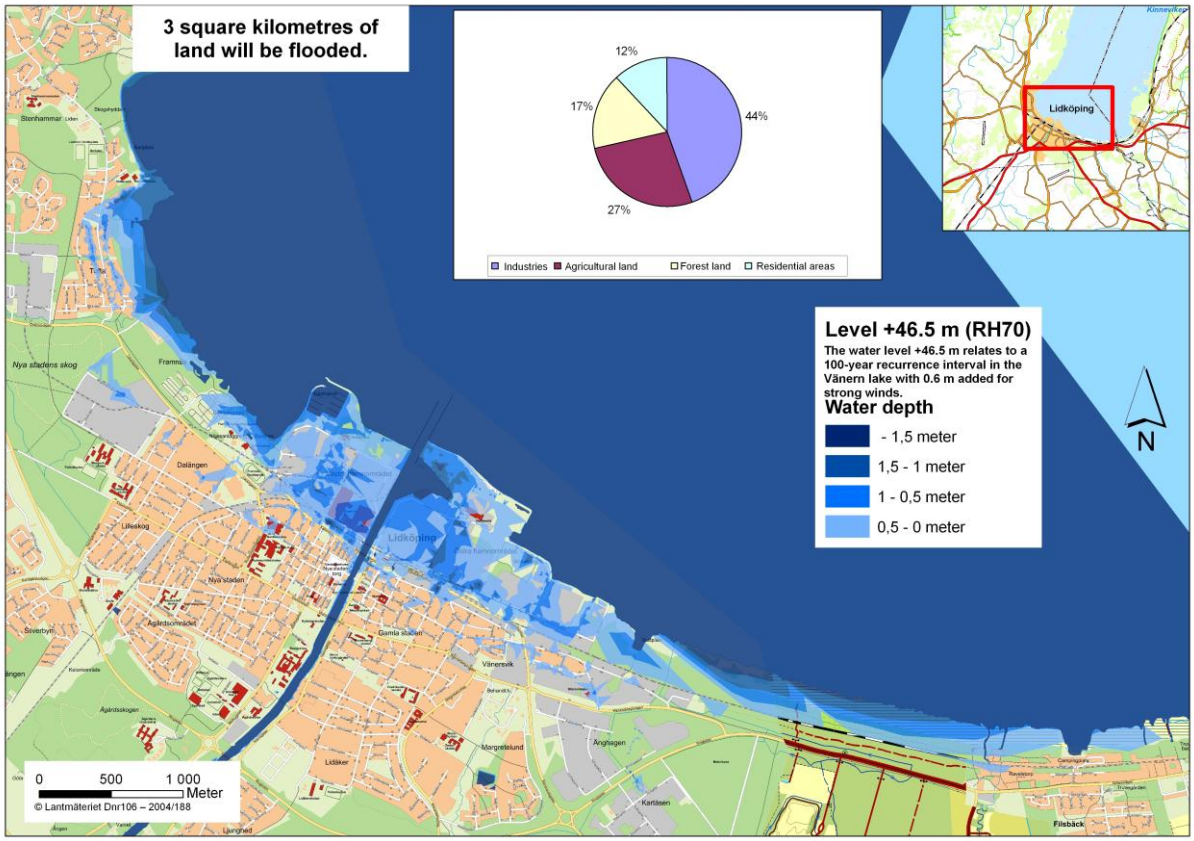

Figure 3 *The impact of a Lake Vänern water level of 46.5 m above sea level (RH70) at Lidköping. Lidköping is located at the Lake Vänern and through the center river Lidan is running (by Jonas Andreasson, Länsstyrelsen Västra Götaland, 2010, based on data from © Lantmäteriet).*

The water level of Lake Vänern may increase in future. For example in the flood risk assessment by the county administration SAWA partners Västra Götaland and Värmland (Hogdin et al., 2010), the current 100 year level at Lidköping is 46.5 m above sea level (RH70), while in future the maximum level that is regarded, is 47.4 m above sea level (i.e. +46.5m and +47.4m (RH 70)). Both levels were based on a previous investigation (SOU 2006:94). A level of +46.5m is considered to have a 100-year recurrence interval in today's climate, with a 60cm premium for high winds in an unfavorable direction. The impact on Lidköping is shown in Figure 3. A water level of +47.4m is considered as worst case scenario which takes into account climate change by 2100, and a wind effect of 0.5m. The impact on Lidköping is shown in Figure 4.

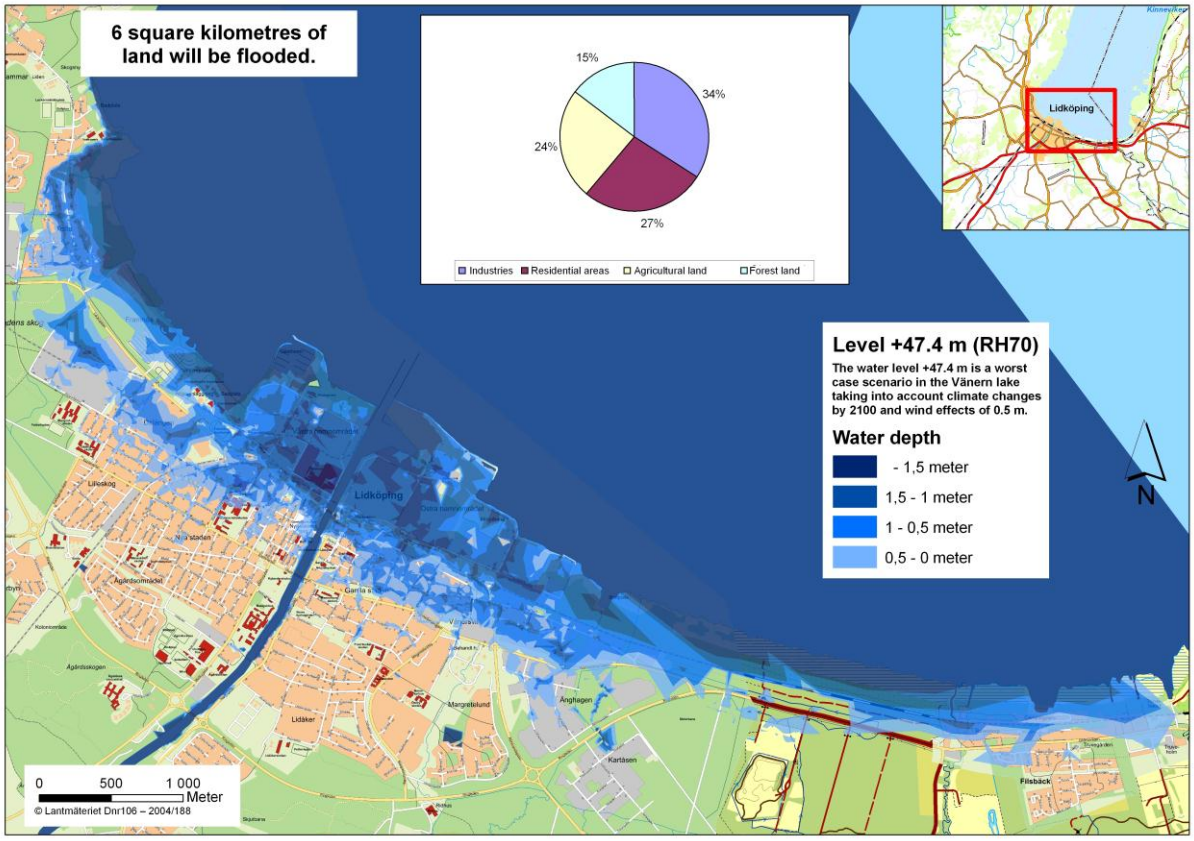

Figure 4 *The impact of a Lake Vänern water level of 47.4 m above sea level at Lidköping (by Jonas Andreasson, Länsstyrelsen Västra Götaland, 2010, based on data from © Lantmäteriet).*

5.1.1 Using the MDST

The use of the MDST in Lidköping is based on information provided by Frida Björcman and her collogues (civil servants) in the municipality. Within the framework of SAWA Björcman made a questionnaire. The aim was to obtain information on the municipal's different departments views, experience and expectations of potential vulnerability due to potential flooding today and in a changing climate. The questionnaire was made as part of SAWA, and as part of the test on how to work with parts of the Floods Directive in Sweden in co-operation with the county administrative boards of Västra Götaland and Värmland. Part of the results from the questionnaire is also presented in the SAWA report "Flood risk and mapping" (Hogdin et al., 2010).

The MDST was tested by Frida Björcman Lidköping Municipality and SGI staff (Yvonne Andersson-Sköld and Ramona Bergman) at two occasions January 13 and February 3, both 2010. At the first occasion also Jan Fallsvik and Stefan Falemo (SGI) attended.

The first meeting was a brainstorming activity. The aim was to summarize the consequences of the current situation at the event of flooding, identify potential measures that could be taken to reduce the negative consequences (and/or the probability of the event), and to identify consequences (pros and cons) of the suggested measures.

5.1.2 Result and discussion

The brainstorm results were summarized into matrix 1. Examples of consequences of the current situation at the event of flooding included flooded buildings, reduced or stopped activities of important objects such as the water and sewage system, telecom, heating plant, waste disposal plant, rail, roads and streets, cultural and natural values, due to direct consequences or due to power cuts and secondary natural accidents such as landslides etc.

Both physical and non-physical measures were suggested. In Table 1 some suggested physical measures are presented. The table also includes the pros and cons identified for those examples. Initially all measures mentioned were physical, while by the end of the meeting also activities such as risk investigations and risk mapping were presented as well as activities to increase the awareness including information, education and communication with land owners. Some of the suggested measures were at once regarded as to expensive and complicated for further considerations. These included to move the sewage treatment plant and the heating/waste disposal plant to higher locations.

During this first meeting also the first attempts to start filling matrix 2 and 3 for two of the alternatives was initiated. This step was thereafter done by SGI staff and at the second meeting the matrixes were updated and finally agreed on. An example of the final result of Matrixes 2 and 3 are shown in Table 2 and Table 3 respectively.

Table 1 *Examples of physical measures suggested for reducing the flood risks in Lidköping and the identified consequences of the measures.*

Reserve force on wastewater treatment plant	The measure would reduce the risk that the treatment plant would stop functioning due to power failure.
Embankment of the sewage plant to 46,5 m.	The measure would ensure the facility to manage a water level “return time” in Vänern on a once every 100 years + 60cm for not favorable wind. Impossible to barricade to 47.4 (10 000 year flood). Landslide risk needs to be investigated at the embankment.
Heating plant / waste disposal: dike with garbage and plastic	The business is managed (only the cellars have a problem) as long as you have garbage and plastics (46.5). Require geotechnical investigation. Risk to barricade themselves and can then not accept garbage for incineration and garbage from the city will reach the heat plant. There is backup power plant in the port using oil - today via car, but could have a pipeline to both works. Waste is temporarily stored or disposed elsewhere.
Measure alternatives 8 and 9 which at once were found to expensive as manageable alternatives	• Water and sewage: Move the sewage treatment plant: Central question - too expensive and require many technical solutions. Would prevent blockage in the sewerage system • Heating plant / waste disposal: Transfer to a higher altitude: Insanely expensive.

***Table 2** Matrix 2 - Categorising of environmental and social aspects*

Embankment to 46,5 m **Measure**	**Short term**	**Long term**
Global warming	Temporary increase in emissions resulting from the action	Less emissions than no action and the only installation of backup power because less urgent action is required and less requirement for employment as a result of the action. Valid up to 46 m, above that the same as without action
Large-scale air quality	As global	As global
Local air quality	As global	As global
Water quality	No known change.	Drinking water quality may deteriorate, but crucial lower risk of spread of infection associated with floods (s). Valid up to 46 m, above that the same as without action.
Land quality	No change.	No change.
Land resources	No known change	No known change
Energy	As a global but energy rather than emissions	As a global but energy rather than emissions
Raw materials	As a global but commodity usage rather than emissions.	As a global but commodity usage rather than emissions.
Wel-being/ perceived welfare	High, positive event	Up to 46 m as for secured power. Then as no action.
Direct costs	?	Up to 46 m as for secured power. Then as no action
Socioeconomic aspects	As above in short and long term.	Up to 46 m as for secured power. Then as no action
Flexibility	As above	

***Table 3** Example of Lidköping Matrix 3 – Assessment of environmental- and societal aspects*

Measure	Global warming	Large-scale air quality	Local air quality	Water quality	Land quality	Land resources	Energy	Raw material	Wel-being/perceived welfare	Direct costs	Socioeconomic aspects	Flexibility
None	0	0	0	0	0	0	0	0	0	0	0	0
	-1	-1	-2	-1	0	-1	-1	-1	-1	-2	-1	
Reserve force on wastewater treatment plant	0	0	0	0	0	0	0	0	1	0	0	0
	-1	-1	-2	1	0	-1	-1	-1	0	-1	-1	
Embankment to 46,5 m	-1	-1	-1	0	0	0	-1	-1	1	0	0	0
	-1	-1	-2	1	0	-1	-1	-1	0	-1	-1	

One of the aims was to test the tool. The tool was found to encourage the discussion and was useful on identifying measures and their consequences. The results indicated that the tool can be relevant and applicable.

The step from Matrix 1 to Matrix 2 was found interesting but time consuming. It is an important step, and it is important to take part of it, but the results indicate that it partly can be done in between two consecutive meetings. As a result of the discussion and process of completing matrixes 2 and 3 new suggestions of measures were formulated. This indicates that it is important to start the process on matrixes 2 and 3 for doing nothing and one of the suggested actions/adaptation measures. It can, however, be relevant to speed up the process and prepare a suggestion of the content of matrixes 2 and 3 in advance of the second meeting. In addition, to be able to complete Matrixes 2 and 3, based on relevant level of information, the impacts on some aspects may need expert or more deepened judgements. Through the course of the discussion, the need of further information and knowledge for the impacts of alternatives were identified and documented. At the moment of time there was no need to make any weighting of the different aspects in relation to each other, i.e. all aspects were assigned the same value (1) and the result of Matrix 4 was identical to Matrix 3.

5.2 Gothenburg

The city of Gothenburg was also part of the test in a parallel national funded project, i.e. as part of a research project investigating the vulnerability and adaptation to climate change using a case study area Gullbergsvass, in Gothenburg, as a pilot (Glaas et al., 2010).

Gothenburg is located at the West coast of Sweden. Through the city center runs the River Göta älv. Due to climate change the sea water level is expected to increase. In Gothenburg the MDST was applied on the case study area Gullbergsvass. The area is located in the center of Gothenburg by the river Göta älv. The pilot involves the renewal of an inner-city area to serve as the transportation and communication hub for the city and region (in the comprehensive plan adopted 26 February 2009, the area is identified as a future development area). The tool was applied at two occasions in a similar way as the Lidköping case, by discussions with Ulf Moback head of the Gothenburg extreme weather and climate change group and general planner in the municipality. The extreme weather group was assigned to assess the potential impacts of extreme weather events, and consequently climate change. In 2005 a general risk identification/analysis of the municipality was done. Thereafter the aim was to do a more comprehensive assessment of a case study area, Gullbergsvass, within the municipality which was the reason for the choice of the area also for the research project.

The process was done by involving Moback in all assessments in all matrixes 1 to 3. Also here the results of applying the tool indicate that the use of the tool encourages discussion, and that the systematic view of sustainability increases awareness of the holistic perspective. The process is time consuming if going through all aspects and alternatives. This was accepted when involving only one person, but may be regarded as too time consuming in a large group. Therefore, the suggestion is to start the filling of matrix 2 and 3 for one measure, as done in Lidköping, at the first occasion and prepare for the other measures in advance. The results can thereafter be discussed and updated during the second event. Also here initially physical measures were suggested and discussed, but as in Lidköping, the discussion when applying the tool directed attention towards institutional

adaptation measures as a complement. The main identified negative impacts of the institutional measures were that they were time consuming (municipal officials have very limited available time), may lie outside the mandate of local administrators (e.g. may require national political decisions), and may require organizational changes.

The activity showed that the MDST is applicable. The activity was, however, done late in the research project as the MDST development was done in parallel to the other parts of the research project. Therefore, the time to test and apply the tool was very limited and the application of the tool could not be part of the R&D process.

5.3 Arvika

The municipality of Arvika, situated in Värmland County of Sweden, has got a population of approximately 26,000 people, of which 14,000 live in the city itself. The Swedish Commission on Climate and Vulnerability (SOU 2007:60) points out the area as one of the worst affected in Sweden with respect to increase of the most intensive rainfall and extreme flows. This will pose a challenge for the city of Arvika as the current capacity of the stormwater drainage system is insufficient even for the climate of today, with basement flooding as result. Arvika has in the past experienced high water levels in lake Glafsfjorden, with critical consequences for the economy, environment and delivery of services (e.g. evacuation of people, damaged property, reduced industrial production, poor sewage treatment, closed railway and roads). Predictions indicate that this kind of event will be more severe and more frequent in the future.

The aim of the MDST activity in Arvika was the same as the municipalities aim within the CPA project, i.e. to:
- Analyse impact of climate change in a local perspective
- Identify consequences for infrastructure and capacity to deliver basic services
- Identify and evaluate realistic adaptation alternatives

Independent of the Climate Proof Areas project, a barrier between the lagoon Kyrkviken and the lake Glafsfjorden were already planned by the municipality. The aim of the barrier was to protect the city of Arvika and the area surrounding the lagoon from damage caused by high water levels. Also this measure was included in the Arvika MDST application.

The MDST activity in Arvika was done in spring 2011. SGI staff visited Arvika in 2011. At the meeting CPA members participated, i.e. Elin Alsterhag, Maria Dåverhög, Anders Norrby from Arvika municipality and Ramona Bergman and Yvonne Andersson-Sköld from SGI. After the meeting the results of the activity were updated by information from the recent environmental risk assessment of the barrier (Vectura 2010-06-30) and the matrix was reviewed and completed via e-mails. The results are presented in Appendix 1.

The results from this activity showed that the most viable option is flood protection of the strait and then to take further actions which consist of a mix, ie a combination of increased the dimensions of existing pipes, new pipes and detention basins. Also in this activity nonphysical measures appeared towards the end of the physical meeting in Arvika, i.e. that the civil servants can actively provide information to land owners and to make a water management plan.

Also in this case, the main identified negative impacts of the institutional measures were that they were time consuming, may lie outside the mandate of local administrators and may require organizational changes.

The activity showed that the MDST is applicable. The activity was, however, done late in the CPA project as the MDST development was a major part of SGI work through the course of the CPA project. Therefore, many of the results could be included in the matrix based on already available information and assessments. The matrixes summarised those results and could visualise the impacts of the different alternatives in Matrix 3. This is, of course, relevant, but the full aim of the tool, i.e. to identify climate change adaption measures (or other land use actions), and their consequences, early in an iterative process was not possible to test any further.

5.4 Melhus

NVE and Melhus municipality are SAWA partners, and are within SAWA, cooperating in developing a flood risk management plan. The aim is to provide examples and experience that can be used for the implementation of the flood directive in Norway.

The plan shall include actions to reduce the flooding and/or the consequences of flooding. In June 26, 2011, SGI, NVE and Melhus had a meeting in Melhus. The aim was to use the MDST to investigate potential measures that can be taken.

At the meeting, Bent C. Braskerud and Oddrun Sunniva Waagø from NVE, Yvonne Andersson-Sköld, from SGI, and Tove Hellem, Terje Fagernes, Jan Henrik Dahl, Arild Karlsen from Melhus municipality attended.

The meeting was initiated by a presentation of potential measures by Bent C Braskerud followed by a presentation by Yvonne Andersson-Sköld about the MDST. Thereafter the MDST was utilised in the discussion on potential measures. The group worked through the process for the reference alternative (doing nothing) and decided on two measures to start the MDST process, i.e. disconnection of water drains and green roofs. The results are presented in appendix 2.

5.4.1 Expericence of the MDST by spontaneous response:

- There is a need to have the explanations of the headings handy during the working process.
- Some of the headings would gain from being changed. For example, Water quality could be clarified that it rather is Ecological status and not only chemical quality. This fits in to the requirements from the water frame directive.
- Initially there was a request that the headings should be more in line with the flood and water directives.
- The activity helps creating awareness on how one can include new measures in the spatial planning and execution.
- Change in attitude to how to manage surface water (storm water). What is needed for new measures to be taken?

- How and for what shall we use it? We can implement measures in Melhus, and most will have the same proc and cons everywhere, but some will be site specific. Shall we do this with all activities? (very time demanding).
- Maybe a good idea to make the assessment in advance, while local adaption can be made locally even if the matrix documents are pre-filled. As an alternative, or as a complement, a local expert group could go through the list of more than 100 physical and organisatoric measures and pick out the most interesting for the area.
- There is a demand on fact sheets on relevant measures including information in general together with information on the impacts on the different categories (global warming, ecological status etc).
- Fine (good/useful/) tool to show politicians, documentation on what civil servants in the municipality have emphasized suggestions and recommendations.
- Technical/ special day on flood issues for politicians.

5.4.2 The decision process

The group was very positive on rain gardens as risk mitigation measure. The question arise if this was due to the idea had been presented before or because it is a very good measure? Will the attitude change as more alternative measures are being assessed?

After the test the aim is to follow up for subsequent use it in the flood risk plan. The follow up can be more concrete suggestions on in which areas measures, and which type of measures, can be taken. At the same time it is great if one can manage to include the municipality as a whole. The measures that will be assessed can be used in other areas at later occasions.

6 Summary and conclusions

The MDST was found to be applicable and it is a new way of incorporating civil servants and experts in evaluating alternative measures.

The discussions created awareness and the method encouraged structured discussions and documentation of the discussions.

As a result of the Melhus MDST application process, the tool was developed to respond to the request that the headings should be more in line with the flood and water directives. The resulting matrixes are presented in appendix 2.

The process is time consuming and would gain from some preparatory work in between the meetings and/or in advance. For example a local expert group could go through a brut list of physical and organisatoric measures and pick out the most interesting for the area, some preparatory work can be done by the one running the process on the matrixes between meetings etc.

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Appendix 1 - Arvika

Matrixes 1 and 3 for the case: "Adaptation to climate change impacts on urban storm water: a case study in Arvika. Sweden"

Climate change Arvika

Date:
Version: 1

Participants:	**Contact details:**
Elin Alsterhag	Arvika Municipality
Maria Dåverhög	Arvika Municipality
Anders Norrby	Arvika Municipality
Ramona Bergman	Swedish Geotechnical Institute
Yvonne Andersson-Sköld	Swedish Geotechnical Institute

Responsible:
Yvonne Andersson-Sköld, Swedish Geotechnical Institute

Earlier versions	Responsible
None	

General comments:
This study is a test of the MDST in the Arvika Pilot.

The test was done in co-operation with the Arvika Municipality and based on available information from CPA and previous investigations.

The test study includes both the impact on doing nothing and from adaptation measures to climate change including both the planned barrier and impacts on urban storm water. The study was initiated 100413_and was continued until May 2011.

The results of the study are presented on the forthcoming pages and also in separate for Matrix 2 results. In the more formal presentation it will be part of the report (august).

Workflow

- **Identify risks in today's conditions(enter them in matrix 1)**
- **Identify measures, measure proposals**
    - Brainstorm (possible measures – save them with any comments attached to this document)
    - Prioritise measures to further work with: Write the prioritised measures in matrix 1. *NOTE Don't forget to document what the priority is based on and by who.*
- **Identify risks, effects and consequences of the measure suggestions: write these in matrix 1.**
- **Identify cost: write these in matrix 1.**
- **Matrix 2 – categorise effects**
- **Matrix 3 –assess the size of the categorized effects**
- **Not involved in the test case but for generic use: Make a plan what you need to move forward with regarding the need for additional support or expertise. If there is enough evidence one can go forward with a weighting and the final score.**
- **Optional**
    - Weighting/valuation of the different categorised effects
    - Assessment of overall performance, including weighting/rating (Matrix 4)
- **Make a plan for further work**

Climate Change Arvika
Matrix 1 – Identification of potential risks, effects and consequences

Measure	Identification of potential risks, effects and consequences	Possible costs
None Taking no action means that current conditions are maintained, but the environment is changing in the normal way. These changes may be, for example, changes due to climate change and changes already planned or decided measures. In addition the actions are taken at the municipal level and / or municipal initiatives. (Individual properties can themselves take action)	Insecurity and anxiety for future high water levels. Damage to buildings, major failure of the city's electricity, water and sewage can occur at a major flood situation. This may include, among other things to health risks increases. Flooding and increased flows could also result in increased emissions of pollutants from port area where there are contaminated sites. Availability and ability of transport will be hampered by flooded roads and even some rail transport could become impossible. For some groups, such as those that depend on domestic help, this can lead to serious consequences. There is also a risk that the church and burial grounds are flooded. A flood situation will also affect industrial output in the area. (WSP, 2005, Vectura 2010) In addition to acute flood risk that already ispresent due to current climate variability, climate change can lead to other consequences. These may include heat stress, deteriorating water quality and changes in forest and agricultural characteristics (SOU2007: 60). Basement Flooding is a problem for the municipality and property owners, there is a need of upgrading of storm water network / alternative solutions for storm water management. During heavy rains culverts can be washed away.	The aggregated economic cost of Arvika was 313 million (2009 prices) (Bluhmentahl et al., 2010). According to investigations the situation could have been even worse. The water level might have risen to 48.90 m (RH00) instead of 48.36 m (RH00)), which likely would have been devastating for Arvika town and city infrastructure (Vectura 2010-06-30). Insurance matters, liability investigations, may be claims, negative publicity for the City (confidence against the municipality as an organization can be weakened and reduced attractiveness of the municipality in general). Costs associated with heavy rain can be 0,5-1 million. Estimated standard value for the total cost per basement SEK 50 000. (Maria Dåverhög, Arvika municipality, 2010-03-25

Flood protection in the Strait The alternative is some form of permanent protection in the Strait into the Kyrkviken that can shut off the flow into Arvika in a flood situation. The protection should protect Arvika town to a water level of + 48.9 m, with a margin of waves up to + 50 m. The main choice is a concrete dam that closes at flood risk. It is possible to raise the barrier height, if necessary. Permanent crest level + 47.5 m with an option to increase to +50.0 m.	Psychosocially the flood protection may be important to remove the insecurity and anxiety. The protection involves a local change in the landscape of the Straits. The construction requires excavation, dredging, construction of temporary road, resources for the construction (materials, fuel, etc). However, it requires substantially less natural resources, and emissions will be less, than if valuable parts are moved or if embankment is used. Boat traffic is not possible when the flood protection is closed. Pumping is necessary when the it is closed (noise + resource). (WSP, 2005, Vectura 2010)	The cost is big 82 million (Technical description Hydro Terra Engineers, 2010)
	High flows and water levels Glafsfjorden: The measure protects Arvika´s buildings and infrastructure in flood times. The most tangible effect is that Arvika municipality may be able to control the water level in Kyrkviken and can prevent the water level to rise in the port area, flooding streets and causing disruption on the city's electricity, water and sewerage. The ability to limit high water levels will also eliminate the risk of flooding to about 200 individual properties along Kyrkviken. (WSP, 2005, Vectura 2010). There will still be able to experience problems with drinking water (raw water, turbidity), problems in the treatment plant due to the arrival of more water and overflow, flooding outside the bunded area, for example sulviksbädden, Kyrkvikens water quality will remain the same as under current conditions, road and rail can be flooded (outside the bunded area) which affects the accessibility and availability.	Costs of flooding outside the dam – the impacts outside and costs outside the area protected by the dam will be about the same as without the flood protection (ie as the current situation).
	Downpour The measure does not provide protection against heavy rain, which raises problems of storm water network.	).

Removal of parts of Arvika (treatment plant, cemetery and church, the harbor area (Restaurant Olsson brygga), open-air museum Sågudden, railways and railway station	Protects the necessary activities, increased security, difficult to implement, involves substantial changes in landscape and cityscape, is labor-intensive and probably also resources (raw materials, fuel, etc.) to be implemented. (Vectura 2010)	Extremely expensive, both from economic and environmental perspectives (resource consumption and emissions in the implementation), the option is not considered further (even if only few of the activities concerned are moved, this is judged to be excessive cost compared to other options).
Embankments with reinforced rail embankments and temporary barriers	An new built embankment can provide the same protection as a flood in the Strait, provided that the walls are 4.4 km with an additional barrier in the inner city, it also requires 8 pumping stations to manage storm water and tributaries (Viksälven and Sävsjökanalen). The measure represents a major effort and the localization involves manipulation of the urban environment. The rail embankment can not be used because it has the wrong route, is not high enough and does not hold for unilateral water pressure. This means that it requires the construction of 4.1 km of permanent / semi permanent / temporary dikes. This option can protect Arvika town but the security of protection is low given all the barriers and pumps that could collapse. An accident could have devastating consequences for the city and its inhabitants as a result. (Vectura 2010)	The embankment's height and location suggests a very large plant cost which nevertheless does not meet the primary requirements (Vectura, 2010). Estimated cost of 157 million. Resource consumption and emissions that occur in the construction work are expected to be great. The option is not considered further.
Tunnel between Skäggebol and Borgvik The tunnel is to divert water that normally flows through Byälven to Vänern and comprises a 6 km long tunnel with a cross-sectional area of 170 m2.	This option has not been chosen in the EIA on the grounds that a tunnel with the reported cross-sectional area only lowers the water level in Glafsfjorden by about 0.7 meters compared to 2000 which do not meet the purpose and that the prejudice to the environment is probably significant (WSP, 2005, Vectura 2010).	The cost of this tunnel is estimated to be very great. Requires a lot of resources, large emissions and large damage to the environment. The benefit is very low. The option is not considered further.

Storage upstream Glafsfjorden	The effects of the measures in the Swedish part of the catchment area would result in a reduction of the maximum level of about 0.4 meters in 2000. The measures would, at a time corresponding to the flood in 2000 mean that 13.8 km public road and 10.3 km private road would be affected by the level of increase in the magazines. In addition approximately 292 hectares of arable land, 26 plots with houses and / or holiday homes and a church would be filled with water. In environmental terms, the option would lead to enormous damage to the environment upstream Glafsfjorden. Neither using the storage capacity in Norway, it can achieve the requirements needed for a similar occasion in 2000 and a rise in water levels would again result in major consequences for the properties and the environment along its banks. (Vectura 2010)	Very high cost and fail to satisfy the objective. Option is not considered further.
Increased discharge in Byälven	This option does not meet the purpose of the damming of Kyrkviken. This option has not been chosen in the EIA with regard to that performed simulations show that even very extensive measures (improved discharge by Säffle, dredging of rivers, widening of stretches of rivers) only reduces the water with a few inches (in 2000) which does not meet the objective of the measure. It would also include significant operations in Byälven aquatic environment and large issues in the implementation of the measure. (Vectura 2010)	Large cost and fail to satisfy the objective. Option is not considered further.
Measures to reduce adverse impacts on rainfall		

Action 2: Increased dimensions of existing pipes, new pipes and detention basins	Reduced risk for basement flooding in buildings,. Temporary interventions that disrupt traffic (negative), temporary impacts in the city at construction (negatively), can take the opportunity to arenew other pipes (positive).	If all storm water areas in Arvika and Jössefors should be addressed to the full to cope with a future ten-year rain, this means enormous costs. Realistically is that priorities are implemented and the most cost efficient measures are choosen. A priority will be made in connection with taking up a 5-year plan for VA.
Action 3: Back flow stop (ultimately - direct dialogue between property owners and municipalities) (can be stand-alone measure, but in matrix 2 and especially in matrix 3 of this compilation, we assume that there is a mix of measure 2 and 3 for this alternative)	Must take interventions in individual properties - requires dialogue with the property owner, a case-by-case assessment on who is paying, more vulnerable installation (management more robust) (= additional elements are introduced).	Cost of the operation, the cost of further dialogue, more vulnerable installation (management more robust)
Activity 4: Information for property owners what they can do on their sites = self help	Property owners can influence their own situation (positive), may be perceived as impositions (negative).	an save money because of the effect of delaying the water.
Write storm water policy for new areas for both the purification and capacity (internal working documents and information to the municipality)	A well thought out and documented storm water policy in itself is good for getting things right from the beginning, good to optimize so that the cost could be as low as possible, to have a documented policy provides greater transparency for citizens in the community and increase opportunities for collaboration between departments and units within the municipality.	A documented policy for both new and existing fields is an important tool to optimize so that the cost could be as low as possible and to avoid costs associated with confusion, loss of synergy within the municipality and the loss of confidence among citizens, and by being able to be more pro-vision.

Comments:
Matrix 2 is available in a separate file.

Basis:
Vectura, 2010, MKB associated application for water activities regarding flood protection of Arvika town, 2010-06-30
Blumenthal et al , 2010, 10 years after flooding in Arvika. Karlstad University press.

Climate Change Arvika

Matrix 3 – Assessment of environmental- and societal aspects

Åtgärd	Kategori											
	Hälsa och miljö					Resurser			Sociala och ekonomiska aspekter			
	Global uppvärmning	Stor-skalig luftkvalitet	Lokal luftkvalitet	Vattenkvalitet	Mark-kvalitet	Land resurser	Energi	Råvaror	Välbefinnande/upplevd välfärd	Direkta kostnader	Socioekonomiska aspekter	Flexibilitet
Ingen åtgärd	0	0	0	0	0	0	0	0	0	0	0	0
	-1	-1	-2	-2	0	-1	-1	-2	-2	-2	-2	
1	-1	-1	-1	0	0	-1	-1	-1	1	-1	0	1
	0	0	0	-1	0	1	0	0	2	-1	1	
2	0	0	-1	0	0	0	0	0	2	-2	1	2
	0	0	0	1	0	1	0	0	2	0	1	
3	0	0	-1	0	0	0	0	0	1	-1	1	2
	0	0	0	1	0	1	0	0	1	0	1	

Comments:

1. Which methods/basis have been used?

Based on matrix 1 and 2. The content of these matrixes is based on Vectura, 2010 and Blumenthal et al , 2010 where stated otherwise CPA Report by WSP 20101108.

2. If basis is missing, indicate for which matrix/what aspect basis is missing.

3. Was the basis appropriate/enough for the assessment? If not, what more is needed in the basis? Se *next step* below.

4. Is a more thorough assessment needed? Are there any suggestions of assessment methods? Se *next step* below.

5. Further comments: Se *next step* below.

Results of the assessment (average)
According to this assessment the most viable option is, in addition to flood protection of the strait, to take further actions which consist of a mix of increased dimensions of existing pipes, new pipes and detention basins. In the current test, the method was used too late in the process because the method was under development as part of the CPA and barrier project.

Next step
Within the CPA project (regardless of the matrix result): Suggestions for further work, after that a discussion with policy makers (politicians) in Arvika on how you look at climate change and adaptation measures in the short and long term.
It would be interesting to interview some citizens living in the central part of Arvika, preferably supplemented by NGO's and so on. Probably there is no time for this within CPA.

References
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Vectura,, 2010, MKB associated application for water activities regarding flood protection of Arvika town, 2010-06-30

Blumenthal et al , 2010, 10 years after flooding in Arvika. Karlstad University press

Appendix 1:2

Matrix 2 for the case "Adaptation to climate change impacts on urban storm water: a case study in Arvika. Sweden"

Matrix decision support tool – Climate change Arvika
Date: 2010-04-13
Version: 1

Participants:	**Contact details**
Elin Alsterhag	Arvika Municipality
Maria Dåverhög	Arvika Municipality
Anders Norrby	Arvika Municipality
Ramona Bergman	Swedish Geotechnical Institute
Yvonne Andersson-Sköld	Swedish Geotechnical Institute
Responsible:	
Yvonne Andersson-Sköld	Swedish Geotechnical Institute
Earlier versions	Responsible
None	

Matrix 2 - Categorising of environmental and social aspects

Measure	Global warming	Large-scale air quality	Local air quality	Water quality	Land quality	Land resources	Energy	Raw materials	Wel-being/perceived welfare	Direct costs	Socioeconomic aspects	Flexibility
None – short term	Probably no change, but increased pumping at occastions with increased water levels in Kyrkviken and otherwise as below but less frequently (0)	Probably no change, but increased pumping at heavy rain and otherwise as below but less frequently (0)	Probably no change, but increased pumping at heavy rain and otherwise as below but less frequently (0)	As below but less frequent than with future climate (due to heavy rain and normal climate variability) (0)	No change (0)	No change (0)	Probably no change, but increased pumping at heavy rain and otherwise as below but less frequently (0)	Probably no change, but increased pumping at heavy rain and otherwise as below but less frequently (0)	Insecurity and anxiety for the next high tide level, no other change-s otherwise(0)	Earlier flood occasion (2000-2001) cost 300 million (2009 prices). Costs of future events are expected to be similar in magnitude, possibly slightly lower because there is a greater readiness, available machinery, tools and materials (0)	Costs associated with decreased mobility and delay, lost or reduced production. Attraction value of the municipality may decrease in relation to flood occasions. Insurance costs and insurance issues, liability investigations, claims, loss of confidence in the municipality and reduced attractiveness of the municipality in general (0)	Greater flexibility because you have not lock into any stationary measure, but inflexible as the city limits from a future perspective if measures is not taken. (0)
Long term	Elevated emissions locally due to increased pumping and urgent action efforts, and after work to repair damage. (-	Elevated emissions locally due to increased pumping and urgent action efforts, and after work to repair	Very high emissions of particles, etc. locally as a result of increased pumping in the acute stage, and in after work to repair damage and in cases of urgent action efforts	More pollutants, including nutrients, chemical pollution and toxic microorganisms into Kyrkviken with storm water, overflow and tributaries (sewage network and	No major changes (possibly a risk of flooding leading to the disruption of industrial operations and similar, and disruption of	Increased precipitation may cause increased erosion and flooding which can lead to loss of use key parts of Arvika (alternatively, steps may need to be	Increased energy consumption due to increased pumping and emergency action efforts, and after work to repair damage. (-1)	Increased consumption of raw materials (especially fuel) due to increased pumping and emergency action efforts, and large consumption	Discomfort, loss of comfort and functionality in the city on the flood dates, nuisance with action efforts and in connection with after work and the work to repair the	The above costs related to heavy rain will arise more frequently than before. (-2)	Infrastructure is not working which means that if it becomes frequent flooding, large parts of the city can not be used and the city's service fails. The above cost	

	1)	damage. (-1)	undertaken (transportation, machinery, etc. - high particulate emissions, etc.) (-2)	treatment plant). The treatment plant is not working as it should in an emergency, which means less purification, thereby increasing load (dilution reduces treatment). (-2)	electricity, water and sewerage network, which can lead to the emission of pollutants that can contaminate the soil). (0) (Can do a site-specific study of the risk in the event-giving concerns.)	taken on an individual property level) to maintain the current usage. (-1)		of raw materials for after work and to repair damage (-2)	damage, any loss of personal items and possibly including destruction of homes and more. (-2)		will arise more frequently than before and the attraction value of the municipality falls for every occasion. (-2)	

Measure	Global warming	Large-scale air quality	Local air quality	Water quality	Land quality	Land resources	Energy	Raw materials	Wel-being/perceived welfare	Direct costs	Socioeconomic aspects	Flexibility
1: Flood protection in the Straits (main alternative to this solution is to put concrete dam or hinged doors) – short term	Increased emissions due to construction work (-1)	Increased emissions due to construction work (-1)	Increased emissions due to construction work (-1)	As below but less frequent than with future climate (0)	As below but less frequent than with future climate (due to torrential rain and normal climate variability) (0)	Some intrusion into the natural environment resulting from construction of dams and roads and the need for storage of dredged material during the working phase (-1) very short-term	Increased energy consumption due to construction work and increased pumping at the occasions with increased prrecipitaion but to less extent than without the protection. (-1)	Increased consumption of raw materials due to construction work. It can also be increased pumping at times of high water levels and consumption of raw materials for treatment of heavy rain, but less frequently than those below. (-1)	Perceived concerns about possible flooding times reduces, but the locally changed land view can have a negative effect on individuals, those living outside the defended area may feel that the they are not protected as much as the other citizens, there may be expressed among somet hat money may not be used on the right things which can have a negative impact on welfare and subjective well-being. It is therefore a mix of positive and negative, but our assessment is that it is mostly positive, ie. moderately positive. (+1)	82 million in construction costs. The downpours could mean costs to repair damage in and out of the protected area. (-1)	Possible creation of jobs associated with construction, you can use the city's essential services even in flood times. Some cultural values are negatively affected. Secondary costs because rail and road can be flooded (outside the protected area) affect the accessibility and availability. In this case, there may be insurance costs and liability investigations, etc., and loss of confidence and reduced attractiveness of the municipality in general (0)	The protection is flexible which contributes to a high, very high, flexibility, apart from the values that completely disappear in connection with the construction. (1)
Long term	Slightly increased emissions during maintenance work. Increased pumping when there is a flood and possible	Pumping occasionally, very small emissions as a result of increased pumping and possible contribution by the rerouting of	No significant emissions that affect health and the environment at local scale (the energy that can be used is	In the long run significantly reduced risk of leakage from flooded streets and harbor area, reduced risk of disruption in the VA	Significantly reduced risk of leakage from the activities protected by flood protection, which means that the risks of	The possibility to use land is much better than not to take any action because the flood risk is reduced for a large part of society. However,	Slightly increased consumption resulting from pumping when there is a flood, some redirection of transportation and any action in connection	There may be some increase in consumption by some measures at rainfall and increased pumping at higher water levels (-1)	Reduced inconvenience and greater functionality in the city on flood times than with no action. Pumping can make noise in connection with the use of protection. Sustained reduced	Moderate cost of maintenance and operating costs. Costs associated with the torrential rain, as for no action, but more	That you can use the city's essential services even in flood times. Remaining is that certain cultural values are negatively affected. Apart from that it can not be expected to	

	contribution from the rerouting of traffic in areas not protected by the measure (more controlled, energy-efficient and less emissions than more acute pumps and acute operation) (-1 - 0)	traffic (because the energy that can be used is controlled by small NOx and other emissions) (0)	controlled by small NOx and other emissions) (0)	system as compared with no action. But even if the risk of flooding is reduced, even for this measure it will leak out more pollution in Kyrkviken due to increased rainfall and heavy rains. (-1)	pollution that affect soil quality decreases compared to not take any action at all (0)	many properties are affected today outside the area that can be protected and decision has been taken in respect of construction in areas that may be flooded. Roads are eroding today, and it requires maintenance. (1)	with flood occasions outside the protected area (0 - see Air Quality)	It prevents that much is destroyed, the use of resources will then be 0 compared with today with no action. (0).	accessibility in areas not protected by flood protection. The value will depend on the frequency of heavy rain, but we assume these increases in the future, but because the city can live in spite of floods this action is considered as very positive in the long term. The overall assessment without further action is (+2).	frequently and it is potentially a more vulnerable system that require more maintenance and supervision. (-1)	create several new jobs it is as above, but more frequent and possibly more widely.	

Measure	Global warming	Large-scale air quality	Local air quality	Water quality	Land quality	Land resources	Energy	Raw materials	Wel-being/perceived welfare	Direct costs	Socioeconomic aspects	Flexibility
2: Increased dimensions of existing pipes, new pipes and retention basins	Short time perspective: the manufacture and building machines during construction. Very short temporary response (0). Long-term (0)	Short time perspective: the manufacture and building machines during construction. Very short temporary response (0). Long-term (0)	Dusting and some particulate emissions at construction (-1) Long-term (0)	Drinking water has no effect, reduced risk of storm water overflow, and thereby potential reduced load on Kyrkviken , function in the plant is maintained. Short term (0) Long term: reduced burden on Kyrkviken (compared with no action) (1)	Not affected (may possibly get some contamination increase due to pollution of surface waters, the scale depends on the degree of pollution, and which pollutants (degradation ability) (0) (0)	Claims of land for the magazine + construction works (0) short term (1) long term.	The same conditions as for global (0) (0)	The same conditions as for global (0) (0)	Positive much anxiety disappear (basement is safe) city picture is improved, awareness of water + beautiful waterways (2), (2)	According to Matrix 1: (-2) short-term In the long run (0)	Beautiful city more attractive for inhabitants (1), (1)	Very high. No "no-regrets" solutions, but the ability of handling large quantities of water when there are heavy rains (2)
Back-flow stop (ultimately - direct dialogue between property owners and municipalities) (can be stand-alone measure, but in this matrix and in particular in matrix 3 of previous compilation, we assume that there is a	e same conditions as above, the otherwise dominant of alternatives 2 and 3 (0) (0)	e same conditions as above, the otherwise dominant of alternatives 2 and 3 (0) (0)	e same conditions as above, the otherwise dominant of alternatives 2 and 3 (0) (0)	e same conditions as above, the otherwise dominant of alternatives 2 and 3 (0) (0)	e same conditions as above, the otherwise dominant of alternatives 2 and 3 (0) (0)	e same conditions as above, the otherwise dominant of alternatives 2 and 3 (0) (0)	e same conditions as global (0), (0)	e same conditions as global (0), (0)	tisfied property owner with the cellar-problem fixed (1), (1)	e measure can be costly for the municipality, because of the number of properties that must be addressed and to what extent municipal / property owner is responsible for the cost (-1) short, 0 long-term as above If the only measure (0)	The contribution of these individual effort does not affect the local socio-economic level, but large parts of the municipality is addressed in this option as before (action 2 and 3) if the only action (0), (0) otherwise (1), (1) Choose to work with now as a mixture with (2 / 3)	If individual action remains flood risk in heavy rain in several places (1), if accompanied by measures (2 / 3) remains the high flexibility (2). Choose to work with now as a mixture with (2 / 3)

mix of measures 2 and 3 above)										(0) Choose to work with now as a mixture with (2 / 3)		
Information for property owners what they can do on their sites = self help	only individual efforts that are expected to be small in the context	only ndividual efforts that are expected to be small in the context	only individual efforts that are expected to be small in the context	only individual efforts that are expected to be small in the context	only individual efforts that are expected to be small in the context	only individual efforts that are expected to be small in the context	only individual efforts that are expected to be small in the context	only individual efforts that are expected to be small in the context	ay be perceived as impositions (0) but increased awareness (1) long-term	or the work required by municipal officials in the short term, long term 0	Not expected to affect socio-economic (0) (0)	If only this action would be taken into account so little impact (1). if accompanied by measures (2 / 3) remains the high flexibility (2). Choose to work with now as a mixture together with (2 / 3)

Comments:
Proposal: Writing storm water policy for new areas for both the purification and capacity (internal working documents and information to the municipality)
Information activities is likely to have an impact, but because its contents could affect more than the aspects mentioned in the matrix above, we do not proceed with it in matrix 3.
Range is chosen based on the options we are discussing (ie maximum 2 and minimum -2 is used). If we had choosen the options we have not worked with further from matrix 1 the spectrum probably would have been different.

Basis: Matrix 1
Working group: Anders, Maria, Elin, Ramona, Yvonne

Appendix 2 - Melhus

Matrix 1 for case Melhus

Action:	Identification of consequences	Rough estimate of costs for action/consequenses
Zero alternative (no action)	Short time perspective: Little or no change in comparison to current situation. Lont time perspective: More sealed plains. CC: Increased run off and more intensive/heavy rain. This will cause basement flooding and flooding of infrastructure : Water and storm/sewage water, electricity (e.g transformation station at Strandveien, kote 6). Interuptions in telephone and internet. Flooding in Gaula, like risks: Flooding of houses and other areas and infrastructure. Increased erosion and landslide risk (9 out of 10 land slide occasions are said to be due to a combination of wrong filling and precipitaion events). Contaminataion will increase due to leaching from agricultural areas and mis-coupling of water/sewage pipings.	More frequent land slides and flood events. More frequent financial compensation and regress demenands from ensurance companies on the municipality, increased costs for house owners and in general. Social cost and worries about water damages, Reduced life qualtiy.
Action 1: Disconnecting water drains	Pros: Easy, cheap, reduces the amount of flood water and may also reduce some of the flood top (magnitude), takes away the need to upgrade (increase the pipe dimension) the water and sewage system in use today. Flexible system.Cons: Thre may be infiltration problems in claiy soils, new uncontrolled flood/water ways, rivers that need to be erosion secured, and/or rain beds, ie the measure may need further measures. Impact of ising during winter? Will the water still flow into the existing water and sewage system? Fredrikstad municipality (Ole Petter Skallebakke) can tell more on the pros and cons.	Short time perspectivet: OK. Technically low costs, but there will be a need to inform the ones that may be impacte, need to increase the knowledge base and awareness among politicians and the public.May demand new actions such due to or to prevent excavation and erosion.
Action 2: Rain garden	Pros: Reasonable establishment. Many can do it. Reduces the impact on the water system and reduces the flood top. Looks good, increase the biodiversity. Construction afterward is possible. Cons.: Need space (but creates green areas). Need to be loked after of estecial reasons, which demands interest among hte landowners. Fincincial contribution for establishment? Will need drainage and excavation to change clay, when the dominating soil, into gravel/sand - a cost.	Cost when establishing. Cost for municipal opretaion of municpal rain beds. Saving in relation to other actions that are avoided by this measure instead of more expensive measures.
Action 3	Retardation baisin, below surface	
Action 4	FInancial insentives: Reduced muncipal fees (for what?)	
Acgtion 5	Spatial plan	
Action 6: Controled water/flood routes	Pros: Awareness/knowledge on where the water/flood will run. Controlled run off. Can be a positive supplement to green areas and structures. Can manage large amounts of precipitation.	Mapping is costy.
	Cons: Areal demanding, the area can not be used for buildings or other constructions. Need to inforce the rivers (to avoid erosion and to ensure the water way).	

Matrix 2 for case Melhus.

		Health and environment			Resources		Social and economic impacts			Flexibility	Risk	Target
	Contribution to global change	**Air quality, (acidification, eutropfication, toxic gases and air borne particles)**	**Ecologic status in water and water coarses**	**Land use (plan and use)**	**Energy**	**Raw material**	**Perrcieved welfare**	**Direct cost for measure/consequence**	**Sosio-economic impacts**	**No regret**	**Status for risk due to flooding and consequences due to that.**	**Goal: 1. No mortalities (due to flooding). 2. Individual management and awareness. 3.Reduced ecomic losses.**
Zero alternative (no action)	-	-	Sea trout threatened. No good spawn conditions	More and more frequent seald plains	-	-	Some unsafetey and uncertainty in comparison to nature damages	-	-	-	Some risk for flooding and landslides already today.	-
long time perspective	Possibly some negative impact due to acute actions at events with flooding/landslides (eg pumping and transportation).	Possibly some negative impact on particulates and NOx due to acute actions at events with flooding/landslides (eg pumping and transportation).	Sea trout may vanish. Increased risks for leaching of e-coli, phosfate and other nutrients to water courses.	Even more sealed plains. Faster run off. Some areas may not be able to be in use (eg Varegga)	Increase electricity costs, shorter pump life times	Some increased use of material	Increase unsafetey and uncertainty at home nad more unpleasant ground level flooding etc.	Likely increased costs for renovation and other acute measures due to flooding and landslides	Pros: Positive for entrepreneurs.Cons: Negative for the habitants in the municipality. Less attractive for new establishement. Moving inside/out of the municiapility.	More frequent acute situations. Less alternative solutions when acute siutations. Larger costs when large expansions in hazardous areas.	Increasing risk	1. Does not contribute to fulfil the goal. Increased risk for mortal events due to flooding and landslides. 2. Increased awareness due to more frequent events. The ability for private managment (self help) is related t o

												the financial status in the municipality and less service from the municipality. 3. Low fulfilment of the goal. Increased costs.
Action 1: Disconnecting water drains	No significant impact	As global	Mulighet for noe utvasking av næringsstoffer i jord i det takvannet renner over plene og vasker ut.	minimal	minimal	minimal	less hunidity in the cellars, if the construction is not done properly: there is a risk of slipping on the pipe and the humidity may remain (increase) but if done properly these risks will not appear.	minimal cost for investment over time some reparation of the construction may be neededreparasjon av konstruksjonen (minimal investeringskostnad)	little	high flexibility	very efficient	2: Høy. 3. Normalt god reduksjon, sparer VA-investering.

long time perspective	Ingen signifikant påvirkning, ingen kunnskap?	som over	Possiblyt better stauts for fish due to less flow tops(magnitudes)	Same land use, possibly there will be a need of additional measures. Føringer i arealplan=?	minimal, but may need additional measures, less pumping	minimal, but may need additional measures, less pumps	more attractive living due to more water in the area.	The measure lasts very long but may need additional measures.	little	When being used in new built areas: Sliglty less felxibitiy due to no available pipe system, very high flexibilty in built up areas with exisiting storm water pipe system.	Very efficient, we think..	2: High. 3. Normally good reduction, saves water and sewage system investments, the costs for the municipality will not increase due to the investments.
Action 2: Rain garden	Some cost	Minimal positive impact.	Redused run-off	Need decisions in the spatial plan. Other use of the land. More green areas.	Very little energy in the establishment phase (depend on how the constrructio n is done and type of soil)	Soil, when shifting for example clay to gravel/sand	Increased green areas, increased percieved wellbeing for the habitants in the area	Some cost when establishing (from almost zero to some ten thousends as the cost depend on the type of soil)	Minimal, but some increase in activity among entreprenears for rain bed establishent and plant nurceries	high flexibilty when establishe d in built up areas (where there is an exisitng storm water system)	Reduced risk	2. Increased awareness? 3. Reduced economic losses.
long time perspective	Recuded contribution to global warming	Minimal, but positive impact	Reduced run-off, may achieve increase water quality due to natural processes in the soil.	Bestemmelser i arealplan. Annen bruk av areal. Mer grønnstruktur	No or minimal	No or minimal	Increased green areas, increased percieved wellbeing for the habitants in the area	Minimal	Healthier habitants, attractive municipality, reduced transport and more local activity.	stor fleksibilitet ved etablering i gammel bebyggelse, mindre fleksibilitet i nye områder.	Reduced risk	2. Increased awareness? 3. Reduced economic losses.

	Health and environment			Resources			Social and economic impacts			Flexibility	Risk	Target
	Contribution to global change	Air quality, (acidification, eutropfication, toxic gases and air borne particles)	Ecologic status in water and water coarses	Land use (plan and use)	Energy	Raw material	Perrcieved welfare	Direct cost for measure/consequence	Sosio-economic impacts	No regret	Status for risk due to flooding and consequences due to that.	Goal: 1. No mortalities (due to flooding). 2. Individual management and awareness. 3.Reduced ecomic losses.
Action 3: Construction of controlled water ways	Large negative impact due to the construction											
long time perspective	No or little impact											

Matrix 3 for case Melhus.

		Health and environment			Resources		Social and econoic impacts			Flexibiliy	Risk	Targets
	Contribution to global change	Air quality, (acidification, eutropfication, toxic gases and air borne particles)	Ecologic status in water and water coarses	Land use (plan and use)	Energy	Raw material	Perrcieved welfare	Direct cost for measure/consequence	Sosio-economic impacts	No regret	Status for risk due to flooding and consequences due to that.	Goal: 1. No mortalities (due to flooding). 2. Individual management and awareness. 3.Reduced ecomic losses.
Zero alternative (no action)	0	0	0	0	0	0	0	0	0	0	0	0
long time perspective												
Action 1: Disconnecting water drains	0	0	-1	0	0	0	0	0	0	2	1	1
long time perspective	0	0	-1	0	0	0	1	1	0	2	2	1
Action 2: Rain garden	0	0	0	1	0	0	1	-1	0	2	1	1
long time perspective	0	0	1	1	0	0	1	0	1	1	1	1
Action 3 short time perspective												
long time perspective												

Statens geotekniska institut
Swedish Geotechnical Institute
SE-581 93 Linköping, Sweden
Tel: 013-20 18 00, Int + 46 13 201800
Fax: 013-20 19 14, Int + 46 13 201914
E-mail: sgi@swedgeo.se Internet: www.swedgeo.se