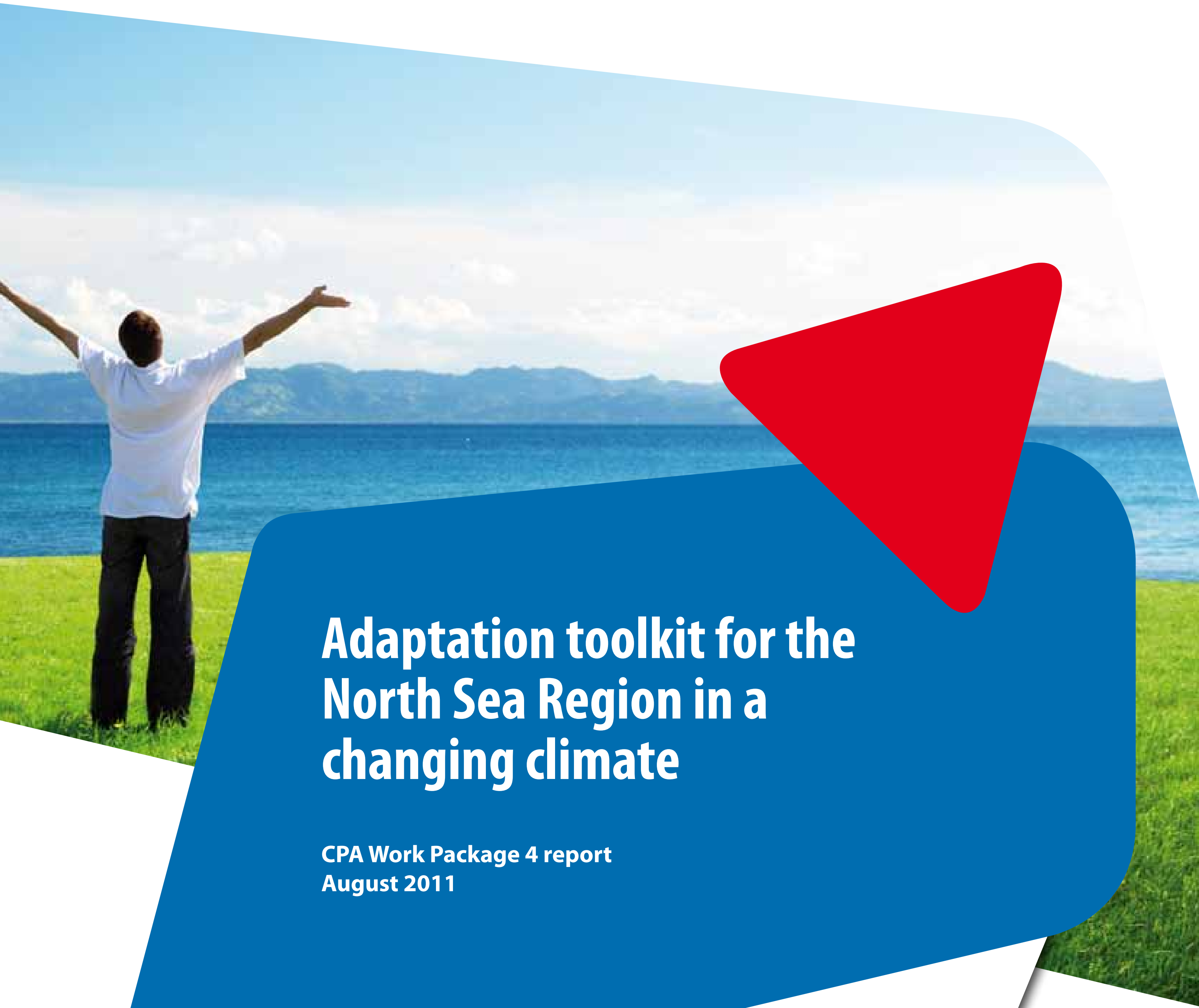
CLIMATE PROOF AREAS
TIME TO ADAPT



Adaptation toolkit for the North Sea Region in a changing climate

CPA Work Package 4 report
August 2011

The Interreg IVB North Sea Region Programme

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Preface

This document is a product of the Interreg IV-b project Climate Proof Areas (CPA). It is intended to assist process managers who are setting up or managing a process of climate proofing an area. This report describes the experiences of tools used by the CPA project team.

As you might have experienced, climate proofing is an undefined problem. This means that there is no clear definition or agreement on what climate proof is and what solution(s) should be applied. Good process management is therefore very important. Part of process management is to use a proper set of tools in the proper way. This toolkit aims to give insights into the kind of tools that can be used in the process of climate proofing.

Climate adaptation is often a response to problems that are already existing or becoming apparent in the near future. Climate adaptation is therefore not only a long term planning issue, but also needs to be considered in current decision making.

The authors would like to thank the other CPA-participants for their valuable contributions to this toolkit.
We hope this toolkit helps the readers in finding a way to adapt your area to a changing climate.

The authors.

Niels van Oostrom (Deltares, Netherlands)
Yvonne Andersson-Sköld (SGI, Sweden)
Helge Bormann (University of Oldenburg, Germany)
Ger de Lange (Deltares, Netherlands)
Lybrich van der Linden (Deltares, Netherlands)

1 Introduction

Climate change will have effects on different sectors (e.g., water management, agriculture, living and recreation) in the countries of the North Sea Region. This is investigated and concluded in the Climate Proof Areas (CPA) report "Comparison of climate change effects across North Sea countries"[1]. It requires at least attention and awareness of possible problems or opportunities in the future. This toolkit aims to be helpful in an adaptation process by offering an overview of experiences with supporting climate adaptation tools.

Climate adaptation can be considered as a project or a process or something between this. It can be a project working stepwise towards a vision of an area in the future or as an ongoing process of progressive steps towards a new (undefined) situation. The new situation or vision does not automatically refer to changes in the physical system alone, it also refers to another way of experiencing and utilising the opportunities and threats that are imposed by another climate.

1.1 The project Climate Proof Areas

The aim of the Climate Proof Areas project is to accelerate the climate change adaptation process in the North Sea Region (NSR) by means of joint development and testing of innovative adaptation measures. This is done in demonstration (pilot) locations that are exemplary for the NSR as a whole. The CPA results are used to give recommendations for regional, national and NSR wide adaptation strategies. One specific part of the project is to create a toolkit for adaptation in the NSR, thus helping prepare these regions, countries and the NSR for anticipated changes in the climate.

CPA aims to work on a strategic, NSR wide (top down) approach and on a more concrete level (bottom up). On the strategic level, the partnership aims to improve national and regional climate change adaptation strategies by means of working together on innovative pilot adaptation measures, combining all available expertise.

The innovative pilots comprise a real life adaptation test lab in the NSR. This practical experience is currently lacking due to lack of experience in developing and implementing concrete and innovative adaptation measures. This will be proposed to the members of the North Sea Commission in order to create a certain level of political support which promotes future implementation of the results. The NSR adaptation toolkit is meant to transfer the practical experience to all NSR stakeholders and accelerate the climate change adaptation process in the NSR as a whole.

This project also intends to improve adaptation policies on a regional and national level by means of targeted communication actions to the various political stakeholders. The EC representatives will also be invited to the closure conference and informed bilaterally in order to provide input to the Blue Print to Safeguard Europe's Waters[2].

1 De Sutter, R., B. Verhofstede, Comparison of climate change effects across North Sea countries, CPA work package 1 report, February 2011
2 European Commission DG Environment, A blueprint to safeguard Europe's waters, background document - water directors' meeting 26-27/5/2011, May, 3rd 2011

1.2 Aim of this toolkit

It is the ambition of CPA in general, and the toolkit in particular to offer a practical guidance for identifying and using helpful tools. The intended users of the toolkit are primarily process managers who are setting up or leading adaptation processes. They will be provided with inspiration through our experiences and recommendations.
In complicated decision processes, like climate proofing, it is not always obvious which tools are effective and appropriate. This toolkit will shortly describe the adaptation process and offer our experiences with tools in the 'Climate Proof Areas' project. It is not meant to prescribe what actions have to be taken. Climate proofing is too illusive, location specific and situation dependent.

This toolkit is both a toolkit and a practical guide to identify and use tools in such a manner that will lead to advancement in the decision making process.

Tools are not easily classified into groups; the purpose of the tools is complex and they can be used multi-functionally. Therefore guidance is needed in which the use of the tools in practice is described. The aim of this toolkit is to give examples and experiences on tools from the CPA pilots. In addition it refers to other relevant information sources.

The aim of this toolkit is not to be a manual, but to be a guidebook with examples and experiences of tools. The descriptions of the tools have been made generic, but are based on the experiences in the CPA-pilots.

1.3 Work method and outline of the toolkit

Chapter 2 gives an introduction on the theory of an adaptation process and the role of tools in these processes. It starts with a short introduction to the observed climate changes and their effects on the pilot locations. This introduction is based on the work from work package 1 of the 'Climate proof Areas' project. After that, some remarks about and characteristics of the adaptation process are made to highlight some insights into the challenges of climate proofing.

In this report the decision process will be simplified in order to have a clear outline of the report. Therefore a schematization of this process into a problem solving cycle model with 6 phases will be used. This model is explained in section 2.4. In section 2.5 the definition and the role of tools is described.

In chapter 3 some process oriented tools are described. These tools have a role during many phases in the problem solving cycle. In the chapters 4 through 9 the tools that can be used in the different phases of the problem solving cycle are mentioned. This is done by an overview of tools used in a table. Besides these tools the pilot members have named some tools as recommended tools. These tools turned out to be very useful when dealing with climate proofing in the pilots. These tools are further analyzed on how they were used and what the added values they had for the pilot process. Each chapter ends with some short conclusions about the tools in the respective phase.

In chapter 10 a reflection and general recommendations are given about the tools.

The information in this toolkit is based on the experiences in the pilots of the CPA project. In the pilot areas the involved parties have made progress in the decision making procedure for climate proofing. The tools mentioned in this toolkit have been applied in order to support the decision making process in the pilots. As most pilots have not yet completed the whole problem solving cycle, most tools are identified in the first process steps. Per step and at the end for the whole process there are some remarks and recommendations added as a reflection on general application of these tools.

1.4 Position of the toolkit in the CPA project

A range of locations that is representative of the NSR as a whole are brought together in this project. The project plans of the pilots were developed transnationally and integrally in order for each pilot location to benefit from specialized knowledge of all other partners. This illustrates integrated thinking, combining safety issues and water management with nature conservation and management, opportunities for tourism, urban development and infrastructure etc.

All project results will be collated in recommendations for a NSR climate change strategy, which will give an overview of the expected impact of climate change on the NSR, main options for adaptations, a methodology to develop a regional adaptation strategy and a contingency overview of viable adaptation measures that could be taken given the situation. In this toolkit, only tools that have been applied within the CPA project are presented.

Work packages of CPA

The project is structured into 5 work packages: WP1 Analysis, WP2 Developing and testing adaptation measures, WP3 Policy recommendations, WP4 Adaptation toolkit and WP5 Project management and communication.

WP1 (coordinator University of Gent) focuses on gathering, updating and synthesizing all existing information on the expected impact of climate change on the various partner regions involved in the project and create a NSR wide impact analysis.

WP2 (coordinator Rijkswaterstaat Zeeland), Pilot adaptation measures, is focused on the joint development and testing of various innovative adaptation measures. The range of sites represents a real life innovative test lab in the NSR where innovative adaptation solutions are developed jointly and tested.

WP3 (coordinator University of Oldenburg), Policy Recommendations, builds on the results of WP1 and WP2. The practical pilot experience is evaluated and used to make recommendations to the existing regional and national adaptation strategies from an integrated point of view where issues of safety, water management, nature, agriculture, tourism and urban development are all considered and combined (Memorandum of Understanding and Political Statement)

WP4 (coordinator Deltares) is focused on synthesizing all the project results in an adaptation toolkit for the NSR. The toolkit gives an overview of tools to identify the expected impact of climate change on local scale, main options for adaptation, practical guidance and a methodology to develop an adaptation strategy and a contingency overview of viable adaptation measures that could be taken given a particular situation.

Finally WP5, Project management and communication, ensures sound international project and financial management and communication, including controlling project activities, deliverables and finances, international co-operation structures and the development and implementation of a communication plan, which will mobilize political support for the adaptation policy recommendations on all levels.

Connections between the work packages

The main work in CPA is done in the pilots (WP 2). The activities in the pilot areas are the main source for all the findings in this project. In work package 1 the impacts of climate change for the different regions are highlighted and then collated and general conclusions for the NSR region have been drawn. The conclusions on the expected impacts are the basis for the pilots to continue searching for adaptation strategies. For WP 3 and 4 the conclusions from WP 1 define the urgency to draw up a Memorandum of Understanding and Political Statement respectively a toolkit for easing the process to evolve towards more climate proof areas.

In the pilots, as well as during the writing process of this toolkit, conclusions about the usefulness and/or lack of tools were drawn. Combined, the results of all work packages describe the whole process from starting with a climate change via climate effects, climate impacts, an adaptation process (including the tools) to a decision about required measures. The WP 5 communication is aimed at a broader spread of all the messages that have been formulated in the project.

These connections show that it is important to see this toolkit as a part of the results of the CPA project. The stand alone tools themselves do not represent any added value without the realization that they are just tools and not objectives themselves. The toolkit itself is a guidance that is meant to be helpful in a climate adaptation process, but will not describe all aspects of climate adaptation. To receive a more complete insight of climate adaptation, reading the additional information from the other work packages is strongly recommended.

In the Memorandum of Understanding (WP 3) recommendations about the development or enhancement of some tools are made. The main findings of this toolkit have been added to the MoU in an appendix. By writing in this toolkit about the tools that are used in processes, it is evident that there must be something said about the process itself. This is kept short in this toolkit as WP 2 and 3 are elaborate more on this.
In the WP 2 reports the pilot based processes are described. In WP 3 the adaptation process on a higher (abstraction) level was influenced by formulating the Political Statement and eventually adopting it on the NSR level.

2 Tools for climate proofing

2.1 Climate change in the NSR

The effects of climate change in the NSR are described in the CPA Work package 1 report[3]. In this paragraph a summary of this report is presented. The climate change effects are the main drivers for climate adaptation and for that reason a summary is incorporated. This toolkit is complementary to the work of WP 1 by offering tools for enabling measures to prevent, decrease or utilize these impacts on different sectors.

It is clear that the projected change in climate will significantly impact the hydrological cycle in all NSR countries. The issue of sea level rise is well documented. Due to a warmer climate, evaporation will increase, the magnitude and frequency of extreme weather events will increase, and so hydrological extremes such as floods and droughts are also likely to be more frequent and severe. A changing precipitation regime will impact run-off, sediment transport, water quality and groundwater levels.

The range of problems, as summarized above, encountered (or assumed to occur) within the different North Sea Regions show numerous similarities. However the awareness and hence the knowledge of the different effects is quite varied. This difference in awareness seems to be the case in most countries.

3 De Sutter, R., B. Verhofstede, Comparison of climate change effects across North Sea countries, CPA work package 1 report, February 2011

Some of the overall conclusions are that:

- there is need for more detailed, integral and regional information about the effects of climate change;
- it remains unclear whether the available data and climatologic scenario models currently allow further downscaling and integrated assessments, there should be no more delay to invest more detailed and integrated assessments on a more local (catchment) scale;
- more work is needed on the determination of "tipping points". For what "value" (of temperature, rainfall intensity, number of droughts, …) does the situation become intolerable, unstoppable, …
- the sensitivity of each sector will be determined by the influence of (water-related) climate change effects on the functioning of the system.
- sector specific assessments should incorporate socio-economic scenarios in parallel with the climate change scenarios. Demographic change, land use change, economical and technological developments - regardless of climate change or partly influenced by mitigation policy – will also affect (increase or decrease) the vulnerability and resilience of NSR ecosystems, infrastructure and human settlements;
- there is a general lack of political interest at the local level (e.g. municipalities), which is in strong contrast to the belief in and urgent need for local solutions and a planning approach based on local socio-economic and climate change effect conditions;
- adaptation policy is not a "new policy" or thematic issue, but there is need for a common goal, namely which decisions have to be taken now to adapt to the future?
- a hesitating role of spatial planning in the adaptation strategy is perceived;
- although the planning tools should be assessed for the challenges of climate change, a clear need for "space for climate change adaptation measures" (or an efficient sharing of space) seem to be present;
- from the organizational point of view, it is often unclear who is responsible for developing and implementing an adaptation strategy at the different policy levels. For that reason the importance of stakeholder identification and integration in any adaptation project cannot be underestimated.

2.2 Adaptation process

Climate adaptation cannot be achieved by a single or simple decision. It is intertwined with many sectors i.e. water management, spatial planning and private interests etc. Climate change is already an issue (see paragraph 2.1), although more significant effects may occur in future; connecting these with present day problems and solutions makes climate change more tangible.

In climate proofing, a difference in comparison to everyday decision making are the levels of uncertainty that have to be considered. As the climate scenarios are uncertain and varying on different scales, so are the potential impacts (IPCC, 2001; 2007). Consequently, the solutions and adaptation strategies may vary for a region, even within a region, and among different municipalities. For long term solutions there is a need to evaluate flexibility and sustainability of solutions and adaptation strategies under various conditions. The potential solutions and actions are often new, with low or no experience of their performance under different conditions. Another aspect that is specific for climate proofing is the varying level of awareness and perception of climate change and its impacts.

The uncertainty and high degree of variation demands a systematic and transparent decision making process, creating options for a successful interactive and iterative decision process thereby offering potential for a new sustainable strategy. There are various levels and tools that can be used for successful participatory processes.

Tools for climate adaptation are not just meant for implementing a single solution, but are mainly aimed at retrieving and/or adjusting perspectives of different sectors and parties. Most of the time climate adaptation is about incorporating (views on) climate effects into the decision process.

For any certain action, especially systematic, a decision process is involved. A systematic decision procedure includes several steps, which are mentioned and explained in section 2.4.

In the literature and elsewhere there are several methods describing potential procedures and suggestions of methods. For those who want to read more and find more information, please see for example the climate adaptation web-portal in Sweden[4] and results from previous Interreg projects such as Comcoast[5] presented in Ahlhorn, 2009[6] .

The appropriate steps and their content depend on what action is being considered and under which conditions or context. In general, however, the process is recommended to be transparent, iterative, interactive and participatory. This is also the case for decisions for climate proofing (IPCC 2001[7], Ahlhorn 2009, Climate adaptation web-portal[8] (Klimatanpassningsportalen)).

A successful decision process is transparent, iterative, interactive and includes all relevant stakeholders from an early stage of the process.

Although process management (or the specific tools for good process management) itself is not further elaborated in this toolkit, it is very important to contemplate the process and the intended purpose of the process. Writing down these purposes and the required activities is essential. When the process deviates from the time path or intended purpose, it is easier to correct the process or to oversee the consequences of a (desired) deviation. The first sentence in this box is not a hollow phrase, but an experienced conclusion from the pilots. We therefore recommend to set up a climate adaptation process that is transparent (being open about the goals and the planning), iterative (it is not always a step back to go back to an earlier stage of the process, sometimes it is needed because of changing circumstances) and includes all relevant stakeholders (who a stakeholder is, is dependent on the objectives and solutions and can vary during the process).

4 The Swedish climate change adaptation web-portal (in Swedish) http://www.smhi.se/polopoly_fs/1.8068!image/10%20steg.png_gen/derivatives/fullSizeImage/10%20steg.png

5 www.comcoast.org

6 Ahlhorn, F., Long term perspective in Coastal Zone Development, multifunctional coastal protection zones, Universität Oldenburg. Springer Verlag Berlin, ISBN 978-3-642-01774-2, 2009

7 IPCC, 2001: Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Integov ernmental Panel on Climate Change [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp.

8 The Swedish climate change adaptation web-portal (in Swedish) http://www.smhi.se/polopoly_fs/1.8068!image/10%20steg.png_gen/derivatives/fullSizeImage/10%20steg.png

2.3 Characteristics of climate proofing

Climate proofing has a couple of characteristics which make these processes more complex than other decision processes. These characteristics make it rather unlikely that a simple solution, in an isolated sector, can solve the problem. Projects with the purpose of climate proofing an area can, or will, differ from other regular projects on these characteristics:
1. Long term decision making and short term measures
2. Regional and national scale
3. Uncertainties due to (the sum of) incremental deviations
4. Restricted commitment and low sense of urgency

In order to make a toolkit that is suitable for climate proofing, it is useful to create an overview of tools that can be used to deal with these characteristics besides the tools that are regularly used in other kind of projects. These characteristics will be used further on in the toolkit to evaluate the tools that were used in the pilots.

Long term decision making and short term measures (time scales)

Climate change will evolve during the coming century. As a result, climate proofing is a process that will continue on a long term. This requires continuous attention when taking measures for current problems. On the other hand, it is a challenge to achieve short term measures which are meant for supporting the long term vision in which climate adaptation is incorporated. Not every sector has the same perspectives on time scales and the need for further measures at a short term.

Regional and national scale

Climate change occurs on large scale (world wide/Europe) and also affects regional and local climate. The related problems on a national scale may be different from a regional or local scale. Some solutions on the national scale may affect the regional scale and vice versa. For problem definition and solutions it is important to take the differences into account when working on climate proofing a region (regional impact assessment, what to do nationally and what to do regionally?).

Uncertainties due to (the sum of) incremental deviations

An almost inherent aspect of climate adaptation is the uncertainty that comes with the predictions and scenarios for the future. This is not only the case for the climate scenarios themselves, but also for the socio-economic development and the un/foreseeable changes in the views of the involved parties (what may be a problem today, doesn't necessarily have to be a problem in 2050). However, using today's problems for raising today's awareness for possible climate change impacts might be useful.

Restricted commitment and low sense of urgency

Climate adaptation is in many cases an abstract problem and for that reason there might be little commitment from several parties to actively join the problem solving process of climate proofing. Climate change itself is a slow process, which makes it difficult to set widely agreed deadlines on the decision-making. This might be a result of a low sense of urgency. Commitment from decision makers in organizations is required in order to maintain a consistent strategy and implement disputable measures.

2.4 Problem solving cycle

Climate proofing an area is not a simple process. In this section a simplified flow diagram of the stages (or phases or steps) in the problem solving cycle is presented and explained.

This model of the problem solving cycle is intended as a simplification of an adaptation (or climate proofing) process. It is meant as a schematization in order to offer a logical framework for identifying and assessing the tools. The precise following of these steps does not guarantee a satisfying outcome. The statement in section 2.2 "A successful decision process is transparent, iterative, interactive and includes all relevant stakeholders from an early stage of the process" should be kept in mind when reading this report.

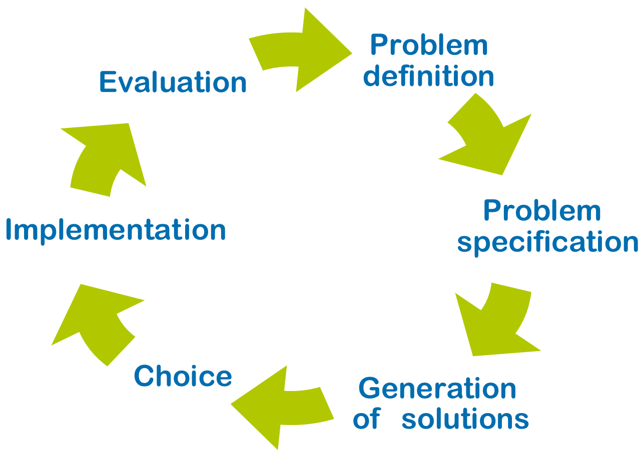

Figure 2.1 Problem solving cycle as a simplification of the adaptation process

An iterative process however implies that there are also smaller loop-backs. For example, when, during the generation of solutions, it is discovered that a party has been overlooked and is crucial in order to successfully implement a solution. To correct this, one has to go back to the problem definition and include the missing party before taking the next step in the problem solving cycle.

The toolkit is structured according to the steps mentioned above and will not explicitly describe the smaller loop backs. This means that the tools will be placed under one step, but the application of the tools will not be limited to one step in practice. Each chapter discusses a different phase or stage in the problem solving cycle. The chapter starts with a table with tools that are mostly applicable in a specific phase. The table provides the reader with an overview of the applicability of the tool within the context of climate proofing.

The purpose of a tool can change if it is used in another phase/step in the process. This can be illustrated by an example of a risk assessment. A risk/win/prevail assessment can be used on several ambition levels. The depth, input, details and robustness of the analysis depend on several factors. The lowest ambition level is to decide if further assessments may be either needed or not. For this ambition, the assessment may be very short or already performed. In later steps of the problem solving cycle it may become necessary to redo the analysis (with the same tool) based on new or more detailed information from several actors.

Problem definition

In time, effects of climate change may occur on local or regional level. On a global level, climate change is widely recognized and acknowledged as a phenomenon that will have an effect on the environment in which we live. This does not mean that people recognize a short-term problem within a specific area. When there is no immediate problem, it is difficult to find a sense of urgency and subsequently commitment among stakeholders for climate proofing. Therefore, it is important that there is evidence that effects of climate change in time can occur. This can be achieved by linking these possible long term effects to already occurring effects. The first step of the process will be raising awareness of a problem holder that there might be a gap between their objectives and the realityof the future state of the physical system.

In this phase problem holders will identify the problem and look around for indications to support their suggestion of the problem. This also includes the exploration of the fields of interest of other possible stakeholders. This phase results in a decision whether or not to further analyze the problem and to constitute a group of interested stakeholders.

Problem specification

In order to determine the sense of urgency for climate proofing an analysis should be done regarding the extent of the effects of climate change, the time scale on which they occur and the impact on different sectors within an area (see CPA WP1 report).

The specification results in more insight in the functioning of the system and quantifies the expected changes and how it affects the different stakeholders. The outcome of this step is common knowledge on the possible effects and the urgency and intention to identify appropriate measures.

Generation of solutions

The analysis provides the basis to appoint a sense of urgency. In this step, possible strategies and measures will be developed to adapt to, or counteract the problems that, have been identified under the previous step. The solutions will be analyzed and pre-selected based on their capabilities of solving (or at least reducing) the problems. The outcome of this step is a list of possible solutions and their characteristics (effectiveness, side effects, costs etcetera).

Choice

In this step an assessment of different strategies will be made. The relevant criteria for a choice will be determined by the involved parties. After negotiation and loop-backs to previous stages (mainly generation of solutions) the parties with decision power will make a choice which strategy and/or measures will be implemented. This is often based on indicators such as costs, durability, maintenance, flexibility etc.

Implementation

After choosing a strategy, the accompanying measures have to be taken. The measures can be physical (i.e. construction of a levee) or the development of policies. Implementation usually gets little attention, but it is in this phase in which outside parties or individuals can become obstructive or the costs exceeds the prospects. Preventing surprises can partly be done in earlier stages (i.e. good stakeholder analysis, cost benefit analysis), but should be done mainly or also in this stage. In these cases loop backs can be needed or adjustments have to be made. The outcome of this step is an implemented strategy and accompanying measures.

Evaluation

After implementation it is important to monitor and evaluate the intended an unforeseen consequences of the strategy and measures. This step is often ignored. In case of a strategy, the evolution of the developments have to be continuously monitored, evaluated and adjusted. When needed additional measures have to be taken. When the problem is not solved or a new problem emerges, a new problem definition is needed.

2.5 Tools

The tools themselves are instruments for supporting the climate adaptation process. This means that the tools are not physical measures like dams, barriers, water storage etc. In this toolkit the focus lies on tools that are helpful in dealing with the characteristics of climate proofing. General process tools are not specifically mentioned in this report, unless they are placed in the context of an adaptation process.

A tool in the climate proofing process is defined as an instrument that facilitates one or more steps. Examples of tools are methods used for identifying, evaluating and communicating the measures that can be taken. They can also be used to facilitate the process to achieve the most sustainable alternative regarding social, health and environment and economic aspects. A tool can, for example, be a guide describing a process, a checklist, a model, an informative map etc. as well as a communication plan. A tool can be used to achieve a calculated result, a map as well as a way to perform a coherent set of actions.

The purpose of a tool is to contribute to advancing the decision making process. Using the tool for the simple reason that it is recommended in this report, does not help any decision process. The value of a tool is dependent on the purpose of the process, the way the tool is used and if the timing of the application is suitable.

In this toolkit the tools used within CPA are presented regarding their purpose, advantages, disadvantages, costs and duration to achieve results. Details about each individual tool and all results from applying them within CPA are described in separate documents (background reports or the CPA work package 2 pilot reports).

In this toolkit a couple of tools have been labelled "recommended". These tools were particularly interesting or were helpful for the pilots in order to reach the objectives. These tools are further described than the other tools. If a tool is not labelled "recommended", this does not mean that this tool is not recommended or rejected by the partners.

The guide also provides a list of tools that can be used, including where to find further information, but they are not further described as they have not been actively used in any of the CPA pilots. Examples of toolkits are:

- UK Department of Environment, Food and Rural Affairs (DEFRA) has made a toolkit named the climate resilience toolkit. It can be found at: www.businesslink.gov.uk/climaterisk
- NL The region Haaglanden, Living with Water, TNO and Deltares have made a Dutch website with tools and planning instruments. It can be found at: www.waterwerkvormen.nl

3 Process management

Process management is not a step in the problem solving cycle, but it is imperative to have a good process management in order to achieve a useful outcome. A good process design and management are critical success factors. For this reason a couple of process management tools that were used in the pilots are mentioned here separately from the process phases of the following chapters.

A very important part of process management is communication. Communication is one of the greatest challenges throughout each step of the decision making process. Once an implementation plan is taking form, the need of successful external communication becomes apparent, not at least to get acceptance for the planned action. But starting with communication at that time is not recommended; communication in different ways is needed in all stages.

There are methods that contribute to successful communication in the planning or rather in the whole decision process. The next sections of this report therefore focuses on the communication tools and methods used within CPA.

3.1 Communications plan

In CPA, in particular for the English pilot location of Titchwell Marsh, a detailed communications plan has been made and actions are taken accordingly.

Communications plan

Purpose and aim of the tool
To enable a project to proceed smoothly through the planning process and to have measures successfully implemented.

Strength
A communications plan is an overarching strategy that assists a project in identifying its key stakeholders - those that are affected by and or have power over the project and thus influence successful implementation. The communications plan assists with gaining support for your project and advertising the project to the right target groups. In order to do this it provides a structured process for ensuring that all the relevant stakeholders are engaged in the project. It clarifies key messages for each audience. It then identifies the appropriate and most effective method and timing of communicating to the stakeholders. There are likely to be many additional communications tools that can be identified with the communications plan that helps to execute the overarching communication strategy.

Weakness
The communications plan is a living document. It needs to be regularly evaluated and updated as stakeholders come and go, views and the external environment change over time. This can be both considered as a weakness as well as strength. However, this requires staff time and in effect a substantial amount of budget to put into place and implement properly.

Relevant data needed or other needs, to be able to use the tool.

A successful communications plan is determined by a good understanding of the surrounding environment. An environmental manager can be of assistance to manage stakeholders and anticipate on changes in the external environment. Basic understanding of the purpose of communications planning is also essential as is the ability to collate information on key stakeholders.

Cost

Staff time / interpretation materials

Duration

Should be established at the earliest possible point within the development of the project to help ensure buy-in from key groups/individuals. It should be monitored and evaluated throughout the life of the project.

Where to find the tool or further information:

Template from the Swedish Environmental Protection Agency (in Swedish):
http://www.naturvardsverket.se/upload/03_lagar_och_andra_styrmedel/ekonomiska_styrmedel/rovinfobidrag/N-mall-kommunikationsplan.pdf
Template from the Gothenburg University (in Swedish):
http://www.gf.gu.se/digitalAssets/1030/1030890_Mall_Kommunikationsplan.doc
http://www.gf.gu.se/digitalAssets/1030/1030891_Mall_Kommunikationsschema.xls

Example: Pilot Titchwell Marsh, United Kingdom

The project helps raise awareness of innovative forms of flood defence as a way of adapting to the impacts of climate change. By raising public awareness and understanding of the issues surrounding climate change and its impacts on our coastlines the CPA project wants to support the Titchwell Marsh Coastal Change Project. CPA wants to educate the public and stakeholders about the necessity of this innovative flood management technique.

How was the tool used?

A communications plan was developed at an early stage in the development of the Titchwell project. The RSPB realized that something would have to change at the reserve in the future even though the exact solution had not been determined. As the site has a big impact on the local economy and is well loved by many visitors, it was evident that there was potential for major difficulties securing a solution. By going through the process of preparing a communications plan it allowed the RSPB to identify the need for early discussions with various stakeholders from local communities, Members of Parliament, decision makers etc. The first stage of the communications plan allowed the RSPB to to discuss the problems that the reserve was facing and to ensure that the problem was recognized and understood by the different stakeholders. The benefits of the communications plan were due to the fact that it was applied at an early stage in the process, and there was a good understanding of the role Titchwell Marsh played in the regional community. By discussing problems early on, the stakeholders became owners of the problem. This created commitment for discussions about the solution.

In which phase/stage/steps was it used

The communications plan has been used at the onset of the project and was evaluated and adapted throughout the different stages of the project.

Who used the tool and who was involved?

The tool was used by the RSPB to effectively communicate with the stakeholders involved in order to gain support for the project.

How the tool handled the relevant time perspectives and uncertainties involved?

The communications plan was reviewed every two months and revised and updated in line with project developments.

Due to the way the communication plan was used at Titchwell Marsh project it resulted in a constructive relationship between the RSPB and stakeholders. This paved the path for difficult decision-making and ultimately the implementation within the time frame.

In what way did the tool support the aim of the project– if not what would help to reach the goal?

By setting up the communications plan at the start of the process and this allowed stakeholders to understand the difficult issues faced by the reserve and ultimately allowed an much easier transit through the statutory consent framework.

Lessons learned

The communications plan needs to be fully reviewed and updated on a regular basis in line with the development of the project.

3.2 Participatory methodology

The participation of the public in a climate change adaptation process is of central importance in order to achieve the maximum success of such a process. Participation raises awareness of a problem (e.g., climate change), provides a platform for the dissemination of information, ensures that the public can propose their own ideas in order to get part of the process, and participation probably increases the acceptance of climate change adaptation measures as it provides the floor for intense discussion of relevant questions and problems. Participation of local people can provide local knowledge to the process which is not in always available to regional or national level decision makers. For example, while implementing the European Water Framework Directive, participation plays an important role for the development of river basin management plans in particular9. Similarly, the public should be able to participate in the climate change adaptation process.

In a participation process the public is mostly represented by a number of stakeholders from different groups. For example, in the German pilot studies (Wesermarsch County) within the CPA project, the first steps of the problem solving cycle applied to the climate change adaptation planning process were carried out in a participatory manner, integrating the stakeholders in all steps. After identifying the most important stakeholder groups, a regional forum was organized which identified the most urgent questions of the investigation area and was extended by additional stakeholders (stakeholder groups) as suggested by regional forum members. Subsequently, the problem analysis was carried out for the region of interest. Urgent problems and possible solution options were discussed in one-to-one interviews with all members of the regional forum and in the regional forum itself. Then, a joint vision was developed by the regional forum in order to define the desired state of the future landscape. All members of the regional forum agreed upon this vision. Similarly, common principles of good water management were developed within the regional forum, for which there was also consensus within the group. For the development of alternative climate change adaptation options for two pilot locations the regional forum split up into two focus groups and elaborated independent suggestions. By going along with the entire process, the regional forum contributed substantially to the development of a joint vision on future water management in the Wesermarsch under climate change conditions. At the end of the process most stakeholder groups agreed on this joint vision and asked for further collaboration within the regional forum.

The success of such a participation process depends on asking the right questions, but also on giving all stakeholders the floor for their opinions. Here, an adequate mix between public meetings and one-to-one meetings is required. Local experience should be taken seriously; in combination with scientific expert knowledge, it provides a solid basis for successful climate change adaptation. Detailed information on the process and the tools used are provided in this climate change adaptation toolkit and in the related CPA documentation on the Wesermarsch pilots.

The former EU-Interreg project Comcoast (www.comcoast.org) composed a document on key messages for public participation based on project experience (do's-and-don'ts of public participation[10]).

9 For details see: http://ec.europa.eu/environment/water/participation/about_en.htm
10 http://www.comcoast.org/pdfs/participation/Dos_and_donts.pdf

▸ 3.3 Process checklists and process guides

Process checklists and process guides are tools that are used to keep sight of the execution of the complex processes of the climate adaptation in land use projects. The complexity lies in the different characteristics and sectors (economy, environment and society) that are influenced by or are of influence on land use planning. In addition, climate proofing is not well defined in terms of output (when is an area climate proof?). Within the frame of CPA a matrix based decision process tool was developed on the basis of the Arvika pilot project.

▸ Matrix based decision support tool

Purpose and aim of the tool

The matrix based decision support tool (MDST) provides
1. a checklist for monitoring complex integrated processes
2. a methodology that stimulates discussions among stakeholders at crucial points in the process.
The matrix facilitates the identification of potential measures and consequences related to land use issues and compiles these in short and long term perspectives. It should contribute to a more transparent decision making process. The tool is based on classic technical risk- and vulnerability analysis[11], comprising all steps from risk/hazard identification to appraisal of measures. The different steps can be summarized as:

- Problem/risk/hazard identification,
- Problem/risk assessment,
- Problem/risk analysis - acceptance of risk level and need for measures,
- suggestions of measures
- analysis of measures,
- documentation for evaluation and prioritizing of measures and
- proposal for the decision of measures.

Strengths

The tool can be used, and the results updated, as the process described in sections 4 and onwards in this report. The tool is intended to involve experts and policy makers to identify and demonstrate all potential realistic consequences from an economic, social and environmental perspective. These are then shared to the whole stakeholder group in order to gain support for the project. (experts, policy makers, the public etc.).

The tool is constructed by a chain of matrices and is called The Matrix decision support tool (MDST). One of the important steps in the process is to allow weights of the impacts from various actions to be measured. The goal is to have a transparent weighting process that also allows the weights to be changed and their impact on the result to be assessed. In this part of the process it is especially important to involve key stakeholders and policy and decision makers.

11 The MDST is not a vulnerability analysis itself, but can be based on these tools. In Sweden the inundation map with exposed entities is sometimes referred to as a vulnerability analysis eg: Rydell, B, Persson, M, Andersson, M., Falemo, S, 2011, Hållbar utveckling av strandnära områden Planerings- och beslutsunderlag för att förebygga naturolyckor i ett förändrat klimat, SGI Varia 608, Linköping 2011

Weaknesses

The method facilitates discussion based decisions. The aim is that the experts and stakeholders involved in the procedure contribute in identifying risks and consequences. The weakness is that the results depend on the experts and stakeholders involved in the procedure. The identification of relevant and appropriate experts and stakeholders, as well as at which parts of the procedure they should be involved, shall be part of the development of the stakeholder analysis and the project and communications plan. The method itself does not include any description on whom to involve when.

Cost

The method is free. The costs involved are the time of personnel, i.e. use of facilitator, experts and stakeholders involved in the process.

Duration

Time required to execute the MDST is two or three separate sessions of about one hour.
The goal is to repeat the process cycle when/if new information is available. The duration of the process depends on the time to acquire and embed the information.

Where to find the tool or further information:

The tool description and the matrices involved in the process are found in Andersson-Sköld et al[12] (2011). The matrixes can also be downloaded as Excel spread sheets from http://www.swedgeo.se/upload/publikationer/Varia/pdf/SGI-V613.xls

Example: Arvika, Sweden

Lake Vänern and its surroundings have been pointed out as an area particularly at risk to flooding as a result of climate change. The water level outside of the city of Arvika is dependent on the water level of the lake and/or on the water flow of the river Byälven. This is the river on which Arvika is situated. In Arvika there have been floods causing large amounts of damage, and climate change will result in more frequent and severe events, unless preparations or pro-active steps are taken. The CPA-project has analyzed the impact of climate change in a local perspective, identified the consequences for infrastructure, capacity to deliver basic services and evaluated realistic adaptation alternatives.

12 Andersson-Sköld, Y, Helgesson, H., Enell, A., Suer, P., Bergman, R., Frogner-Kockum, P., Matrix Decision Support Tool for Evaluation of Environmental, Social and Economic Aspects of Land Use 2011, CPA Report and Statens geotekniska institut, SGI. Varia 6131

The tool has been applied in Arvika (Sweden). The tool has further been tested in other Swedish municipalities. The main result is that the discussion often starts with physical suggestions for solutions for the problem and gradually more soft measures and mixes of measures are raised. The process is sometimes slightly demanding, but also interesting, informative and systematic.

The results of the process, where selected alternative measures or actions are described in traffic light colours, were found to be descriptive and informative. Towards the end of the discussion, a mix of soft and hard measures/strategies were found by the participants to be more successful alternatives than solely applying physical solutions.

How was the tool used?

The tool was used by a group of experts in Arvika. The aim is a transparent process describing economic, social and environmental impacts of selected alternative action strategies and their perceived importance among key stakeholders. The aim is also to include both a broad group of experts and stakeholders.

In which phase/stage/steps was it used

1 Problem definition
2 Problem specification
3 Generation of solutions
4 Assessment and valuation of solutions

Who used the tool and who was involved

The tool was used by a group of experts in Arvika municipality with SGI as the facilitator.

How the tool handled the relevant time perspectives and uncertainties involved

The tool includes both short and long term perspectives. The uncertainties depend on the knowledge and information available. But as the aim is to allow an iterative process the results and uncertainties can be clarified during the process. In Arvika the basis of the first application was performed on previous flooding experience. Also prior updated information was available. An update was performed based on new local climate change scenarios (including several models thereby presenting some information regarding uncertainties), hydrological and hydraulic modelling and inundations maps as well as updated knowledge and information regarding potential measures. The method includes today and future perspectives on selected management alternatives.

In what way did the tool support the aim of the project– if not what would help to reach the goal

It generated valuable ideas and compiled available results from various tools used at the pilot. It also visualizes the impacts of selected management alternatives. The use of the tool in this pilot was part of the tool development thereby contributing to updates of the methodology itself.

Lessons learned

The tool was too new as it was developed through the CPA project. Therefore it was partly used too late in the process. The tool will be applied and tested in other projects such as SAWA and SMOCS where it will be used at earlier stages of the planning or decision process. Such evaluation is needed before any conclusions regarding lessons learned can be drawn.

4 Problem definition

4.1 Description

In time, effects of climate change may occur on local or regional level. On a global level, climate change is widely recognized including that this phenomenon will have effect on the environment in which we live. Because of the long term perspective it is difficult for people to recognize short-term problems that already occur within a specific area. When there is no immediate problem, it is difficult to find a sense of urgency and subsequently commitment among stakeholders for climate proofing. Therefore, evidence that climate change effects in time can occur is important. The first step of the process is to create awareness among stakeholders of a gap that might occur between the stakeholders desired future objectives and the possibilities of the physical system to accommodate these objectives.

In this phase potential problem holders will identify the problem and look around for indications to support their suggestion of a problem. This also includes the exploration of the fields of interest of other relevant stakeholders. Therefore, involvement of other parties is needed. Communication is used to retrieve data but above all to share the views of different parties. This phase results in a decision whether or not further analyzing the problem is necessary and whether constituting a group of interested stakeholders is desired.

4.2 Overview of tools in the problem definition stage

The tables give an overview of the different tools used in the definition stage of the CPA pilot project. The tools are organized by stakeholder identification, communication, interactive and quick scan tools. Per tool the application within the CPA pilot project is mentioned and the type of output, the time scale, uncertainties, necessary data and duration are described.

These tools are predominantly used in the problem cycle phase step 1 and monitored during the remainder of the project.

- The tools in bold are the recommended tools that are more detailed described in the next paragraph.
- In the column Tool description: The abbreviations stand for:
  NL (The Netherlands)
  SD- Pilot Schouwen Duiveland
  CC- project Comcoast
  OS- project Oosterschelde
  GL- project Galgenplaat
  BR- project Bruinisse
  DU (Germany)
  WM- pilot Wesermarsch
  SW (Sweden)
  AK- pilot Arvika
- In the column Time scale: P, N, M, L represents Present, Nearby future, Mid term future and Long term future respectively
- In the column Duration: H= hours, D=days, W=weeks, M=months, Y=years

Table 4.1. Stakeholder identification tool(s)

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Stakeholder analysis *Examples:* *Du(WM), NL (SD)*	- Stakeholder profile - Overview of involved parties and their interests, power and capacities	P, N, M	Representativeness of stakeholder groups and changes in groups over time	**(+)** ▪ Creating commitment for project ▪ Insight in current distribution of power	- Sectors, representatives, linkages and relationships - Interviews	D, W

Table 4.2. Communication tools

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Powerpoint presentation *Examples:* *All CPA countries*	Distribution of information		Raising awareness	**(+)** - Cheap, illustrative - Informing on uncertainty **(-)** The form of the presentation should be well thought-out.	Depends on purpose and project phase	H
Conference *Examples:* *NL (OS)*	Attention to the problem	P, N, M, L All sectors	Raising awareness	**(+)** ▪ All relevant parties are present ▪ Raising awareness of the problem ▪ Towards a common statement ▪ Find connection to similar initiatives **(-)** - Time consuming - Can be costly	Project results	Organization W, M
Newsletter *Examples:* *All CPA countries*	Distribution of information	P, N, M	Informing on uncertainty	**(+)** Disseminating knowledge to create awareness for the problem. **(-)** Does content fit the information needed by the target group?	Project results	H, D
Press release *Examples:* *All CPA countries*	Distribution of information	P, N	Raising awareness	**(+)** - Chunky information, wide access - Informing on uncertainty **(-)** No background information (black box)	Project results	H

Table 4.3. Interactive tools

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Regional forum (round table conference) ***Examples: DU (WM)***	Participatory discussion sharing and harvesting knowledge.	N	Discussion of different possible futures, rising awareness on uncertainty	**(+)** Participation, engagement and involvement	local knowledge, relationship between stakeholder groups	H,D
		All		**(-)** Process often dominated by individual persons or dominant stakeholder groups Make sure all relevant stakeholders are present.		
School projects **Example: NL (SD)**	- Innovative, creative out of the box ideas for physical measures when dealing with climate change - Influencing future generations and their acquaintances	P,N,M	Students are often not bothered with uncertainties and face the problem ahead	**(+)** ▪ Raising awareness of students and their environment ▪ Obtaining creative, innovative out of the box ideas ▪ Letting students become acquainted with the work field.	Lectures and background information	W, M
		All sectors relevant for an area		**(-)** ▪ Gap in knowledge and speaking different language ▪ Intensive guidance ▪ School curriculum and project planning do not match.		
Dealing with climate adaptation on local level **Example: NL (OS)**	Action on dealing with a specific acute local issue	P, N, M,L	Depends on the availability of data. Taking flexible or robust measures can be used as a no regret measure when dealing with uncertainties.	**(+)** ▪ Tackling acute problems without getting tangled in complex discussions that are inevitable when dealing with integrated visions. ▪ Short term effects of measures can have a positive impact on long term effects and thus supporting area development	Data on physical processes.	M, Y
		Depends on problem issue.		▪ Often not enough data is available to develop sense of urgencies among decision makers. ▪ Measures may have impact on other processes in an area or might not be of added value for greater area or in future expected effect.		
Defining clear roles and responsibilities **Example: NL (OS)**	Alliances that strengthen chance of implementation of climate adaptation project.	P, N,M, L	Sharing knowledge and responsibilities making parties less vulnerable to negative project results.	**(+)** ▪ Gaining support for implementation of project ▪ Sharing and disseminating knowledge ▪ Sharing costs and responsibilities	Knowledge of external environment and stakeholders that might be of interest to your project. Good understanding of expectations of different parties involved.	Q, M, Y
		Depends on ambition.		**(-)** ▪ Different levels of expectations ▪ Unclear defined project management may result in disagreements and discussions endangering the success of the project.		
Connect to local problems, projects or organisations ***Examples: NL (SD, BR)***	Achieving more climate proof solutions in local decision processes by adding knowledge on climate adaptation	P,N, M	Solutions to short term problems are less sensible for long term uncertainties in climate change. Mainly the direction of the climate change is regarded.	**(+)** ▪ Possibilities to make solutions more robust or flexible to climate change against small additional costs ▪ Forming alliances ▪ Connecting future climate change to present day problems ▪ Creating ambassadors of climate adaptation	- Project data - Climate scenarios - Sector specific perspectives	- Depends on the local process - Maintaining the network - All stages of the process
		Depends on the local project		**(-)** ▪ Present problems determine the possibilities for change ▪ No overall vision ▪ Different interests		

▸ Table 4.4. Quick scan tools

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Literature research *Examples:* *DU (WM)*	Overview of the state of the art knowledge	P, N, M	Documentation how to deal with uncertainty	**(+)** State of the art knowledge **(-)** Predominantly theoretical knowledge	Access to papers/journals	D,W
Reviews of previous local published work and solutions *Examples:* *SW (AK)*	Identification and primary inventory of potential benefits and risks.	P Depends on the local project	Qualitative descriptions can be part of the review	**(+)** Use of published results and previous work **(-)** - The results depend on the available information, the interests, knowledge and experience among the individuals performing the reviews - Qualitative descriptions can be part of the review	Previous published reports	depends on ambition and the availability of information.
Local, regional scale inventory on climate change impacts Examples: SW (AK)	The aim is to identify and make an inventory of potential benefits and risks.	N, P, M Depends on the local project	Can describe uncertainties	**(+)** Identified potential benefits and risks are the basis to identify potential or beneficial actions or needs/demands of climate proofing on local, municipal and/or regional scale. **(-)** There are several methods that can be used and some may be more costly than needed and some aspects may be missed.	I.e. Inundation or flood risk, landslide risk maps including elements at risk.	
Interviews with relevant stakeholders and experts Examples: DU (WM)	▪ The aim is to identify and make a primary inventory of potential benefits and risks. ▪ Personal opinions, assessments	P Different sectors	Discussion of different possible futures, rising awareness on uncertainty	**(+)** ▪ Several aspects can be highlighted. ▪ Can have less potential friction than group meetings or brainstorm activities. ▪ participation, collecting the opinion of 'all' participating stakeholders in an "intimate" surrounding **(-)** ▪ Not a quantitative method by itself but interviewed experts can provide quantitative data (e.g. sea level rise, temperature rise etc). ▪ The results depend on the individual participant's interests, knowledge and experience. ▪ It is a single point of view.	information on the difference between positions and interests and needs of stakeholder groups	H, D (preparation, participation, analysis)

▸ Table 4.5. Decision process oriented tools

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Political attention *Examples:* *NL (OS)*	Political attention gives a project a status and can lead to an assignment for a further survey on the topic	P Depends on the project	- Political attention often does not last long but results more often in process agreements on how to work towards decisions	**(+)** Problem is known at national scale **(-)** It takes considerable time to achieve	It requires good foundations of the problem	M
Adjusting ambitions *Examples:* *NL (SD)*	New realistic targets for the project	P, N, M, L	Flexibility in the ambitions make it possible to adapt to changing circumstances	**(+)** ▪ Maintaining a realistic objective ▪ Flexibility **(-)** - Reopening discussions on the ambitions takes time - Adjusting often means lowering ambitions	Insight in the views of the stake holders and decision makers	- Giving account (requires good process management) - First stages of the process

4.3 Recommended tools

School projects for creating awareness by future stakeholders

In this section general information about the recommended tools are given. Also the experiences with these tools in one or more pilots are described.
School projects for creating awareness by future stakeholders

Purpose and aim of the tool
A method to create awareness of a problem is to involve the future generation practitioners in a project. Participation of, for example, High school students generates innovative ideas, they are free to think out of the box. High school students are not restrained by political views or biased due to experiences. By including students in a project broadens their view of the problems that are dealt with in practice. Spin off is also created to parents and the community in which the students live, thereby creating possibly more interest in a problem.

Strength
Generating out of the box ideas while raising the awareness of students to their immediate environment.

Weakness
Support is needed from the faculty staff in order to generate successful input for a project. Project staff are required to provide knowledge and guidance to the students. This can be time consuming. Students have to understand the background of a problem and the problem itself in a short amount of time. Also the language of students differs from that of professionals. Another difficulty is to match the project planning to the schools curriculum.

Relevant data needed, or other needs, to be able to use the tool:
Information input for students to work with.

Cost:
Low

Duration:
Months

Examples Zierikzee and Goes, The Netherlands

How was the tool used

The tool had several purposes: communication about climate change (awareness), social responsibility (supporting schools by offering project cases as a part of their curriculum), and obtaining new ideas.

In which phase/stage/step(s) was it used

In essence the students set up and execute their own project, thus covering all the different phases. The results of the projects (pictures, animations etc) can be especially useful in the generation of solutions.

Who used the tool and who was involved

The project group, the teachers, the students and the parents were involved. The teachers were very interested in the theme and have also learned from this case: what is climate change in practice? The downscaling of the climate change problem to a local case made them interested in this project.

How the tool handled the uncertainties involved

The students turned out to have a good capacity to deal with uncertainties very well. They make and accept assumptions quite easily.

How the tool handled the relevant time perspectives involved

Students tend to think in the present situation. Thinking about the long term future is therefore quite difficult for them.

In what way did the tool support the aim of the project– if not what would help to reach the goal?

In example of the Dutch cases the scholar projects take up to 9 weeks. That is too short to go through the whole process. Some student of the group from Goes had done a similar project before resulting in a quicker start. They knew more about climate change, climate robust designing and about working in projects. It is thus beneficial to develop a learning process together with the schools.

Lessons learned

School projects are a good instrument to involve students in climate adaptation. Start with the basic principles. The projects should be geared to the pupils' perception of their environment. Several projects in a row with a school can be beneficial. Students are very handy with computers and software. That can be very useful.

Keeping climate adaptation on a local level: avoiding discussions on a higher abstraction level

Purpose and aim of the tool

The purpose is to define a local problem setting and measures that can be achieved without avoiding abstract discussion i.e. about a long-term vision for the wider region. These discussions involve many sectors and parties, resulting in a long process that can take years before a decision is reached. This leads to a situation in which concrete measures are not taken on the short term and short-term problems are not dealt with.

The aim is to solve a local problem with measures that will eventually support the area in achieving climate proofing, without having a formalized vision.

Strength

Local problems with a short-term and long-term component can be solved without the delay of abstract discussions regarding broader visions on different scales. The results of the project can be made clear and the decision to take measures is relatively easy to make. These short-term measures can, in the long run, be of added value to a broader vision of the area. It then can function as showcase pilot to reach and communicate with decision makers and residents.

Weakness

In order to get the green light, sufficient data is needed that will justify the suggested measures. To achieve a sense of urgency for a problem on the decision making level requires a thorough analysis. Especially as, depending on the problem, measures can be quite expensive.

Short term problems require short term actions. However, the lack of a larger scale common vision might result in measures that are, in the long term, counterproductive. This should be kept in mind and weighed against an integral vision and measures for the region.

A third weakness is the availability of knowledge in order to conduct an analysis that visualizes the extent of the perceived problem. Without this data it is difficult to establish a sense of urgency and resulting in lack of support from the decision makers. Data can be acquired through data collection. However this can be costly and does not guarantee that the acquired data will support your perception of the urgency of the problem.

Relevant data needed, or other needs, to be able to use the tool:

In order to gain support for the suggested measures sufficient data is needed to make a thorough analysis. Although a lot of data is already available it is often not easily accessible or essential data is not available yet. In order to acquire these, fieldwork and monitoring can be considered.

Cost

Measurements are in general quite expensive, but it depends on the scale and time. Monitoring should start at the beginning of a project in order to compare the effects of measures with the situation before. When there is no data available and the measures can be innovative, the budget might become 25-50% of the total costs.

Duration:

The data collection, analysis and implementation of the measures can take months. The decision making process is often more time consuming.

CLIMATE PROOF AREAS
TIME TO ADAPT

Example: Oosterschelde Sand nourishments and hanging beaches, The Netherlands

On the south coast the island Schouwen Duiveland is bordered by the estuary "Oosterschelde". The intertidal area of the Oosterschelde, which is a national park in the Netherlands and a Natura 2000 site of European importance, is subject to structural erosion. The hydromorphology of the Oosterschelde is out of balance due to the construction of the storm surge barrier and auxiliary dams of the Delta Project. This structural erosion is known as the "sand demand" of the Oosterschelde. The sand demand has a direct effect on the natural values of this natura2000 area and on a longer term will have an effect on the flood defence.

How was the tool used?

The focus was only on the problem with the sand erosion of the Oosterschelde plates. Due to the high rate of erosion, problems with flood defence and destruction of natural habitats have to be dealt with on a short term basis. This short term problem is directly linked to the long term problem of sea level rise and the existence of the Oosterschelde storm surge barrier. A vision on the future of the Oosterschelde will have consequences on the plates, but the outcomes of these discussions will not help to solve the existing problem of erosion. The measures are presented as pilots for retrieving data on the underlying physical processes and can help in predicting further erosion.

In which phase/stage/step(s) it was used?

The tool was used in stages:
1 Problem definition
2 Problem specification

Who used the tool and who was involved?

The Dutch Rijkswaterstaat Zeeland (Regional executive arm of the Dutch Ministry of Infrastructure and the Environment), responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands, has the lead. They are working together with the province of Zeeland, the ministry of Economics, Agriculture and Innovation and the board of the National Park Oosterschelde.

How did the tool handle the uncertainties involved?

The tool will give insight in the underlying physical processes and thereby reducing the assumptions in the modelling. By doing pilots step by step, the process and choice for measures remain flexible.

How the tool handled the relevant time perspectives involved?

The primary time perspective for the pilot is the short term (10 to 20 years).

In what way did the tool support the aim of the project– if not what would help to reach the goal?

The tool gave the opportunity to investigate the rate of the sand erosion of the Oosterschelde plates and establish sense of urgency at the decision making level. By focusing on this isolated problem quick decisions can be made and countermeasures can be taken to tackle the short term problem of habitat loss and flood protection. In the long run these measures contribute to the development of the larger area.

Lessons learned?

Without the long series of measurements the extent of the erosion problem would not have been clear. Without these measurements the effects of erosion on the Natura 2000 objectives would not have been known. Measurements of the erosion alone are barely sufficient to inform the public about the problem.

Regional forum

Purpose and aim of tool

The regional forum is a communication tool to institutionalize the participation. It serves as an information distribution platform, creating awareness, establishing participation and providing the floor for intense discussion of relevant questions and problems. A regional forum is a means to establish and maintain contact with regional stakeholders that have influence over or are affected by a projected change. When properly used, it effectively involves the stakeholders in the project creating awareness of a problem and support for implementation.

The purpose of forming local alliances with existing networks is to create a network thereby strengthening the project and the awareness of climate adaptation. In addition, the message that there is a need to adapt to climate change is not only spread among residents and local groups but also at different scales of government. This can result in a pressure towards the government to take action. The bottom-up approach can result in small scale pilots to a more integrated vision on climate adaptation.

Strength

The strength of the regional forum is the involvement of relevant stakeholders to the project. The regional forum is a means to establish participation, raise awareness and, when used correctly, motivate people to get engaged in the climate change adaptation issue. It can also provide important information to the project. People who are selected can act as ambassadors of climate adaptation within their projects, network and social environment creating pressure to the decision makers to take action on climate adaptation.

Weakness

When not all relevant or wrong stakeholders are identified the purpose of the tool will not be reached. This also might result in delaying a project or gaining insufficient support for execution. Another weakness is the possibility that the discussion and therefore the process may be dominated by individuals, groups or organizations. Therefore, we recommend to also perform face to face interviews with all members of the regional forum in order to get information from all members regarding their opinions.

Relevant data needed, or other needs, to be able to use the tool:

The most relevant information is a good view of all the relevant stakeholders, local knowledge on the range of interests, issues and needs. Relationships between stakeholders might facilitate the participatory process.

The group of stakeholders can be willing to provide data or practical knowledge that can be very valuable. In order to be able to communicate with them, the information they receive has to be tailor made to their perspectives. Abstract information on long term effects of climate change on national lies far from their interest. This translation requires very good insight in trends and uncertainties.

Cost:

Working time and travel costs.

Duration:

Days to weeks. Complete process, i.e. running through the problem solving cycle, may be years.

Where to find the tool or further information:

- Wesermarsch vision booklet (in German; Ahlhorn, F., Bormann, H., Giani, L., Klaassen, K., Klenke, T., Malsy, M., Restemeyer, B. (2011): Klimasichere Region Wesermarsch - Die Zukunft der Wasserwirtschaft. Erste Schritte auf dem Weg zu einer Klimaanpassungsstrategie für den Landkreis Wesermarsch).
- Bormann, H., Ahlhorn, F., Giani, L. & Klenke, T. (2009): Climate Proof Areas - Konzeption von an den Klimawandel angepassten Wassermanagementstrategien im Norddeutschen Küstenraum. Korrespondenz Wasserwirtschaft, 2 (7), 363-369. DOI: 10.3243/kwe.2009.07.002.

Example: Regional Forum Wesermarsch, Germany

Climate Proof Areas aims to ensure that the watering system and the drainage function for the low rural hinterland of the county is functionable. In summer, fresh water from the river Weser contributes to the agricultural water supply of the area. Higher salt concentrations in the river has negative effects on the watering system and the utilization of this water. Higher precipitation in winter, accompanied with a shifting seasonal distribution, as a consequence of climate change, means the existing drainage system needs adapting.

Within CPA (Wesermarsch pilot), we performed a joint, cross-sectoral problem analysis. The regional forum was used to come to agreement on joint water management principles and discussed the portfolio of possible adaptation options. This was suggested by urban and rural focus groups including all relevant stakeholders.

How was the tool used?

The regional forum was organized twice a year. The regional forum was put in place to identify relevant sectors suffering from climate change, to discuss the strategy of the climate change adaptation process. The regional forum identified knowledge gaps that between meeting was gathered and fed back to the group. Between meetings it is also important to regularly report on the progress for participants to feel involved. The regional forum allowed for joint agreements.

In which phase/stage/step(s) it was used?

The regional forum was used during the following phases: problem identification, regional climate impact analysis, and the identification of possible adaptation strategies to climate change.

Who used the tool and who was involved?

The University of Oldenburg used the tool for communicating to and with the regional stakeholders. All relevant regional stakeholders were involved.

How the tool handled the uncertainties involved?

Uncertainties in climate projections were reduced by choosing a mid-term time horizon (2050) for which the different IPCC scenarios show relatively similar impacts.

How the tool handled the relevant time perspectives involved?

All stakeholders agreed on a joint time perspective (year 2050).

Lessons learned

It is necessary to combine the regional forum with face to face meetings with all members of the regional forum in order to get information from all members regarding their interests and needs, judgements, visions, etc.

The stakeholders identified the same major problems compared to the scientific experts. In order to reduce uncertainty, Wesermarsch stakeholders preferred to stick to one single climate change scenario as basis for discussion of adaptation options. The provided scientific information on regional climate and hydrological change in the Wesermarsch County was actively adjusted to both the existing local and regional experiences and to external knowledge on different climate change impacts. The recommendations of the regional forum are aimed at a minimisation of change in their "home" region.

Example: Pilot Schouwen-Duiveland: Forum Schouwen-Duiveland

In CPA, the island will be used to study and demonstrate potential solutions for climate adaptation. Within the area particular attention will be paid to the design of an area surrounded by dikes and water, for living, working and leisure. New ways of coastal defence, combining functions on how to deal with sea level rise, surplus of rain water, land use planning to reduce damage in case of a flood, etc. will be studied. This will allow the CPA partners to conduct a comprehensive, integrated design for development of the island.

How was the tool used?

The forum was used to gain stakeholder support for the pilot and involvement of the residents of Schouwen-Duiveland. It was used as a parallel route besides the formal decision making process of the governmental organizations.

In which phase/stage/step(s) it was used?

The tool was used in stages:
1 Problem definition
2 Problem specification
3 Generation of solutions

Who used the tool and who was involved?

The process manager of the pilot Schouwen-Duiveland was the leading party. The forum exists of farmers, residents and entrepreneurs

How the tool handled the uncertainties involved?

Long term uncertainties of scenarios are made less decisive by connecting to existing problems. This forum works bottom-up. This means that every step is connected to local decision making in which robustness or flexibility can be integrated.

By taking relatively small steps (one or a few pilots at a time), the flexibility is large. In the pilots the distant future can be taken into account (in case the involved parties share the urgency of climate adaptation).

How the tool handled the relevant time perspectives involved?

The primary time perspective for the members of the forum is 10 to 20 years. This time horizon is determined by their own investment agenda (farmers, entrepreneurs) or their perception. By adding information about climate change on the long term, their relatively short term decisions may be influenced in a more climate proof direction.

In what way did the tool support the aim of the project– if not what would help to reach the goal?

The aim is to achieve commitment to the process and more local knowledge of climate change. These objectives were achieved. The forum has been a starting point for connecting climate proofing to local initiatives.

Connecting to local problems and initiatives

Purpose and aim of the tool

When an idea to make an area more climate proof is connected to planned or existing projects, climate adaptation knowledge is easier dispersed into land development plans. This is also a cost and time effective way to showcase the knowledge. This will save you time and effort to lobby for pilot funding, which can take many months or even years. Long-term effects of climate change are an abstract discussion hence it is difficult to create a sense of urgency among local stakeholders for climate adaptation. A way to deal with this is by connecting climate adaptation to problems that already occur; for instance shortage of fresh water for agriculture. Climate change after all is not something that will be expected to occur in the future but is already going on. Measurements from the last 100 years show for example an increasing trend in summer days and days with extreme precipitation. Support can be gained by showing that the current situation is already becoming urgent and that a short term action can lead to a long term durable solution.

Strength

Makes the long term effects of climate change applicable to local stakeholders, by linking these to present day problems while creating short term benefits, as well as sustainable long term solutions.

Weakness

Climate change is a widely accepted phenomenon. On national and global scale climate scenarios are available. However the effects of climate change effects that might occur on regional scale can deviate significantly from the global or national scenarios. These describe general trends while on a regional and local scale more detailed information is desired. Translation of these high scale scenarios to regional and local levels are not or hardly available.

Relevant data needed, or other needs, to be able to use the tool

Good quantitative data on past events and present situation. Insight into the vulnerability of the different local and regional sectors. The effect of climate change translated to the sector and this effect of climate change compared to other changes in the system.

Duration

Study and design: 1 year
Prototype and demonstration: 1-2 years

Example farmers as self supporting fresh water managers, The Netherlands

On the Island of Schouwen-Duiveland the farmers suffer with inundation and drought as well as salinisation of the ground- and surface water. In the past decades they saw a trend of increasing weather extremes. With up to 30% crop damage due to fresh water shortage, there's a sense of urgency to deal with this problem. The island has a yearly precipitation surplus, but the spreading throughout the year isn't optimal.

Several pilot studies in the low-lying parts of the Netherlands search for improving the fresh water availability. For example, at Walcheren a pilot of the Water Farm has started. Farmers work together with local authorities and knowledge institutes in order to use every drop of the available fresh water.

At Schouwen-Duiveland a numerical model made it possible to identify the areas with increasing salinisation and drought due to climate change. Those areas already have a sense of urgency and together with simulation tools, to predict the effects of climate change, CPA started the process for innovations on fresh water supply on Schouwen-Duiveland.

How was the tool used?

By illustrating the need for climate adaptation through present day issues, stakeholder support was ensured. There is commitment for generating climate proof solutions for fresh water supply for now and in the future.

In which phase/stage/step(s) it was used?

The tool was used in stages:
1 Problem definition
2 Problem specification
3 Generation of solutions
The main work is in stage 2 and the design phase of stage 3

Who used the tool and who was involved?

The investigation of solutions for fresh water supply was conducted by Deltares with support of the province of Zeeland. Important stakeholders involved were: farmers and nature organizations as well as local authorities.

How the tool handled the uncertainties involved?
Long-term uncertainties of climate change scenarios are made less difficult to understand by connecting to an existing problem to provide an example.
Research solves quantitative uncertainty of the concept. The urgency was investigated by interviewing stakeholders.

How the tool handled the relevant time perspectives involved?
Over the last couple of years urgency to find solutions has increased due to drought damage on crops. The farmers say that the weather extremes increase drought and inundation damage. The period of investments is about 20-30 years and within this period the problem of salinisation increases. On the other hand, with solutions for fresh water supply the economical benefits can start today and support a climate proof agricultural sector.

In what way did the tool support the aim of the project– if not what would help to reach the goal?
Yes

Lessons learned?
- Support from businesses and government, and knowledge is needed to adapt to climate change
- For individual entrepreneurs, a current sense of urgency is needed in order to make sustainable investments for the future
- A groundwater model made it possible to understand and quantify the effects of climate change compared to other processes.

Defining clear roles and responsibilities in regional alliances

Purpose and aim of tool
As mentioned before, to assure a good outcome of a project it is relevant that you acquire support for your project, not only by your investors but also by people or groups that might be affected by your project. Embedding the problems and or solutions that are relevant to the environment in which you operate (government, businesses etc.) is hereby essential. Ways to ensure support is to form alliances with relevant people, groups and other projects. This enables the exchange of information and a clear dividing of the tasks. This tool goes beyond information exchange, it aims at forming an alliance in which every party has an active role in performing tasks.

Strength
It delivers support for your project, because actively involved parties are good ambassadors for the project. The exchange of knowledge is easier when every party in the alliance has responsibility for its success. Also, the dividing of the work can mean that the work is done cost effectively.

Weakness
However when many people and or parties are involved, lines of responsibility and roles can become blurred. Therefore it is important to know what the parties involved expect from one another, what they need in order to achieve their goals and clearly define and describe roles and responsibilities. Mismanagement of expectations can weaken the commitment for the project.

Relevant data needed, or other needs, to be able to use the tool:
A good understanding of the people, project and groups that are affected by your project (network).

Cost:
It requires time for good coordination and making agreements on the role of the participants.

Duration:
Continuously or as long as the alliance should be active. Sometimes the alliance is only needed during a part of the process. After reaching the objectives, the alliance can turn into a less active network of interested parties.

Example: Sand nourishment and hanging beaches Oosterschelde, The Netherlands

How and by whom was the tool used?
Rijkswaterstaat Zeeland (executive organization of the Dutch Ministry of Infrastructure and the Environment), together with the province of Zeeland and the National Park Oosterschelde, have had consultations to define each actor's role. Based on the interests and powers of each actor, each actor has contributed to placing the problem on the public, civil servants and decision makers agendas. These consultations led to the following division of roles:

- Rijkswaterstaat takes care of the scientific based problem analysis and generation of solutions. The pilot of sand nourishment was adopted into the long term investment program of Rijkswaterstaat.
- The National Park Oosterschelde takes care of the support for the solutions by putting the sand hunger on the agenda by organizing work conferences. When needed the National Park contacts Members of Parliament for questions for the cabinet.

This led to two work conferences and a motion in Parliament to further investigate the problems in the Oosterschelde . The province has continuously asked for attention of the sand hunger on the managerial level.

In which phase/stage/step(s) it was used
This is a continuous process.

How the tool handled the relevant time perspectives involved
The current problems are an example of what can be expected on a larger scale in the future. The current cooperation between the stakeholders can be seen as an experiment for the longer term.

In what way did the tool support the aim of the project– if not what would help to reach the goal?
The division of the roles turned out to be an effective manner to put the problem on the agenda and receive sufficient money for the research done by Rijkswaterstaat. It remains open whether they will succeed in gaining enough societal support for larger measures.

4.4 Conclusions

For this phase many tools were used, of which many were labelled recommended to use in climate adaptation projects. Many pilots have sought for commitment of a wide variety of actors. The used tools were not meant as a single action, but to be part of a larger process of involvement of parties. Therefore, forums and alliances have proven to be essential. The communication and the tools itself are intended to last longer than only this phase.

With respect to content, the tools are used for achieving a good focus and a clear dividing line of what aspects are to be taken into account. The projects are favourably considered to be local, concrete and should connect to local interests and problems.

Both kinds of tools (communication and focusing) were considered recommended tools. The student project tool seems to be rather different than the other tools. This tool does not immediately contribute to a process, although it could have impact on a small community and thereby creating awareness to the students of their immediate environment.

Many communication tools are listed in this phase. In this phase it is important to send out a message and to generate commitment. Although communication is used through all the phases it is crucial to set up good communications at the start of the project. Communication could, or even should, be part of a plan (see Communications plan in chapter 3) or methodology (see chapter 3).

5 Problem specification

5.1 Description of this phase

In order to determine the sense of urgency for climate proofing an analysis should be done regarding the extent of the effects of climate change, the time scale on which they occur and the impact on the different sectors in an area.

The problem specification gives more insight into the function of the system and quantifies the expected effects and stakeholders. The outcome is more detailed and quantified information on the possible effects. Based on this the sense of urgency can be determined for identifying and taking appropriate measures.

5.2 Overview of tools in the problem definition stage

The tables give an overview of the different tools used in the problem specification phase in the CPA pilot project. The tools are organized by stakeholder identification, communication, interactive and quick scan tools. Per tool the application within the CPA pilot project is mentioned and the type of output, the time scale, uncertainties, necessary data and duration are described.

These tools are predominantly used in the problem cycle phase step 2 and monitored during the remainder of the project

- The tools in bold are the recommended tools that are described in more detail in the next paragraph.
- In the column Tool description: The abbreviations stand for:
  NL (The Netherlands)
  SD- Pilot Schouwen Duiveland
  CC- project Comcoast
  OS- project Oosterschelde
  GL- project Galgenplaat
  BR- project Bruinisse
  DU (Germany)
  WM- pilot Wesermarsch
  SW (Sweden)
  AK- pilot Arvika
- In the column Time scale: P, N, M, L represents Present, Nearby future, Mid term future and Long term future respectively
- In the column Duration: H= hours, D=days, W=weeks, M=months, Y=years

Table 5.1 Scenario tools

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Social economic scenario's *Examples:* *NL (SD)*	Gives bandwidth of possible growth of different social economic sectors.	M,L Recreation, infrastructure, housing, population, employment, economy etc.	The predictability of developments is low. It is difficult to translate a combination of foreseen and unforeseen developments to effects in the future.	**(+)** Insight in economic development is needed besides climate change as one of the drivers for change of behaviour or management **(-)** Only available on national scale whilst developments on local and regional scale differ from the general development patterns	- Socio economic data - Insights in development of economic parameters	
Model based scenario analyses ***Examples:*** ***NL (OS)*** ***DU (WM)***	Calculations maps, time series, trends	N,M,L Water safety and nature	- Process description and scenario-analysis - Monte Carlo analysis, - Consideration of different scenarios, - Climate models	**(+)** Insights and predictions of morphological processes Forecasts, scenario calculations **(-)** ▪ Requires a good model and data availability Uncertainty due to data, process representation, subjectivity by the modeller, … ▪ Requires lots of data ▪ Model dependent (climate, soils, demographics, land use, scenarios, etc.)		W,M
Quantitative methods (i.e. model based scenario analysis) ***Examples:*** ***DU (WM)/ SW (AK)***	Basis to assess the potential probability for flooding which in turn can be used to make a quantitative inventory of objects that may be at risk.	M,L AK focused on the water and sewage systems(municipal scale). Other elements at risk can be identified and mapped	Model based scenario studies have been performed to increase the knowledge on pilots and local scale climate change impacts.	**(+)** Detailed quantitative or semi quantitative information as a basis to assess further steps in a risk analysis **(-)** can be costly and time demanding depending on the ambition level	Depend on the study to be performed. For the Arvika study estate maps, topographic maps and climate change scenarios were used as the basis for the analysis.	W,M,Y
Local, regional, national scale climate change scenarios	The aim with climate change scenarios on local and regional scale is to achieve local information to identify primary	M,L	The uncertainty can be highlighted by visualising the variation among different models and time scales and results from sensitivity	**(+)** - An increased knowledge basis to identify potential benefits and risks on local and regional scale. The uncertainty a municipality has to plan under for the nearest decades can be illuminated and visualised	Local scale scenarios can be achieved from national meteorological and hydrological institutes such as SMHI. SMHI and most of similar national	

Examples: DU (WM)/ SW (AK)	inventory of objects that may be at risk.	AK focused on the water and sewage systems(municipal scale). Other elements at risk can be identified and mapped	change impacts.	**(-)** can be costly and time demanding depending on the ambition level	scenarios were used as the basis for the analysis.	
Local, regional, national scale climate change scenarios ***Examples: SW (AK).***	The aim with climate change scenarios on local and regional scale is to achieve local information to identify primary climate change impacts	M,L Water and sewage systems(municipal scale). Mainly water safety	The uncertainty can be highlighted by visualising the variation among different models and time scales and results from sensitivity analysis of assumptions and known uncertainties within the simulations	**(+)** - An increased knowledge basis to identify potential benefits and risks on local and regional scale. The uncertainty a municipality has to plan under for the nearest decades can be illuminated and visualised. plausible description of future development, neither false nor true, but possible - Insights in bandwidth of effects - Commitment to the national scenarios **(-)** - Can be costly to perform on local scale, may not be needed in some regions (for many municipalities in Europe and also some parts of the Scandinavian countries the national or European scale scenarios may be relevant enough). - There are risks of disinformation if the uncertainties are not shown/highlighted. - No probability, uncertainty, the assumptions might not be verifiable	Local scale scenarios can be achieved from national meteorological and hydrological institutes such as SMHI. SMHI and most of similar national institutes can offer such analysis for other countries Temp., Precipitation, Wind, Sunshine (radiation) Requires data and assumptions	

Table 5.2 Data acquisition

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Workshop with residents and stakeholders *Examples:* *NL (SD)*	- Views and ideas of residents. - Knowledge transfer	P	Climate scenarios for creating a bandwidth of climate impacts that have to be handled	**(+)** ▪ Views of the residents ▪ Opportunity to explain the project ▪ local knowledge of residents	Basic information on the current situation and cause of the project	
		Depends on fields of interest of the residents		**(-)** No extensive knowledge of climate change and all sectors		
Data collection *Examples:* *DU (WM)*	Data set	P	Consideration of all possible data sources	**(+)** Best available representation of the system	- The more the better - Consideration of all possible data sources	D,W
				(-) Data gaps, short time series, limited system representation, costs, limited availability, inadequate quality, quantity.		
Thorough facts-based analysis of the urgency of the problem ***Examples:*** ***NL (OS)***	- Facts based on numbers - Maps	P	Reduction of the amount of assumptions	**(+)** Less discussion about the underlying assumptions		
		Depends on the project		**(-)** Requires lots of data		

▸ Table 5.3 Analysis Tools

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Impact assessments on water safety and nature *Examples: NL (OS)*	Predictions on the impacts	L	Climate scenarios and process descriptions give insights in possible bandwidth of effects	**(+)** Insights in bandwidth of effects	Requires data and assumptions	W (Obtaining data, Analysis)
		Water safety and nature		**(-)** Assumptions in the assessment		
Soil functional assessment *Examples: DU (WM)*	Changes in soil functions	N,M,L		**(+)** Change in soil potentials	Soil types, texture, groundwater, climate change	Months
		Agriculture		**(-)** Partly dependent on the (uncertain) scenarios		
Statistical data analysis *Examples: DU (WM)*	Trends, significance	N	Analysis of statistical significance	**(+)** Trend analysis, system dynamics	Collected data	D,W
		Depends on research topic		**(-)** Limited system representation, limitations of statistics Analysis of statistical significance		
Effect analysis *Examples: CPA WP1 reports*	Overview of expected effects on different sectors		Climate change and economical developments and probable changes in policy	**(+)** ▪ Systematic approach for different sectors Insight in relative impact: urgency Long term outlook	Many different sources	W,M,Y
		For each sector and an integral overview		**(-)** ▪ No solid figures ▪ Difficult to make distinction between factors local knowledge required Climate change and economical developments and probable changes in policy		
GIS (Visualisations and maps) *Examples: DU (WM) NL (SD)*	Maps, spatial analyses	P,N,M,L	Illustration of uncertainty	**(+)** Illustrative presentations, maps, evaluation, visualisation Communication Long term visions and spatial overview of current and/or expected impacts Current state	Collected data- Spatial distributed data	
		All sectors		**(-)** ▪ Content difficult to validate, heterogeneous quality and quantity of data, data rights, different projections of spatial data, scattered data bases ▪ Not all information can be drawn on a map or incorporated in a design sketch ▪ Illustration of uncertainty		

				in policy		
GIS (Visualisations and maps) *Examples:* *DU (WM)* *NL (SD)*	Maps, spatial analyses	P,N,M,L All sectors	Illustration of uncertainty	**(+)** Illustrative presentations, maps, evaluation, visualisation Communication Long term visions and spatial overview of current and/or expected impacts Current state **(-)** ▪ Content difficult to validate, heterogeneous quality and quantity of data, data rights, different projections of spatial data, scattered data bases ▪ Not all information can be drawn on a map or incorporated in a design sketch ▪ Illustration of uncertainty ▪ Effects under uncertain circumstances (requires additional explanation)	Collected data- Spatial distributed data	
Expert group discussion *Examples:* *DU (WM)*	Discussion, expert assessment		Discussion of different possible futures, rising awareness on uncertainty	**(+)** Participation, preparation of solutions based on expert knowledge **(-)** No interaction with 'non-expert' stakeholders Discussion of different possible futures, rising awareness on uncertainty		H,D
Field-test *Examples:* *NL(GP, OS)*	- Evidence for broader application of a technique - Examples of tested measures including advantages, disadvantages experience and lessons learned if available.	Depends on the project (in this case water safety)	By performing a test, conclusions about the results in case of a broader application can be drawn	**(+)** ▪ Real life results ▪ Reduction of risks (financial and less assumptions) It yields a lot of data. **(-)** ▪ Large investments Interpolation of results to the future conditions It yields a lot of data.	It requires data for the design of the test.	M,Y

5.3 Recommended tools

Thorough facts-based quantitative analysis

Purpose and aim of tool
The main reason for performing this analysis is to prevent or conclude discussions about the urgency and the size of the impacts that might occur. Based on the current situation, more insight in the functioning of the system can be obtained. Models without proper system relations cannot predict the outcomes if the situation becomes different.

Strength
Measurements improve the modelled relations and thereby improve the reliability of the outcome of the model. This will subsequently support the process of decision making.

Weakness
There should be an opportunity (time, money, place) to conduct measurements. The current system must be representative for the possible future state of the system. A good monitoring program must be set up.

Cost and duration
Measurements can be costly and take a while before the results are available.

Pilot example: Oosterschelde

The worth of a model is determined by the input of information. The sand nourishment pilot in the Oosterschelde provided the opportunity to measure and obtain quantitative data that provided a sound basis for model input. The information output subsequently helped draw different future scenarios concerning the effects of sand hunger when not dealt with. This helped the government to understand the problems that they were facing and supported the decision making process.

How was the tool used?
For the problem specification, measurements of ground levels, bird counts and soil ecology samples were gathered. These datasets enabled a problem definition. This turned out to be a very effective way to raise awareness for the urgency of the sand hunger problem. The analysis of the ground levels showed the rate of drowning of the plates in the Oosterschelde. They also contributed to a prognosis of the further development of the drowning. The water defence system of the nearby island Schouwen Duiveland turned out to be at risk. Due to the drowning of the plates a natural buffer is destroyed that results in higher wave attacks on the coast line. Also the number of birds affected by this phenomenon was made clear. They will suffer from a loss of resting place and feeding ground. Without these measurements the discussion about the size of the problem would still be going on.

In which phase/stage/step(s) was it used
Data retrieval and analysis is primarily of use in the problem specification phase and important in the generation of solutions.

Who used the tool and who was involved

Rijkswaterstaat (Regional executive organization of the Dutch Ministry of Infrastructure and the Environment) used this tool exclusively for the implementation of the pilots and studies for the long term infrastructure investment planning.

How the tool handled the uncertainties involved?

Especially the ground level measurements showed a deviation as large as the measured phenomenon. The uncertainty of the effects is therefore at present already large. This uncertainty exists due to the uncertainty of future sea level rise. This leads to serious discussions about the size of the problem between experts of Rijkswaterstaat and Deltares. The appropriate measures are difficult to define. The discussion resulted in a preference for flexible measures (adaptable to the extent of sea level rise): sand nourishments. Because of the uncertainty it is a learning by doing process.

How the tool handled the relevant time perspectives involved

Time is an important factor in the process of the sand hunger and countermeasures. The measures will have to continue until the storm surge barrier might eventually be removed and a natural sand balance is restored.

In what way did the tool support the aim of the project– if not what would help to reach the goal

The already existing national monitoring network has proven to be essential as it has an extensive database. The reliability of the measurements is unfortunately not sufficient to get a good grip on the problem at hand. It results in a large bandwidth of possible future outcomes. It would have been better to enhance the measurements at the start of the project to retrieve more data.

Regional and local climate scenarios

Purpose and aim of the tool

The aim of local and regional climate scenarios is to gain more insight in which effects occur in what extent and at what possible timescales. This gives a bandwidth of impacts on different sectors: which areas are of risk of drought, which areas are prone to flood, which flora and fauna is affected. The information needed in the pilots is often more specific than on national and global levels. The information of these scenarios is too general for durable spatial planning on local and regional level.

Strength

An increased knowledge base on local effects and the extent of these to identity potential benefits and risks on local and regional scale. This increased knowledge base is also essential for supporting the decision making process regarding local and regional spatial visions.

Weakness

Local and/or regional data is scarce to develop scenarios. Additional research needs to be done. Another weakness is that socio economic scenarios generally have a time span ranging from 10-50 years, while climate change scenarios have a time span of 50-100 years.

Relevant data needed, or other needs, to be able to use the tool:

Regional and local datasets

Example: Arvika, Sweden

In Sweden the change in precipitation will vary significantly and even more the local precipitation and hydrology depending on several factors, and according to recent studies in Sweden there is a large request on climate change simulations for local or small regional scale (SKL 2009; SOU 2007:60). The Swedish hydrological and meteorological institute (SMHI) is performing such down scaled simulations within CPA and other parallel research programs[13]. The aim is to develop a method for local scale scenarios that can be used by all Swedish municipalities and other parts of Northern Europe. At present local scale climate change scenarios (including for example flood risk maps) are available at SMHI.

13 www.smhi.se and www.climateproofareas.com

How and by whom was the tool used?
The climate change scenarios in Arvika have been used to identify primary and secondary climate effects such as the exposure of inundation.

SMHI performed the simulations. The results were used by civil servants for risk analysis of the Municipality as a basis for identifying measures that need to be taken.

In which phase/stage/step(s) it was used
The results were used in the problem specification phase.

How the tool handled the uncertainties involved?
The results include the uncertainties as several regional scenarios were used as the background basis and the uncertainties were presented in a statistical analysis.

How the tool handled the relevant time perspectives involved
The simulations cover different time periods from today until 2100.

In what way did the tool support the aim of the project– if not what would help to reach the goal
The results of the simulations were the basis for the next step, the inundation map, which in turn is the basis for the next steps in the risk analysis which is the basis for the further work in CPA in Arvika.

Quantitative methods for inundation risk maps

Purpose and aim of the tool
Create a basis to assess the potential for flooding, which in turn can be used to make a quantitative inventory of objects that may be at risk.

Strength
Detailed quantitative or semi quantitative information as a basis to assess further steps in a risk analysis

Weakness
Can be costly and time demanding depending on the ambition level

Relevant data needed
Estate maps, topographic maps and climate change scenarios

Duration
Depending on ambition level and available data around some months

Cost:
Inundation, topographic and estate mapping to identify elements at risk of flooding, erosion and landslides on municipal level and regional level can be achieved from private consultants or via SMHI and SGI.

CLIMATE PROOF AREAS
TIME TO ADAPT

Example: Arvika, Sweden

How was the tool used?

Within CPA, Arvika municipality has performed a detailed inundation risk analysis to assess the potential probability for flooding and inundation in Arvika municipality focusing infrastructure in low laying areas along the shores of Glafsfjorden[14]. On municipal scale other elements at risk can be identified and mapped. In Sweden such analyses is performed by different institutes and other actors and consultants.

The tool was used initially in the project as a basis for further analyses, such as identifying buildings subjected to flood risk due to climate change and further uses for identification of other elements at risk.

In which phase/stage/step(s) it was used

The results were used in the problem specification phase.

Who used the tool and who was involved

The municipality ordered the laser scanning as a basis for the development of the map which is used by several departments in Arvika such as the planning and building department and technical department.

How the tool handled the uncertainties involved?

The uncertainties due to climate change were handled in the climate change scenario simulations described above. The topographic map resolution 1dm, future buildings and infrastructure etc. needs to be updated continuously.

How the tool handled the relevant time perspectives involved

The laser scanning must be complemented continuously by updated inventories of elements at risk. The meteorological information, however, is based on the climate change scenarios described above.

In what way did the tool support the aim of the project– if not what would help to reach the goal

This was the second main target of the Arvika pilot project in accordance of the application.

14 see WP 2 pilot report of Arvika for further information

Model based scenario analysis

Purpose and aim of tool
A physically based hydrological model is driven by regional climate scenarios in order to quantify the climate change impact on the regional water balance. Based on such an analysis, a hydrological description of a set of plausible futures is feasible.

Strength
The strength of the model based scenario analysis is the plausibility of the climate change impacts on the water balance if regionally downscaled climate projections are available and if a physically based model is used. Physically based models can be assumed to be most reliable in translating climate change scenarios into hydrological change scenarios. Thus, driving a physically based hydrological model by downscaled climate projections, climate change impacts can be quantified in a plausible way.

Weakness
The main weakness is the uncertainty in the climate projections. 'Wrong" climate projections will probably lead to "wrong" hydrological impact assessments. Additionally, changes in other drivers such as land use may also affect the water balance. Hence, in many cases it may be necessary to combine climate projections with socioeconomic scenarios (e.g., land use).

Relevant data needed, or other needs, to be able to use the tool:
Information on historic and future climate conditions, information on the physiographic characteristics of a region (soils, land use, topography, groundwater).

Cost:
Working time, computer time.

Duration:
Weeks to months.

Where to find the tool or further information:
- Wesermarsch vision booklet (in German; Ahlhorn, F., Bormann, H., Giani, L., Klaassen, K., Klenke, T., Malsy, M., Restemeyer, B. (2011): Klimasichere Region Wesermarsch - Die Zukunft der Wasserwirtschaft. Erste Schritte auf dem Weg zu einer Klimaanpassungsstrategie für den Landkreis Wesermarsch).
- Bormann, H., Ahlhorn, F., Giani, L. & Klenke, T. (2009): Climate Proof Areas - Konzeption von an den Klimawandel angepassten Wassermanagementstrategien im Norddeutschen Küstenraum. Korrespondenz Wasserwirtschaft, 2 (7), 363-369. DOI: 10.3243/kwe.2009.07.002.
- Bormann, H. (2009): Analysis of possible impacts of climate change on the hydrological regimes of different regions in Germany. Advances in Geosciences, 21, 3-11.

Example: Model based scenario analysis Wesermarsch rural, Germany

How was the tool used?

Regional climate scenarios of the WETTREG model (based on ECHAM4 GCM) were used to drive the 1D-physically based SIMULAT model. In order to simulate realistic climate change effects, SIMULAT was parameterised using typical properties of the Wesermarsch region (clay soil, grassland, shallow groundwater). Climate change impacts were simulated until year 2100 for three different climate scenarios (A1B, A2, B1).

In which phase is it used

The model based scenario analysis was used within the second phase of the problem solving cycle (regionally specific climate impact analysis).

Who used the tool and who was involved?

The University of Oldenburg carried out the model based scenario analysis and interpreted the results. Afterwards, the most important results were presented to the regional forum (see chapter 4).

How the tool handled the uncertainties involved

Uncertainties in climate projections are reflected by driving the model with three different climate scenarios (A1B, A2, B1) and by representing each decade until year 2100 by 200 years of simulations. Hence, a corridor of possible future conditions can be generated.

How the tool handled the relevant time perspectives involved?

The simulations were performed for the future until the year 2100.

Lessons learned

The regional projected climate change is likely to have severe impacts on the hydrological cycle. Likely changes can be quantified by a model based scenario analysis.
Today’s water management problems can be expected to get worse. Adaptation to climate change is necessary.

5.4 Conclusions

As this phase is called problem specification, the emphasis is on tools that can provide information. This is also done for supporting the phase 1 defined sense of urgency. In this phase data acquisition and scenario tools are widely used. Many of these tools are meant to reduce uncertainty by 1) calculating bandwidths of effects (scenario's) or 2) reducing blank spots of knowledge.

Models and tools are specifically developed to be used in the climate proofing process (all four recommended tools).

The tools mentioned here are mainly intended for analysis and retrieving data and information. After a modelling process the new information is presented to the stakeholders. The tools do not seem to be intended for a joint fact finding, but rather more for underpinning the urgency of the problem. This can be a result of separating the process tools from the more analytical tools. The process tools are described in phase 1 and chapter 3. But in the description of the analytical tools, the involvement of different actors is not mentioned as an important contribution to the tool.

It is recommended to provide concrete numbers when describing climate change effects. Climate change related problems often do have their basis in current problems. Looking back to the (near) history helps to provide these concrete numbers. Statistical tools can use these data to provide more insights.

The data that is retrieved in this stage should be communicable. Large bandwidths or not understandable indicators will not allow advancing to the next steps. Good visualization can help communicating with the public and also experts.

6 Generation of solutions

6.1 Description of this phase

The phases of the problem definition and specification provided the basis to appoint senses of urgencies. In this step 'generating solutions' possible strategies and measures are developed to adapt to or counteract the problems that have been identified. The solutions will be analyzed and pre-selected based on their capabilities of solving the identified problems. The outcome of this step is a list of possible solutions and their characteristics (effectiveness, side effects, costs etc.).

In this report the focus doesn't lie on the measures, but only on the tools supporting the development of measures. In the Swedish pilot Arvika, a structured list of physical measures was made to show the range of possible measures. The list itself is considered a tool and is added to the table of tools.

There are, in principle, an infinite number of potential solutions and actions that can be taken to reduce effects or reap the benefits of climate change. The focus of CPA is on actions to reduce the effects or enhance the benefits of changes in (often increased) water levels or water flows.

Within a parallel Interreg project "Strategic Alliance for integrated Water management Action" (SAWA) a compilation of potential actions to reduce such risks, or to create potential benefits, is being performed (e.g. SAWA Water Wiki, Bergman et al, 2011[15 16]). In Annex A one version of this compilation is shown. It is a list or a "bouquet" of commonly suggested measures describing its known advantages and disadvantages (under specific circumstances). The compilation is based on available knowledge that ranges from experience to laboratory results and pilot scale experiments.

15 Bergman, R., Andersson-Sköld, Y., Fallsvik, J., Hultén, C., Elliot, A-L., 2011, Measures for climate change in Sweden – Altered rainfall and sea levels, Strategic Alliance for integrated Water management Actions (Sawa) Report and SGI Varia.

16 http://iwawaterwiki.org/xwiki/bin/view/Organizations/SAWA

6.2 Overview of tools in the problem definition stage

The table gives an overview of the different tools used in the solution generation phase in the CPA pilot project. Per tool the application within the CPA pilot project is mentioned and the type of output, the time scale, uncertainties, necessary data and duration are described.

- The tools in bold are the recommended tools that are described in more detail in the next paragraph.
- In the column Tool description: The abbreviations stand for:
  NL (The Netherlands)
  SD- Pilot Schouwen Duiveland
  OS- project Oosterschelde
  DU (Germany)
  WM- pilot Wesermarsch
  SW (Sweden)
  AK- pilot Arvika
- In the column Time scale: P, N, M, L represents Present, Nearby future, Mid term future and Long term future respectively
- In the column Duration: H= hours, D=days, W=weeks, M=months, Y=years

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Brainstorming Examples: DU (WM)	The aim is to identify and make a primary inventory of potential benefits and risks. This is mentioned as it is often in decision processes omitted	P,N,M		**(+)** ▪ The process creates new innovative ideas ▪ Participants with different level of knowledge and backgrounds can participate	paper work, flip charts, maps, mind maps	D,W (preparation, participation, analysis)
				(-) ▪ The results are difficult to reproduce. ▪ Not a quantitative method. ▪ The results depend on the individual participant's interests, knowledge and experience. ▪ It shall only be used as a way to create the opportunity to not loose to many aspects otherwise not foreseen. ▪ Subjectivity, limitation to personal knowledge.		
Participatory development of guiding principles (landscape vision) Examples: NL(SD) DU (WM)	Common vision of the future	N,M	- Uncertainties are part of the constraints for solutions - Flexibility of suggested measures	**(+)** Common picture of the region as a target to be realised by adaptation measures	Regional knowledge, experience	H
				(-) Not necessarily in line with policies, subjective		
Overview of possible measures *Examples* *SW (Sawa list)*	Compilation of examples of potential measures, including advantages, disadvantages experience and lessons learned if available.	P,N,M	- Uncertain whether the solutions are applicable to the problem situation	**(+)** Easily extractable information on examples of potential measures, including advantages, disadvantages experience and lessons learned if available	Information about earlier implemented solutions in this area or somewhere else	W
		Integral or sector based.		**(-)** The example descriptions can be based on site specific conditions or theoretical assumptions		
Wesermarsch Landscape vision booklet ***Examples:*** ***DU (WM)***	Distribution of information	P		**(+)** Illustrative, New, visionary Informing on uncertainty	Project results	W,M
		Water management		**(-)** Expensive, labour intensive, distribution		

6.3 Recommended tools

Landscape vision

Purpose and aim of tool
A joint landscape vision is a commonly agreed future vision of an area or region. It is an important prerequisite for the development of successful and sustainable adaptation measures to climate change. Setting priorities helps the decision-making process by, for example, making choices between focusing on technical adaptation measures or on alternative types of land use and landscape development.

Developing such a landscape vision in a participatory way, e.g., by asking a group of representative stakeholders of a region to describe their region for a specific future time horizon, enables a joint vision on the future landscape development. Such a process may assist in achieving consensus on the future state of a landscape and narrow the range of adequate adaptation measures.

Strength
The strength of a joint landscape vision is that it provides the necessary boundary conditions for future development and adaptation alternatives. It provides an opportunity for all different stakeholder groups to get their personal / institutional view on the future development of the region represented. If possible, all relevant stakeholder groups should agree on a joint landscape vision.

Weakness
A landscape vision developed in a participation process is not necessarily consistent with existing policies. Another possible weakness is that the development of a landscape vision may be dominated by individuals (people, organizations). This might result in a vision that is not necessarily representative for all relevant groups. Also a possibility is that that the different stakeholders do not reach a commonly agreed vision.

Relevant data needed, or other needs, to be able to use the tool:
The most relevant information is local knowledge on the region of interest, their inhabitants, regional economy and the respective interrelations.

Cost:
Working time and travel costs of members of the regional forum.

Duration:
Hours to days (excluding the process of the regional forum itself)

Where to find the tool or further information:
- Wesermarsch vision booklet (in German; Ahlhorn, F., Bormann, H., Giani, L., Klaassen, K., Klenke, T., Malsy, M., Restemeyer, B. (2011): Klimasichere Region Wesermarsch - Die Zukunft der Wasserwirtschaft. Erste Schritte auf dem Weg zu einer Klimaanpassungsstrategie für den Landkreis Wesermarsch).
- Bormann, H., Ahlhorn, F., Giani, L., Klaassen, K. & Klenke, T. (2010): 'Climate Proof Areas': Anpassung von Wassermanagement-Strategien im Küstenraum an den Klimawandel. In: Meon, G. (Hrsg.): Nachhaltige Wasserwirtschaft durch Integration von Hydrologie, Hydraulik, Gewässerschutz und Ökonomie. Beiträge zum Tag der Hydrologie 2010. Forum für Hydrologie und Wasserbewirtschaftung 29.10, 151-159.

Example: Landscape vision Wesermarsch, Germany

How was the tool used?

In the Wesermarsch pilot, the regional forum developed a joint landscape vision for the year 2050. During a workshop all participants (stakeholders) were asked to describe their ideas on a future development of the Wesermarsch until year 2050. Based on those ideas the regional forum composed a joint vision on the future landscape on which all stakeholders agreed upon.

In which phase/stage/step(s) was it used?

The landscape vision was defined and used in the identification phase of possible adaptation strategies to climate change.

Who used the tool and who was involved?

The University of Oldenburg used the tool to describe the boundary conditions for the development of possible climate change adaptation options. All relevant regional stakeholders were involved and contributed to this landscape vision.

How the tool handled the uncertainties involved?

Uncertainties in climate projections were reduced by choosing a mid-term time horizon (2050) for which the different IPCC scenarios show relatively similar impacts.

How the tool handled the relevant time perspectives involved?

All stakeholders agreed on a joint time perspective (year 2050).

Lessons learned

The members of the Wesermarsch regional forum do not want the region to change significantly. They want continuity with respect to landscape, agriculture, coastal protection and working conditions. Based on this vision, focus groups out of the regional forum developed different climate change adaptation options.
For comparison we asked the international CPA project members from the other European pilots to think about possible adaptation measures in the Wesermarsch region as well. Based on a different landscape vision (accepting that changing hydrological conditions in the landscape will be a consequence of climate change), they predominantly suggested different adaptation measures (e.g., wetland development, alternative land use).

These findings highlight the importance of setting adequate boundary conditions for a future development. Setting such priorities governs the decision-making process and decides whether the focus is set on technical adaptation measures (as suggested by the Wesermarsch regional forum) in contrast to alternative types of land use and landscape development concepts for a region (as suggested by the CPA international experts).

Focus groups

Purpose and aim of tool

Focus groups were built in the Wesermarsch pilot out of the regional forum in order to develop climate change adaptation alternatives for rural and urban areas. Since water management problems differ in urban and rural areas, the regional forum split up into two focus groups, consisting of stakeholders and experts with particular interest in and experience with water management in urban and rural areas.

Strength

The strength of focus groups is that only those members are part of the group which already have experience with a specific area or a specific problem. The participants contribute expert as well as local knowledge. The topic focus groups work is more specific (compared to the general / regional issue) and therefore requires less disciplines. Thus, focus groups can work more effectively.

Weakness

Focus groups may be dominated by individuals who are particularly interested in a single solution. Therefore, a sound moderation within such groups is required in order to give all members the floor to contribute to the discussion. However, if stakeholders of a particular sector do not participate in a focus group, their absence may lead to disciplinary solutions which may not accommodate the integrative character of a problem.

Relevant data needed, or other needs, to be able to use the tool:

The most relevant information is local knowledge on the region of interest, their inhabitants, regional economy and the respective interrelations.

Cost:

Working time and travel costs of members of the focus groups.

Duration:

Days.

Where to find the tool or further information:

Wesermarsch vision booklet (in German; Ahlhorn, F., Bormann, H., Giani, L., Klaassen, K., Klenke, T., Malsy, M., Restemeyer, B. (2011): Klimasichere Region Wesermarsch - Die Zukunft der Wasserwirtschaft. Erste Schritte auf dem Weg zu einer Klimaanpassungsstrategie für den Landkreis Wesermarsch).

Example: focus groups in Wesermarsch

In which way the tool was used

Focus groups were built in the Wesermarsch pilot out of the regional forum in order to develop climate change adaptation alternatives for rural and urban areas. Since water management problems differ in urban and rural areas, the regional forum split up into two focus groups, consisting of stakeholders and experts with particular interest in and experience with urban and rural areas.

The focus groups met at least three times (for half a day) to discuss specific water management problems and climate change adaptation options for their focus area. They aimed at finding a joint set of climate change adaptation alternatives. In the end of the process both focus groups merged again and presented their ideas to each other within the regional forum in order to discuss a county wide climate change adaptation strategy.

In which phase/stage/step(s) it was used

The focus groups were built and used in the phases of the identification of possible adaptation strategies to climate change. One of both groups already prepared the choice of adequate measures by excluding individual alternatives and focusing on one climate change adaptation solution.

Who used the tool and who was involved

The University of Oldenburg used the tool to describe the boundary conditions for the development of possible climate change adaptation options. All relevant regional stakeholders were involved in one of the focus groups and contributed to the discussion.

How the tool handled the uncertainties involved

Uncertainties in climate projections were reduced by choosing a mid-term time horizon (2050) for which the different IPCC scenarios show relatively similar impacts.

How the tool handled the relevant time perspectives involved

All stakeholders agreed on a joint time perspective (year 2050).

Lessons learned

The members of the focus groups aim at technical climate change adaptation measures, avoiding changes in land use (in line with the landscape vision). Some stakeholders did not yet realise the importance of climate change adaptation, prioritising economic development in urban areas compared to an urban planning taking care of flood protection measures. Therefore, discussion in focus groups was often dominated by our days' problems (availability of money, economic development, drainage and watering) rather than visionary solutions of climate change induced problems.

6.4 Conclusions

Although the content (solutions) is the centre of attention, participation of different actors is an important part of the process of generating solutions. All tools are meant to inspire people (overview of potential measures, Wesermarsch booklet), collect ideas (brainstorming) and/or define a target state of a landscape (landscape vision).

This phase has two recommended tools for the purpose of generation solutions (Wesermarsch Vision and focus groups). As most tools require involvement of many different actors, the efforts in other participatory tools have to be complementary to the solution generation tools.

Show cases are important for generating solutions. These show cases give people an idea of the possible solutions and how they look like and might affect their interests. Clear examples of show cases are the SAWA-list and the demonstration project in the Oosterschelde.

CLIMATE PROOF AREAS
TIME TO ADAPT

7 Choice

7.1 Description of this phase

In this step an assessment of different strategies will be made. The relevant criteria for choosing a strategy will be determined by the involved parties. After negotiation and loop backs to previous stages (mainly generation of solutions), the parties with decisive power will make a choice based on the criteria which strategy and/or measures will be taken. This is often based on criteria such as costs, durability, maintenance, flexibility etc.

7.2 Overview of tools used in the pilots

In the table on the next page, the tools that were used in this phase are mentioned.

- The tools in bold are the recommended tools that are more detailed described in the next paragraph.
- In the column Tool description: The abbreviations stand for:
  NL (The Netherlands)
  SD- Pilot Schouwen Duiveland
  CC- project Comcoast
  OS- project Oosterschelde
  GL- project Galgenplaat
  BR- project Bruinisse
  DU (Germany)
  WM- pilot Wesermarsch
  SW (Sweden)
  AK- pilot Arvika
- In the column Time scale: P, N, M, L represents Present, Nearby future, Mid term future and Long term future respectively
- In the column Duration: H= hours, D=days, W=weeks, M=months, Y=years

Tool description	Type of Output	Time scale & sector	Uncertainties	Strength(+)/ Weakness (-)	Data	Duration
Cost-benefit analysis *Examples:* *NL(GP, OS)*	Overview of costs and benefits of measures/strategies	All sectors	Bandwidth in the outcomes of the analysis is the result of uncertainties	**(+)** ▪ Consistent methodology ▪ Comparison of different impacts on different sectors **(-)** ▪ Comparison between financial impacts and environmental impacts can be difficult ▪ Requires several index numbers ▪ Discussions about valuing effects ▪ Bandwidth in the outcomes of the analysis is the result of uncertainties	Index numbers	W
Participatory assessment (development of measures/ solutions) *Examples:* *NL (CC)*	Common set of possible solutions, integrative process problem analysis and development of solutions	Representatives of involved sectors/ stakeholders.	Suggestion of solution being aware of uncertainty; flexibility of suggested measures	**(+)** Joint development of possible solutions, agreeing on those common solutions **(-)** Not necessarily in line with policies;	Regional knowledge, experience.	H,D
MDST *Examples:* *SW (AK)*	Evaluation of measures and current situation from social, environmental, economic perspective	All relevant sectors (experts and key stakeholders)	- NEW method - Iterative process - Uncertainties can be qualitatively described and the flexibility of the strategy is expressed as one of the important parameters	**(+)** - Includes experts and key stake holder perspectives - Traffic light result presentation - Allows an iterative process **(-)** ▪ Needs participation of experts and key stakeholders. ▪ Can not be left to consultants. Involves a number of steps.	Input is based on best available data and expert judgements.	H,D

7.3 Recommended tools

There are no recommended tools mentioned in this phase, but the MDST-tool is particular meant for making a more transparent decision. This tool is described in chapter 3. A discussion has been held about the absence of recommended tools in this phase. The reason for not having any recommended tools here, is that many pilots have not yet reached this phase. It is stressed that if a tool is not labelled "recommended", this does not mean that a tool is not recommended or rejected.

7.4 Conclusions

All of the tools described in this section can be of varying complexity depending on the financial situation, complexity and size of the project. Both the environmental and integrated assessment tools can include quantitative and qualitative values.

All tools can or should be combined with each other. The complexity of the tool can vary from a simple checklist that can be used as a basis for discussions to a multi criteria matrix. Such a matrix can be based on complex integrated assessment models or quick scan information. The assessment can be qualitative or quantitative or mixing both.

The tools mentioned here are focused on the contents of the decision. A rational model for decision making seems to be the standard. Tools ensuring commitment of people to the decision making process are not mentioned here. In the MDST process tool (chapter 3) is one part the weighing of different criteria depending on the interests of the involved parties.

In many pilots the phase of choice is not yet reached. It seems difficult to point out when exactly it will be decided. For example in the pilot Oosterschelde the decision to start a pilot with sand nourishment is called a decision to retrieve more data and insight in the system for use in phase 2 (problem specification).

The overall recommendation for this phase is to make the decision process more transparent. An instrument like the Climate Adaptation Pre-Assessment (CAPrA, see also Work Package 3) could be beneficial to provide the decision makers with more systematic and standardized information about the effects of the decision at hand on climate adaptation.

8 Implementation

8.1 Description of this phase

After choosing a strategy the accompanying measures have to be taken. The measures can be physical or technical or the development of policies. When implementing one should be aware of individuals who feel neglected in the process or not involved (A good stakeholder analyses and participatory measures in phase 1 and 2 are imperative to circumvent these issues at the implementation stage). This may result in delays in the project and subsequently lead to exceeding costs. In these cases loop backs can be needed or adjustments have to be made. The outcome of this step is an implemented strategy including the implementation of the measures.

8.2 Overview of tools used in the pilots

This stage is not yet reached in most of the pilots. Only the recommended tool "public drop in sessions" applies here (Titchwell Marsh pilot)

8.3 Recommended tools

Public drop in sessions

Purpose and aim of the tool
To provide an opportunity to discuss and explain the purpose of a project with stakeholders in an informative and positive manner. This will eventually lead to a smoother implementation of the measures.

Strength
The traditional style public meeting with a stand up presentation runs the risk of being dominated by a small group of vocal people. This enables those who have the confidence to stand up and make their views heard. This can influence the views of others, and people who are less confident in this setting do not get an opportunity to make their views heard. An alternative to this is a public drop in event where project staff are on hand, over the course of several hours, to meet individuals face to face and explain the purpose of a project. Ideally this would happen over both working hours and non-working hours to allow the maximum number of people from different backgrounds to attend.

Weakness
Required considerable time and good planning to make sure the event is well publicized.

Relevant data needed or other needs to be able to use the tool
An understandingof the audience that you are trying to reach. Thought about a good time, place and method/instruments to engage with them.

Cost
Hire of hall / staff time / preparation of interpretation materials.

Duration
Can be used at any stage in the process but likely to be particularly useful during the implementation stage.

Example: Titchwell Marsh, United Kingdom.

How was the tool used?
Public drop in sessions were held in three local village halls and over a two day period on the reserve.

In which phases/stage/steps was it used?
It was used in the implementation stage

How the tool handled the uncertainties involved?
As a public drop in session allows face to face communication with interested stakeholders it provides a good opportunity to give an in depth briefing, allowing assumptions and uncertainties to be explained.

In what way did the tool support the aim of the project– if not what would help to reach the goal?
Yes, the RSPB did not receive a single objection to the planning application when it was submitted suggesting that public corner had been resolved.

8.4 Conclusions

As many pilots have not yet reached the phase of implementing not many tools were identified in the pilots for this phase. In the UK pilot it is clear that it is still important to have a good communication tool to reduce objections. However problems encountered in this phase can be significantly reduced by a good participatory process. It is important that in this stage stakeholders aren't faced with a fait accompli.

9 Evaluation

9.1 Description of this phase

After implementation it is important to evaluate the intended and unforeseen consequences of the implemented strategy and measures. In case of a strategy, the evolution of the developments have to be continuously followed. When needed, additional measures have to be taken. When the problem is not going to be solved or a new problem emerges, a new problem definition is needed.

Often little attention is paid to this step in the problem solving cycle. It is often a costly and long step and it is difficult to find a party that feels responsible for this step. However, it is a crucial step, especially for long term strategies or effects. On the long run it is less expensive to develop a good monitoring and evaluation program than initiating a new project. This can also lead to stakeholders loosing interest and commitment for new projects.

9.2 Overview of tools used in the pilots

No tools were mentioned for this phase since this phase is not yet reached by any pilot.

9.3 Conclusions

In practice this step is often ignored. Time and money are often limiting factors. It is recommended to communicate the gain of the project by going through this step. I.e. it can advocate the usefulness of your project and thereby make it easier to start follow up projects.

There is a need for one or more strategies for presenting to and convincing the public of the benefits (and side-effects) of the results. Show cases of successes can be part of this strategy.

10 Discussion and recommendations

10.1 Reflection on the climate proofing process

Climate proofing is too complicated for simple decisions by a single decision maker. A successful decision process is transparent, iterative, interactive and includes all relevant stakeholders from an early stage of the process.

Climate proofing projects can or will be distinct from other regular projects on the aspects below.

- Long term decision making and short term measures
- Local, regional and national scale
- Uncertainties due to (the sum of) incremental deviations
- Restricted commitment and low sense of urgency

The tools that were used in the CPA project and mentioned in this report dealt more or less with these characteristics.

The difficulty of climate adaptation lies in the tension between long term effects and the short term decision making cycle. The list of recommended tools in section 10.3 shows many tools that are used to deal with this aspect.

Regional and national scale problems require more detailed site-specific information and data. The available global and national information is too abstract for the information needed at this level. The problem is often known and acknowledged on a national scale, but the pilots operate on a local scale, so they need information for local impact assessments. Local unforeseen developments and local climate scenarios are the start for a basis to appoint a sense of urgency that enables organizations to act on a local/regional scale. Many tools that deal with issue have been developed and recommended.

Uncertainties are mainly tackled by acquiring available data regarding the current situation in order to extrapolate them to possible future problems. Data can be obtained from literature, field work, monitoring, experts and stakeholders. Besides this data, modelling and development of scenarios to retrieve a bandwidth of effects is often done.

Many tools mentioned in this document are part of participatory process tools that are intended for creating commitment among and involvement of stakeholders. Raising awareness tools are used to deal with a low sense of urgency that stakeholders might have about climate adaptation. One of the most important conclusions to deal effectively with this is to entwine climate adaptation with effects of climate change that already occur. Creating networks and connecting to planned and executed projects is also an important strategy for spreading the message. Good participation processes are based on good insight of all interests of the stakeholders, their direct involvement in the project (joint fact finding) and communication between project members and stakeholders. This will also decrease eventual objections by implementing measures.

10.2 Conclusions per phase

In this toolkit, despite the important statement of the first section, a simple process scheme was used to sort the tools. The process of climate proofing is therefore divided into 6 steps or phases:
1. Problem definition
2. Problem specification
3. Generation of solutions
4. Choice
5. Implementation
6. Evaluation

It was not in every case possible to place the tools in one specific phase. Since many tools can have different purposes, they can be useful for more phases. Tools can be like add-a-diamonds: in several phases the tools can be updated and evolve into the next phase. Process tools as communications plan and matrix based decision tool are the most clear examples of this. The iterative character of decision making in climate proofing an area is sometimes very clear and therefore the use of a tool can shift in purpose.

Problem definition

For this phase many tools are used of which many were labelled recommended to use in climate adaptation projects. Many pilots have sought for commitment of a wide variety of actors. The used tools were not meant as a single action, but to be part of a larger process of involvement of parties. Therefore, forums and alliances have proven to be essential. The communication and the tools itself are intended to last longer than only this phase.

With respect to content, the tools are used for achieving a good focus and a clear dividing line of what aspects are to be taken into account. The projects are favourably considered to be local, concrete and should connect to local interests and problems.

Both kinds of tools (communication and focusing) were considered recommended tools. The student project tool seems to be rather different than the other tools. This tool does not immediately contribute to a process, although it could have impact on a small community and thereby create awareness to the students of their immediate environment.

Many communication tools are listed in this phase. In this phase it is important to send out a message and to generate commitment. Although communication is used through all the phases it is crucial to set up good communications at the start of the project. Communication could or even should be part of a plan (see Communications plan in chapter 3) or methodology (see chapter 3).

Problem specification

As this phase is called problem specification, the emphasis is on tools that can provide information. This is also done for supporting the phase 1 defined sense of urgency. In this phase data acquisition and scenario tools are widely used. Many of these tools are meant to reduce uncertainty by 1) calculating bandwidths of effects (scenario's) or 2) reducing blank spots of knowledge.

Models and tools are specifically developed to be used in the climate proofing process (all four recommended tools).

The tools mentioned here are mainly intended for analysis and retrieving data and information. After a modelling process the new information is presented to the stakeholders. The tools do not seem to be intended for a joint fact finding, but rather more for underpinning the urgency of and specifying the problem. This can be a result of separating the process tools from the more analytical tools. The process tools are described in phase 1 and chapter 3. But in the description of the analytical tools, the involvement of different actors is not mentioned as an important contribution to the tool.

It is recommended to provide concrete numbers when describing climate change effects. Climate change related problems often do have their basis in current problems. Looking back in recent history helps to provide these concrete numbers. Statistical tools can use this data to provide more insights.

The data that is retrieved in this stage should be communicable. Large bandwidths or non understandable indicators will not make progressing to the next steps possible. Good visualization can help communicating with the public and also experts.

Generation of solutions

Although the content (solutions) is the centre of attention, participation of different actors is an important part of the process of generating solutions. All tools are meant to inspire people (overview of potential measures, Wesermarsch booklet), collect ideas (brainstorming) and define target states (landscape vision).

This phase has two recommended tools for the purpose of generating solutions (Wesermarsch Vision and focus groups). As most tools require involvement of many different actors, the efforts in other participatory tools have to be complementary to the solution generation tools. Regional knowledge serves the development of tailor made solutions.

Show cases are important for generating solutions. These show cases give people an idea of the possible solutions and how they look like and might affect their interests. Clear examples of show cases are the SAWA-list and the demonstration project in the Oosterschelde.

Choice

All of the tools described in this section can be of varying complexity depending on the financial situation, complexity and size of the project. Both the environmental and integrated assessment tools can include quantitative and qualitative values.

All tools can or should be combined with each other. The complexity of the tool can vary from a simple checklist that can be used as a basis for discussions to a multi criteria matrix. Such a matrix can be based on complex integrated assessment models or quick scan information. The assessment can be qualitative or quantitative or mixing both.

The here mentioned tools are focused on the contents of the decision. A rational model for decision making seems to be the standard. Tools ensuring commitment of people to the decision making process are not mentioned here. In the MDST process tool (chapter 3) is one part the weighing of different criteria depending on the interests of the involved parties.

In many pilots the phase of choice is not (yet) reached. It seems difficult to point out when exactly what will be decided. For example in the pilot Oosterschelde the decision to start a pilot with sand nourishment is called a decision to retrieve more data and insight in the system for use in phase 2 (problem specification).

The overall recommendation for this phase is to make the decision process more transparent. An instrument like the Climate Pre-Assessment (see also Work Package 3) could be beneficial to provide the decision makers with more systematic and standardized information about the effects of the decision at hand on climate adaptation.

Implementation

As many pilots have not yet reached the phase of implementing not many tools were identified in the pilots for this phase. In the UK pilot it is clear that it is still important to have a good communication tool to reduce objections. However problems encountered in this phase can be significantly reduced by a good participatory process. It is important that in this stage stakeholders aren't faced with a fait accompli.

Evaluation

In practice this step is often ignored. Time and money are often limiting factors. It is recommended to communicate the gain of the project by going through this step. I.e. it can advocate the usefulness of your project and thereby make it easier to start follow up projects.

There is a need for one or more strategies for presenting to and convincing the public of the benefits (and side-effects) of the results. Show cases of successes can be part of this strategy.

10.3 Recommended tools

Many tools have been used, tested and developed within the CPA project . Some of the tools have been named as recommended tools because they were especially useful when dealing with the aspects of climate adaptation. Below is an overview of the recommended tools per phase to use in climate adaptation projects:

Process management
- Communications plan
- Matrix based decision support tool

Problem definition
- School projects for creating awareness by future stakeholders
- Keeping climate adaptation on a local level
- Regional forum
- Connecting to local problems and initiatives
- Defining clear roles and responsibilities in regional alliances

Problem specification
- Thorough facts-based quantitative analysis
- Regional and local climate scenarios
- Quantitative methods for inundation risk maps
- Model based scenario analysis

Generation of solutions
- Landscape vision
- Focus groups

Choice
- None

Implementation
- Public drop in sessions

Evaluation
- None

Many recommended tools were used in the first step of the decision making process. This is partly due to the phase of the CPA pilots are in (many of them had not yet reached the choice phase). Putting the need for climate adaptation on the political agenda and raising public awareness are of great importance for getting attention for climate adaptation. Also, retrieving more information on the physical system and the ability to make proper predictions help assigning sense of urgency to the problem en thus supporting political decision making. These tools are also used for communication purposes.

10.4 Recommendations

Starting and leading a process with a process plan (including the intention of using appropriate tools) is necessary. Although sometimes the realisation of more adaptive capacity in the pilots seems to be considered as a project, the climate adaptation has many characteristics of a process. This implies that a clear process management (including a plan) is required. This will help keep the objectives clear and gain a clear view on the process when iterations occur. The process management is needed from the very beginning of the process until the end.

A process manager in a climate adaptation process should use tools. All mentioned tools are meant as a helpful instrument for advancing in the problem solving cycle. They are supportive to the process, but are not means themselves. They are only useful and successful if the process asks for support by these tools. Application of a tool without a proper role for these tools is useless and time consuming.

Tools help improve the transparency of the process. Some tools do this by giving more insight into the role of actors or by making explicit what criteria is used and evaluated. The process will become more systematic; thereby creating more control for the process manager on the direction of the process. The improved transparency will enlarge the chance that in a decision process more sustainable solutions are chosen.

As stated before, processes tend not to follow a straight path from one phase to the next one. Tools can be helpful by assisting the activities in a phase, but can and will be used in other phases. Be aware of the possibilities for (and complications of) tools which are applied in other phases than they might be intended for. Some more process oriented tools have their strength in the application during more phases. The division of the tools in this report to the phase of application is only meant as a framework for positioning the tools.

In this toolkit a couple of tools have been selected by the pilot members and are presented as recommended. This does not mean that without these tools the objectives of a process cannot be reached or that these tools will be automatically needed. These tools have proven to be useful in an adaptation process and for that reason they are worth considering. The overall recommendation is not that someone should use these tools in their process. The recommendation is to get familiarized with these tools and make your own decision whether it is useful in your process or not.

Using one particular tool for solving a particular weak point in a process is not recommended. Many tools receive their strength from the combination with other tools. For example, using a recommended tool for involving the public at the implementation phase (i.e. public drop-in sessions) without prior communication about sensitive aspects will probably not prevent obstructions (from other actors or the public).

For involving the community (decision makers, entrepreneurs and public) a lot of tools are mentioned of which many are recommended. This is apparently a very important aspect when working towards climate adaptation. Participation is not exclusively needed for raising awareness, spreading the message and retrieving information. Last but not least participation is needed because the implementation of a solution depends on the connection of different stakes and means of the actors.

As also stated in Work Package 3, a systematic tool which can help "inserting" climate adaptation into decisions for present day solutions is recommended. This tool is called Climate Adaptation Pre-Assessment (CAPrA). It can contribute to a more transparent decision making by adding the effects on climate adaptation as a criterion. Further research is required to define necessary elements and their linkages within a CAPrA and to suggest possible ways to implement a CAPrA in a regular decision making process.

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11.2 Websites

Climate Proof Areas website
http://www.climateproofareas.com
European Commission, about public participation and river basin management
http://ec.europa.eu/environment/water/participation/about_en.htm
Interreg Comcoast project
http://www.comcoast.org
http://www.comcoast.org/pdfs/participation/Dos_and_donts.pdf
MDST matrixes can be downloaded as Excel spread sheets from:
http://www.swedgeo.se/upload/publikationer/Varia/pdf/SGI-V613.xls
SAWA IWA Waterwiki
http://iwawaterwiki.org/xwiki/bin/view/Organizations/SAWA
Swedish climate change adaptation web-portal (in Swedish):
http://www.smhi.se/polopoly_fs/1.8068!image/10%20steg.png_gen/derivatives/fullSizeImage/10%20steg.png
Template for communications plan from the Swedish Environmental Protection Agency (in Swedish):
http://www.naturvardsverket.se/upload/03_lagar_och_andra_styrmedel/ekonomiska_styrmedel/rovinfobidrag/N-mall-kommunikationsplan.pdf
Template for communications plan from the Gothenburg University (in Swedish):
www.gf.gu.se/digitalAssets/1030/1030890_mall_kommunikationsplan.doc
www.gf.gu.se/digitalAssets/1030/1030891_mall_kommunikationsschema.xls

Appendix A: SAWA list of potential measures

In the Swedish pilot of Arvika a list is constituted with measures that could be taken for climate proofing the area. Many examples of these kind of measures have been collected and structured in this report. The CPA toolkit does not offer any suggestions about physical measures, so it was thought to have this SAWA report added as an complementary appendix to the toolkit. It is written by the SGI, Sweden.

Strategic Alliance for integrated Water management Actions

Measures to manage climate change in Sweden

Altered rainfall and sea levels

Ramona Bergman, Yvonne Andersson-Sköld, Jan Fallsvik, Carina Hultén, AnnLouise Elliot

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Contents

1 Foreword

This report is a very simple analysis of possible measures to reduce risks associated with changes in precipitation patterns, and in particular floods due to increased precipitation and sea level rise. For each measure there is a short overall description, what is generally positive and negative with each action, and where to find more information / lessons learned. The compilation does not provide detailed information for each action, but the intention is to obtain an overview of some of the steps you can take. This list, prepared under the EU Interreg IVB project Strategic Alliance for integrated Water Management Actions (SAWA), is meant to be used by the public and as a first step for planners in municipalities. Then one should proceed to find more detailed descriptions and analysis of a sample of relevant measures.

2 Introduction

In Sweden, as everywhere, we will over the next century have an elevated temperature as a result of expected climate change (SOU 2007:60). Globally there will be a sea level rise, in northern Sweden this is compensated by the elevation of the land while it becomes a net sea level rise in the rest of Sweden. Large parts of Sweden will be affected by increased annual rainfall and a change in precipitation patterns.The expected climate change will give secondary effects such as landslides, forest fires, spreading of pollutants etc. (SOU 2007:60). The influence of heavy rainfall alone may in some cities create overfilled storm water systems and flooded streets. Precipitation and spring floods may also create high flows in rivers which in turn can flood areas and in combination with a high sea level the problems can be even greater. The society needs to be adapted and the adaptation can be performed in several different ways depending on which problem is in focus.

This list was developed within EU interreg project SAWA (Strategic Alliance for integrated Water management Actions) and the focus lies on measures related to change in precipitation and sea level rise, including secondary effects such as landslides and erosion.

A first step for society to adapt to a changing climate is to identify vulnerable objects and to what extent they can be affected. For this several tools may be used. After identifying a city's or building's vulnerable points, one can choose a strategy to work with. We have chosen to focus on the following three strategies (3R): resistance, resilience and retreat. The strategies/measures can be more or less suitable for the specific situation depending on the different conditions in each city.

- **Resistance**

  Resistance is a system's ability to avoid interference. It is a valuable factor before a system suffers from a disorder (Klein, et al., 1998). Resistance is also the degree of change in a system when it's surroundings change (Knapp et al., 2001). If the system has a good resistance it is not affected and changed when there is a disturbance in the surroundings. With a resistance strategy one chooses measures that keep the water away from the city or building.

- **Resilience**

Resilience is a sensitive system's ability to respond to the consequences of a disturbance. Resilience is important to a system after it has been affected (Klein et al., 1998). After a disturbance disappears resilience is also the degree and the speed at which a system can return to the state it had before the disturbance (Knapp et al., 2001). An example of resilience strategy is to allow water to enter the city and be affected by the disturbance for a limited period. With a good resilience the city can quickly return to its original state.

Attack

Attack means that water is not only allowed (resiliency) but also used for construction or other activities. For example, as in one of the concepts being discussed for the Free Port of Gothenburg City (Moback, 2011), water is used by the use of innovative and proven technology. The water is treated as a surface suitable for construction with e.g. floating houses. Many of the solutions used are the same as described in resiliency, but attack may require more elaborate and complex structures, which means more demands for monitoring, maintenance and control.

- **Retreat**

With this strategy one lets a city or district retreat from an area at risk of flooding (SPUR, 2011). For example one is only allowing new buildings in a safe zone and may move the most vulnerable and valuable buildings and facilities to a safe distance or altitude. The strategy includes soft measures by imposing a minimum level of construction, beach protection or other restrictions. Retreat can give a long and safe protection, though the cost may be high if the city already is well established with many constructions close to the water. The most important tool for this, as for the other measure forms, is planning.

The following compilation of measures first describes general steps to adapt a community. These are under the headings planning, resistance and resiliency. Many of the actions described in resiliency can be used in the attack-strategy, but they may then require more elaborate and complex designs. The general steps are followed by physical measures that can be taken for individual properties. Finally some examples of non-structural measures that can be taken with a focus on individual properties are shown. Non-structural measures denote e.g. planning, a way of acting, economical preparedness etc. while structural measures denote concrete prevention constructions.

Our goal is not to completely describe but to give a comprehensive overview of possible measures that could be taken, shortly describe known advantages and disadvantages and where to find more information and experiences.

Table 1 Three different strategies with example of threats and measures.

Strategy	Example of threat	Example of structural measure
Resistance	- Water level rise	- Wall - Barrier - Dam
Resilience	- Water level rise - Heavy or persistent precipitation	- Adapted buildings - Optimized storm water system
Retreat	- Water level rise - Heavy or persistent precipitation	- Move buildings, build further away from the threat - Wetlands as a barrier

3 Planning and Monitoring

Apart from specific structural measures, a well thought out planning for the whole city could be more efficient, sustainable and safe in the long run and some costly measures could be avoided.

Concerning water two primary threats to cities have been identified which are included within the project SAWA: direct (heavy or persistent) precipitation and water level rise in lake/sea/river. To reduce the risk one can reduce the danger, consequence or both. To mitigate the risk appropriate strategies have been suggested. In the strategies resilience and retreat the buildings are planed more efficiently and in a long-term perspective. Restrictions and building codes could also be included. These strategies are suitable for a municipality’s master plan, which is a comprehensive plan for the municipality's long-term vision. Within the strategy resilience one could for example mitigate the effects of direct precipitation through an optimized storm water system.

One can also take measures to reduce the danger at one place by taking measures in other places. For example, one can customize a water system by take measures that delay (retention), store (storage) or reduce the outflow (discharge) upstream so that large masses of water do not affect a more vulnerable area downstream. This can be done through a good regional or national planning. International planning is needed for some rivers. Several of the measures that in this report are described on a local level (dikes, retention reservoirs, multi-functional surfaces, etc.) can also be used for much larger areas. If large catchment areas are to be managed, good planning is required that takes place in cooperation between municipalities and other stakeholders affected by the measures taken.

In the planning for new buildings a mix of the three strategies are proposed (resist, resilience and retreat). For existing buildings the strategy resistance is proposed, but also resilience. For example an optimized storm water system could be a suitable strategy for some areas.

3.1 Basis for spatial planning

There are various documents and tools that can be used in the planning process. Important documents are previous plans and studies but also new knowledge and the knowledge available in the area. This may consist of special knowledge which depends on local knowledge from property owners, operators and officials. It may also consist of data in the form of climate scenarios, surveys, mapping and other site-specific data. For example, an elevation database could be a good basis to start from in the planning to adapt a city, or a specific area, to flooding (Swedish Board of Housing, Building and Planning, 2010a; MSB, 2010c).

A flood map shows which areas that may be susceptible to various water levels. The maps can also show blue spots, where water accumulates during heavy precipitation or when the water level drops. The map can be used for several purposes. It may be used to mark areas that can be used to delay water and show which roads could be used as waterways. In Denmark the maps are called "mulighedskort" (possibility maps) and are used to prioritise in relation to the demands concerning delay of water when new buildings are constructed (Swedish Board of Housing, Building and Planning, 2010b; MSB, 2010b; Terra Firma, 2011).

Other useful documentation is for example maps showing the extent to which the soil is paved in connection to a stream (e.g. "Towards a Green Infrastructure Framework for Greater Manchester"). To these maps a flood-mapping can be linked (Swedish Board of Housing, Building and Planning, 2010b; Pasche, 2009).

These documents can be further refined or developed by computer programs in which various scenarios with sea level and precipitation are simulated and visualized.

3.2 Measures that can be used in spatial planning

In order to prioritize and to select a solution, various decision support tools and combinations of such can be used. These tools can be used together with relevant documentation to identify the most sustainable solutions.

Communication during the process can be crucial for how sustainable a decision will be. Examples and suggestions for tools that can facilitate the communication and decision process with focus on a changing climate are summarized in toolboxes (e.g., Andersson-Sköld et al., 2011a; Jonsson and Simonsson, 2011; MSB, 2006).

In addition to the methods and tools that describe, simplify and systematize the decision-making process, laws and regulations are important tools. Master and detailed plans under the PBL (Planning and Building Act) are among the most important instruments. The Swedish Board of Housing, Building and Planning’s report "Climate adaptation in planning and construction - analysis, actions and examples" (Swedish Board of Housing, Building and Planning, 2010a) and SGI Varia 608 (Rydell et al., 2011) contain a compilation of existing legislation that one can benefit from but also must take into account when planning. The law on protection against accidents indicates that a municipality should establish an action program for prevention and rescue services. An action program has three main purposes: to be a policy document, to be a document where the public get insight and information, and act as a planning basis. Since the action programs are based on local conditions, there is no general answer what they should look like but a common ground is that they should be designed on the basis of the local spectrum of risks (Swedish Board of Housing, Building and Planning, 2010a).

3.3 General non-structural measures

In addition to spatial planning of an area or a city one can plan efforts to raise knowledge, awareness and preparedness to prevent and mitigate the consequences of possible floods. Examples of non-structural measures are:

- Action program in case of flooding
- Plan a clear accountability, collaboration and actions within and outside the municipal organization
- Information, education and training
- Forecast and Warning system
- Monitoring
- Insurance and other financial preparedness
- Evacuation plan
- Management plans for floating debris / material
- Recovery plan

These measures are organization dependent and need to be built up by, with and for local key actors.

3.4 Follow-up and maintenance

As important as planning is monitoring, inspection, review and maintenance. This applies to all measures proposed, i.e. both structural and non-structural. All major structures illustrated in this collection require continuous maintenance and control. The more complex construction, or organization, the more frequent monitoring, reviewing, testing, inspection and maintenance of the structure and organization has to be. When carrying out an action program one must also include a plan for monitoring, inspection and maintenance. This should in principle extend to the construction's final disposal. This may not be reasonable for structures with very long life but, in principle, the plan shall also include the management of risks in the long run.

Even for relatively simple measures maintenance and inspection is required. For example, both debris, plant material, soil and other materials such as ice can be carried downstream, or in other ways obstruct the water passages leading to flooding. To avoid this, one must regularly clear the waterways. To prevent ice plugs one can regulate tributaries to postpone ice unloading. One can also have channels on the side of passages, or dredge narrow passageways. If ice plugs do form one may need to burst it. Manual ice-breaking and sawing are further methods that can be used (MSB, 2010a). Although it requires continuous effort this is a relatively inexpensive measure.

4 Resistance

Resistance is a sensitive system’s ability to avoid interference. The classical methods are structural methods such as barriers, embankments and dams. These measures are usually large, heavy and complex structures, whose foundation requires well thought through and often advanced measures.

In addition, these structures often need to be located where soil conditions are complicated with thick layers of soil consisting of clay, silt, sand and organic soil. For example, they can be localized in the outer parts of bays, watercourse estuaries and other water bodies.

During a prolonged flood water infiltrates into the soil layers underneath the slope towards the watercourse and gives an elevated water table, which reduces the soil strength. When the water against the submerged slope falls away, the elevated groundwater table doesn’t decrease at the same rate. The ground water sinks away particularly slowly in dense, fine-grained soils like clay and silt.

If a heavy construction is built the weight of the construction becomes an extra load which can affect the stability in a negative way and may lead to subsidence. Besides deficiencies in the construction, subsidence can also lead to that the intended level of protection is not achieved.

The combination of a heavy construction, such as an soil embankment, and an elevated groundwater water table can trigger landslides. Similarly, stability problems can arise if the land area is elevated with heavy masses of soil in order to prevent flooding.

If a structure is placed on filling without a sealing screen, leakage can occur through the soil layers beneath the construction and thereby adversely affect the stability.

Stability problems can also exist behind a construction if high flows or water levels occur in combination with high rainfall, which means that land behind a dike may have an elevated water table.

In addition, the soil layers at the sites where construction is carried out can be contaminated. This entails the risk that contamination will spread into the environment in connection with the foundation work.

For all the structures described in this section, it is very important that the soil conditions are well investigated, that consideration is given to the stability and subsiding problems and that the foundation is very well thought out. Many require advanced foundation measures. That is, all heavy structures (barriers, stationary walls etc.) should be dimensioned so that no landslides could be caused and subsidence is prevented.

4.1 Movable flood barrier

Figure 1 Barrier in river Thames (Worldsteel, 2010)

Figure 2 Maeslantbarrier at Rotterdam (Delta Marine Consultants, 2010)

A moveable barrier can e.g. be located at the mouth of a river which is adjacent to an ocean or bigger lake. The barrier can protect the society against a more temporary water level rise in the sea or lake. There are several different designs of a movable barrier. The Maeslant barrier at Rotterdam consists of two floating curved steel gates that automatically are moved to the river channel when the water is on the rise, Figure 2 (Keringhuis, 2010). In river Thames (London) there are nine concrete piers with ten mobile ports located in depressions in the riverbed. With a forecast of upcoming high water levels the gates can be rotated 90 ° and form a barrier, Figure 1(Environmental Agency, 2010).

Generally positive: The barrier can protect a city from occasional floods without permanently changing the conditions surrounding the river. Ecosystem, shipping and possibly drinking water supply need not be affected in a significant way compared to permanent barriers. It is also one measure that will protect the whole city.

Generally negative: However, the measure will lead to some change in the ecosystem. It can also cause problems when smaller rivers transport so much water into the main river that it is impossible to keep the barrier closed without flooding the city from inside. A floating barrier requires functioning electricity supply, is expensive, complicated and requires continuous maintenance. Lack of maintenance can lead to defects in the construction. Major defects may lead to unwanted consequences such as a barrier that breaks.

Geotechnical aspects: Moveable barriers are heavy and complex constructions which need consideration concerning stability and subsidence during the foundation, and may need advanced foundation measures.

Information/experience:

- Information about the barrier in Thames from the Environmental agency in Great Britain: http://www.environment-agency.gov.uk/homeandleisure/floods/38353.aspx
- Keringhuis (2010) http://www.keringhuis.nl/engels/home_flash.html
- In Arvika municipality there are plans for a barrier between Kyrkviken and Glafsfjorden. Here is a report from The Network of river security: http://www.arvika.se/download/18.28d09043124fe680ea280004986/Effekter+p%C3%A5+By%C3%A4lvens+vattensystem.pdf

4.2 Non-movable flood barrier

Figure 3 Afsluitdijk in the Netherlands (Nedwater, 2011).

A solid barrier is designed so that water inside and outside will be separated. It means that the water that possibly enters the bay through rivers regularly needs to be drained outside the barrier. It could possibly be done through the locks used to enable ships to get in and out. The barrier can also be built wide so the top can be used for other purposes. Example of a solid barrier is Afsluitdijk in the Netherlands where a bay has been separated from the North Sea, Figure 3. On top of the barrier, which is 32 km long, is a European highway (Deltawerken, 2010; Wikipedia, 2010).

Generally positive: A solid barrier may work well for a bay where the river flows are low. You can also use the top side of the barrier for transportation, thereby using the barrier for additional advantage. It is a solid and robust design that you know will be in place in case of rising water levels. The possibility to build houses close to water becomes greater when you know you have the protection of a solid barrier.

Generally negative: Ecosystems can be influenced to a large extent when the exchange of water becomes difficult or impossible and the water quality may get worse. The level of protection could be lower than intended e.g. because of subsidence. The construction could also give a false sense of security. It can be a costly design and the construction requires maintenance. Lack of maintenance can cause the barrier to break with huge consequences. The basin inside may also be filled if there is high flows in connecting rivers. Pumping systems may then be needed, which could be a weakness in the system if there is power failure.

Geotechnical aspects: Non-moveable barriers are heavy constructions where the foundation is sensitive for subsidence which can mean that intended level is not achieved. The construction needs great consideration concerning stability and subsidence and well thought through and advanced measures for the foundation.

Information/experience:
- Deltawerken (2010) http://www.deltawerken.com/Why-this-twist/307.html
- Wikipedia (2010) http://sv.wikipedia.org/wiki/Afsluitdijk

4.3 Soil embankment

Figure 4 Soil embankment (Trelleborg Municipality, 2010).

Soil embankment is a permanent measure that provides protection against a certain water level rise. A soil embankment can be built with geo textile fabrics, fillers and a very coarse material that prevents erosion (Trelleborg AB, 2010). The water pipes that cross the embankment must be able to be closed manually or be equipped with check valves so that no leakage occurs through the barrier (MSB, 2010a).When putting up a barrier it is desirable to have pumps, so that water flowing in from behind the barrier (e.g. through rain, sewage systems) can be pumped outside. Pumping systems require maintenance and depending on the volume of water that needs to be pumped the life length varies.

Generally positive: It is a relatively inexpensive measure that can relatively easily be removed or built higher. Depending on the design it can be a positive element as walking path and a positive feeling through the greenery.

Generally negative: Soil embankment does not suit any urban environment and there can be major consequences if an embankment fails. If measures are needed to avoid subsidence, like pillars or piles, it may be more costly and more problematic to achieve a certain level.

Geotechnical aspects: A soil embankment is a heavy construction and may cause subsidence which can lead to that the intended level is not achieved. The construction needs great consideration concerning stability and subsidence and well thought through and advanced measures for the foundation.

Information/experience:
- MSB (2010a) Swedish Civil Contingencies Agency, http://www.msb.se/sv/Forebyggande/Naturolyckor/Oversvamning/Begransa-skador/
- Sandviken municipality has a flood protection plan: http://www.terrafirma.se/%C3%96SP%20-%20Gysinge%20bruk.pdf
- Dahlman, M. (2011) Information about Kristianstad municipality's plans with flood protection. http://www.kristianstad.se/Upload/R%C3%A4ddning%20S%C3%A4kerhet/dokument/Skydd%20mot%20%C3%B6versv%C3%A4mningar/Nordv%C3%A4stra%20vallprojektet/Information%2009.pdf
- Trelleborg AB (2010), http://www.trelleborg.com/sv/Media/Trelleborgs-varld/Hemligheten-som-haller-Hamburg-torrt/

4.4 Wall of concrete or stone

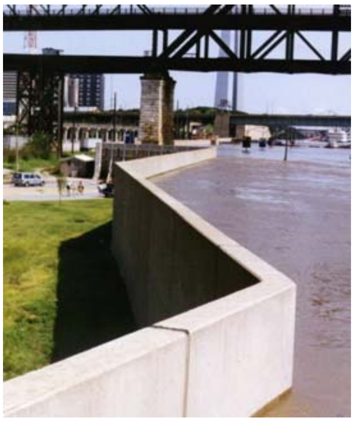

Figure 5 In 1993 in St. Louis District (USA) a concrete wall prevented a flooding of the area, USACE (2011)

One way to keep water out is to set up a traditional wall which can consist of concrete or stone. In connection with the construction the water pipes which cross the embankment need to have the possibility to be closed manually or be equipped with check valves so that no leakage occurs inside the barrier (MSB, 2010a).

Generally positive: It is a stable solution that one knows is in place and provides a secure protection provided it is maintained correctly. The risk is less that human or technical failure should occur in the acute phase. If it is a broad concrete/stone wall, it can also serve as walking path and can aesthetically fit in an urban environment.

Generally negative: A concrete/stone wall can depending on the design create a barrier between people and water and make an area less attractive. There can be major consequences if a wall breaks.

Geotechnical aspects: Possible effects of the wall are the same as for soil embankment.

Information/experience:
- MSB (2010a), Swedish Civil Contingencies Agency, http://www.msb.se/sv/Forebyggande/Naturolyckor/Oversvamning/Begransa-skador/
- Sandviken municipality has a flood protection plan for Gysinge bruk: http://www.terrafirma.se/%C3%96SP%20-%20Gysinge%20bruk.pdf
- New Orleans is protected by a wall which is 200 English miles long and partly consists of concrete. In 2005, the Storm Katrina reach the city which resulted in parts of the wall breaking and it became a large-scale disaster. Experiences and lessons learned are collected: http://www.ce.berkeley.edu/projects/neworleans/report/CH_1.pdf
- About.com Architecture (2010), http://architecture.about.com/od/damsresevoirs/ss/floodcontrol.htm

4.5 *Height adjustable wall*

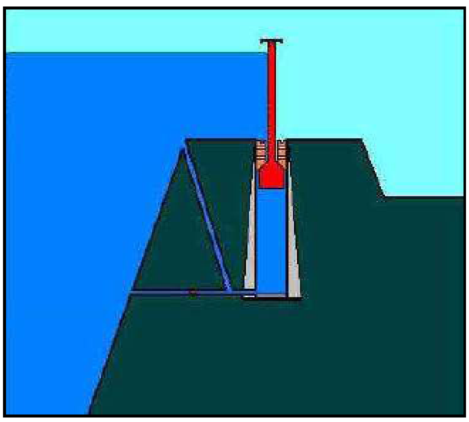

Figure 6 Height adjustable wall (Flood barrier, 2011).

An alternative to permanent walls, which also do not need people's immediate response, is a structure that raises automatically at high tide, creating a protection, Figure 6. There may be several different designs that work with the same basic principle, i.e. the embankment is raised automatically by the rising water (Terra Firma, 2008). In connection with the construction the water pipes which flow across the embankment need to have the possibility to be closed manually or be equipped with check valves so that no leakage occurs inside the barrier (MSB, 2010a).

Generally positive: It is a temporary solution that does not need (acute) human intervention to function. It also works without electricity. At low tide the construction possibly does not need to be visible and can also be aesthetically appropriate to have in an urban environment.

Generally negative: The design requires continuous monitoring and maintenance to maintain the function.There can be major consequences if the wall fails. As a vertically adjustable wall it may be assembled in sections, and thereby it may leak in the joints. It is also uncertain how well it works in a cold climate and with icing. Electrical wires might be useful to de-ice the construction.

Geotechnical aspects: This could also be a relatively heavy construction that can lead to subsidence or trigger a landslide.

Information/experience:
- MSB (2010a), Swedish Civil Contingencies Agency, http://www.msb.se/sv/Forebyggande/Naturolyckor/Oversvamning/Begransa-skador/
- Terra Firma (2008),: http://www.goteborg.se/wps/wcm/connect/4fedc300421651cc936ef73d2a09bb7a/Extremt+v%C3%A4der+-Tempor%C3%A4ra+skyddsvallar.pdf?MOD=AJPERES&CONVERT_TO=URL&CACHEID=4fedc300421651cc936ef73d2a09bb7a

4.6 House as floodwall

Figure 7 Venice (Photo: R Bergman, 2009)

Figure 8 Venice (Photo: R Bergman, 2009)

One way to build near the water is to construct the house foundation so that it can serve as protection against high waters, e.g. in Lauenberg Germany or Venice Italy, Figure 7, Figure 8. When rebuilding or constructing a new house it can be built to cope with water by adjusting the first floor to either be flooded or resist water. Between buildings so called twietes (alleys) can been constructed with stairs that make it possible for people to get down to the water both at high and low water level. The water pipes which exit outside the buildings need to have the possibility to be closed manually or be equipped with check valves so that no leakage occurs through the barrier (MSB, 2010a).

Generally positive: It is a measure that combines an attractive location for buildings with a protection against water level rise. The measure with it's twietes creates proximity to the water at both low and high tide. At low tide one could have walking paths along the foundations. It is a stable solution with stone and concrete, and with good maintenance it has generally a long life.

Generally negative: If special measures aren't taken to raise the flexibility of the construction it is not flexible. That is, like walls, barriers and other complex solutions it can often not (in a simple way) retrospectively be adapted to changing conditions such as climate change. It could be possible to build a wall between the houses in the alleys to further create a higher limit for water protection. Periods with frequent high water can possibly make the foundations and walk path covered with algae and other aquatic organisms that may make the area at low tide less attractive.

Geotechnical aspects: Depending on the weight of the house landslides can be triggered in the same way as with embankments/walls, because of increased load on the ground. As for all buildings the construction's foundation is dependent on the soil's properties and complex solutions with high foundation costs might be needed.

Information/experience:

- MSB (2010a), Swedish Civil Contingencies Agency, http://www.msb.se/sv/Forebyggande/Naturolyckor/Oversvamning/Begransa-skador/
- Manojlovic N., Pasche E (2008) http://library.witpress.com/pages/PaperInfo.asp?PaperID=19304

4.7 Regulate watercourses with dams

Figure 9 A smaller dam that can regulate the water (Willem Vervoort, 2010)

Small dams can be used to control small streams. For some cities and areas, small rivers' water supply can play a role in the flood problem and therefore it may be easier if the stream flow temporarily could be stopped upstream. Both smaller and bigger watercourses can be regulated with dams to decrease the possibility of floods in areas down stream.

Generally positive: One can be in control of the water and regulate it after an upcoming situation.

Generally negative: A dam needs maintenance and control. Regulating the water can give a negative impact on the surrounding natural ecosystem. Space is needed upstream the dam to accumulate the water. There is also a possibility that the dam will fail.

Geotechnical aspects: A pond may be of very different sizes. The dam construction must be adapted to the prevailing geotechnical conditions. The function of the pond, that is to stop the flow or release water results in fluctuation of water levels upstream and downstream of the dam. This fluctuation may affect soil stability negatively. See the geotechnical aspects on page 10.

Information/experience:

- Boyer D. (2009) http://www.wpuda.org/publications/connections/hydro/Chehalis%20River.pdf

4.8 Temporary protection

Figure 10 Temporary pallets (Geodesign AB, 2010)

Figure 11 Tube wall with air bags (Geoline Ltd. 2011)

Temporary protection can be a complement to permanent measures and also be an option if the land is not suitable for heavy constructions. It can also be a cheap solution. There are several different types of temporary barriers, for example pallets Figure 10, sacks of soil, smaller soil embankments and tube walls with air bags Figure 11 (Terra Firma, 2008). Choice of technology can depend on the expected water level, materials available within the required distance, conditions in the foundation and extent of the dike (MSB, 2010a). The protection can either be planned in advance, with a storage that one knows will fit on certain routes, or one could contract with someone who carries the protection to site, and possibly build up the dikes when necessary (Terra Firma, 2011). When putting up a barrier it is desirable to have pumps, so water flowing in from behind the barrier (e.g. through rain, sewage) gets outside.

Generally positive: It is a relatively inexpensive measure that does not leave a permanent change to the environment. Since it is used for short periods it does not wear as much as a permanent barrier and may possibly be more easily to repair when not in use.

Generally negative: It may take time to bring up the measure and human fault can cause the barrier to fail. It is possible that a temporary wall can’t handle high water levels during a long period. If it is necessary to often set up a temporary barrier the running costs and emissions associated with the build up and disassembly can be relatively high.

Geotechnical aspects: Lightweight temporary measures are a better alternative to permanent soil embankments, but it depends on the geotechnical conditions. Heavier alternatives, like sand bags, can contribute to causing a landslide.

Information/experience:
- MSB (2010a), Swedish Civil Contingencies Agency has a list of different methods. http://www.msb.se/sv/Forebyggande/Naturolyckor/Oversvamning/Begransa-skador/
- Terra Firma (2008), http://www.goteborg.se/wps/wcm/connect/4fedc300421651cc936ef73d2a09bb7a/Extremt+v%C3%A4der+-Tempor%C3%A4ra+skyddsvallar.pdf?MOD=AJPERES&CONVERT_TO=URL&CACHEID=4fedc300421651cc936ef73d2a09bb7a
- Åsele Municipality got help from Aqua Barrier to temporary protect with pallets. http://www.geodesign.se/old/seaqasele.shtml

5 Resilience

Resilience means solutions where the system during a period of time can be allowed to be affected by an adverse event and then recover to it's normal capacity. One example is that we can allow water to enter an area during a limited period and be affected by the disturbance. With a good resilience the area affected can quickly return to its original state after the disturbance.

This section provides examples of solutions that let areas be affected during a limited period. It can be done in various ways, for example by buffer areas that have flooding surfaces and / or design the most worthy objects so that they are not adversely affected in case of water exposure. This section provides examples of several different types of measures that can be used to create resilient solutions. A combination of different measures can give the most effective and sustainable solutions. The most sustainable mix of action solutions is area specific.

Depending on the foundation conditions, several of these measures, like the resistance measures described in the previous section, require large, complex and well thought out foundation measures, and thus also involve significant costs.

5.1 Pole houses

Figure 12 Pole house (Inhabitat, 2010)

Figure 13 Pole house (John Koch, 2011).

Houses can be placed on piers so that they can get close to the water without being affected by water level fluctuations. The measure requires that the areas behind are planned to cope with the flood and that they can return to their original situation after the disturbance. That is, the measure protects the building itself, but is part of a resilient solution for an area. The houses on piers can be constructed so that they always stand in water or so that they periodically have free land under. These designs require that the foundations / cornerstones are adapted to withstand anticipated conditions. Alternatively the house is constructed so that water can not reach the foundation. The buildings can be designed so that they stand on a platform with pillars or have piles that are built into the very foundations (Pole Houses, 2011). With various modifications they can be performed in both cold and hot climate (Inhabitat, 2010c).

Generally positive: With well thought through planning of an area houses can be placed on poles and create an aesthetically interesting and exciting development of a city. Houses on poles allow the water to fluctuate freely. Transportation systems can be adapted to both boat traffic and bridges. From a tourism point of view it may be a positive development of a city.

Generally negative: It requires maintenance, particularly if the structures are affected by salt water. At low tide the field can be dull, reek, attract vermin and become waterlogged. It is not a flexible solution that, in a simple way, can adapt to changing circumstances in the future. The design must also be sized to cope with cold climates so that ice movements, that may damage or break the piles, are avoided. The cost to minimize the risk can be high and insurance on the house may be high because the risk seems greater than that of traditional buildings. Transportation to and from buildings must operate at different water levels and the VA system has to be constructed in a sustainable manner. The construction is not suitable for areas with high waves.

Geotechnical aspects: Depending on the foundation conditions significant foundation measures might be required and thus also a large budget. The foundation construction must be able to withstand variations in water level.

Information/experience:

- Pole Houses (2011), http://www.polehouses.com/index.cfm?fuseaction=page.display&page_id=19
- Inhabitat (2010c), http://www.inhabitat.com/2005/09/28/pole-houses/

5.2 Floating buildings

Figure 14 Floating house (Inhabitat, 2010)

Figure 15 Floating house in Maasbommel (Gouden Kust, 2011)

Instead of preventing water from reaching the buildings we can accept it and allow the buildings to float. There is a Dutch project in Maasbommel with houses that either float constantly or float up when there is a high water level, figure 15 (Kengen, 2011). There are several companies with design and technique for floating buildings. One technology for the measure is watertight basements which serve as the lifting force. The houses could be anchored at pillars, with chains or cables of rubber that can be extended as appropriate. Instead of the watertight basement it is possible to have houses standing on floating platforms (Svenska Sjöhus, 2010).

Generally positive: Many different kinds of buildings can be built on floating platforms. The solution allows the creation of a very close interaction between water and development of a city. The solution is also flexible and can adapt to unanticipated water level rises. If there is a problem with a floating house it does not create problems for the entire city.

Generally negative: A risk with floating houses is that the floating platform may break with the risk that the house sinks. The insurance on the house can be high due to that the risk seems higher. Transportation to and from buildings must operate at different water levels and the water and sewage system must function. The construction doesn't suit areas with high waves.

Geotechnical aspects: This measure has virtually no negative impact on soil conditions. Depending on the type of structure, various foundations are required and thus costs can vary. The security against landslides in the surroundings must be satisfactory so the buildings won't be affected secondarily.

Information/experience:

- Kengen (2010), http://www.vereniging-bwt.nl/ufc/file/bwti_sites/028e4669606d529492fc11fc2a11ae1f/pu/W1_8_maasbommel_floating_houses_22november2007.pdf
- Svenska Sjöhus provides ideas on different floating facilities, http://www.svenskasjohus.com/index.php?option=com_content&view=article&id=124&Itemid=144&lang=sv
- Metrohippie have included a film sequence of the construction, http://metrohippie.com/as-modest-mouse-sings-float-on/
- Examples of floating roads/buildings from Dutch Docklands, http://www.dutchdocklands.com/page/70
- Inhabitat (2010a), http://inhabitat.com/2010/06/23/six-flood-proof-buildings-that-can-survive-rising-tides/

5.3 Buildings that can withstand water

Figure 16 A beach house (Monolithic, 2011).

Figure 17 Garage in the beach house (Monolithic, 2011).

One can construct buildings that are either wet or dry protected. Wet protection means that the basement is allowed to be flooded to a certain level. One uses waterproof materials and moves some sensitive equipment to a higher level. There are houses designed to withstand a lot of water by adjusting the first floor to flooding, see figure 16 and figure 17 (Monolithic, 2011). With dry protection water is prevented from entering the building (Ander H. et al., 2009). The difference to house as floodwall is that this measure only protect it self and isn't a protection for a whole area.

Generally positive: With dry protection the basement can always be used.

Generally negative: With dry protection the water outside may not exceed a certain level. If the water level difference is too high between inside and outside there is a possibility that the house floating force becomes too great. To avoid this, dimensioning, based on expected water levels, should be performed.

Geotechnical aspects: The houses are heavy constructions that in itself allow water to flow into the ground floor (garage, etc.). The land around is also allowed to be flooded by water. Just as the option of a soil embankment, etc., it involves risk of subsidence and landslides which mean that special foundation measures might be required.

Information/experience:
- Monolithic has a example of a houses built to withstand water level rise among other things, http://www.monolithic.com/stories/beach-front-homes-building-for-wind-water-and-corrosion
- Pasche E. (2009)

5.4 Permeable asphalt/coating

Figur 18 Permeable asphalt (Ramsey-Washington Metro Watersheld District, 2011)

Figure 19 Permeable coating (Paving Expert, 2011)

By using permeable coating water may be infiltrated into the ground and stored in a reservoir, and then slowly percolate down deeper in the soil (Pasche E. 2009). If many private property owners in a municipality avoided construction of hard surfaces on their site or use permeable coating it would reduce the load on the storm water system (Swedish Board of Housing, Building and Planning, 2010b). The infiltrated water could also be transported to other sites and storage areas. The measure can alone, or together with other measures, constitute so-called local disposal of surface water (Swedish LOD). How well the method is functioning, and how it affects other functionalities, depends on local conditions, design, management and technology choices (Bäckström, 2005; Miljösamverkan, 2004).

Generally positive: Permeable asphalt is similar to conventional asphalt and therefore it makes no difference aesthetically.

Generally negative: There may be problems with the life span of the construction because sediment can be trapped in the pores and prevent water to percolate down. The measure is suitable to take care of moderate rain, but not extreme rainfall.

Geotechnical aspects: A result of urbanization is usually that the groundwater level is lowered permanently due to hard surfaces. In populated areas with sensitive soil the permeable asphalt / coatings can reduce the risk of subsidence. The permeability facilitates the percolation of water into the soil layers so that the water table more easily can be maintained at original level. Because of worse infiltration effects in clays and fine grained soil this measure has not the same effect in this kind of soil as it has in coarse grained soil. The later are also less sensitive to subsidence. The measure is not suitable in or near slopes with poor stability, since rain water more easily can infiltrate into the soil layers with elevation of groundwater pressure as a result. A higher ground water in the soil layers in combination with slopes can result in poor stability, leading to a landslide.

Information/experience:
- Swedish Board of Housing, Building and Planning (2010b). http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Pasche E. (2009)
- Green Road, www.greenroad.net

5.5 *Subsurface transportation/management of storm water*

Figure 20 Infiltrating ditch (Sustainable Storm water Management, 2010).

Shallow ditches can be used to infiltrate water into the soil and either be stored on site or be led away by pipes (filter drains). The ditches are covered with permeable material, such as grass (filter strips) or stone. Some trenches can be excavated and filled with permeable material to form a reservoir (filter trenches) (Pasche E. 2009). The measure can alone, or together with other measures, constitute the so-called local disposal of surface water (Swedish LOD).

Generally positive: There is a purifying effect of the water that is filtered into the ground.The measures are economically advantageous for the infiltration and delay of storm water (Swedish Board of of Housing, Building and Planning, 2010b).

Generally negative: In heavy rain the soil becomes saturated and the function will stop working for the continued influx of water.

Geotechnical aspects: As for permeable coating these measure can lead to a lower risk of subsidence. These measures, however, can locally increase the groundwater pressure too much, which can lead to poor stability in any nearby slopes. If stability is poor, storm water can be headed down in tubes and pipes away from the sensitive area.

Information/experience:
- Swedish Board of Housing, Building and Planning, (2010b). http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Pasche E. (2009)

5.6 *Surface transportation/management of storm water*

Figure 21 Surface transportation (BizzBook, 2010)

There may be small diversion/conveyance structures along streets, walking paths, between buildings, etc. to get storm water to areas that can dispose of it (e.g. to a delay magazine, infiltration surfaces, etc.) (Pasche E. 2009). It can be difficult to plan green surfaces in a city, because of lack of space and because of topography. In such situations, storm water channels are advantageous (Swedish Board of Housing, Building and Planning, 2010b). For some situations the water transport system also needs culverts for diverting water through road embankments. Roads can be constructed to serve as a transportation channel in the extreme events when it is needed (SPUR, 2011).

Generally positive: The transport system can be constructed in various sizes and be adapted to the area's needs.

Generally negative: The system may take up much space. Material can also plug culverts and narrow passages.The system requires frequent and ongoing monitoring and maintenance.

Geotechnical aspects: Leaking surface lines or clogged open lines can lead to the storm water overflowing out over an area, which can lead to increased groundwater pressure in a slope area with poor stability against landslides. Lighter surface lines can be a beneficial solution for transporting storm water to areas that are better suited to handle large amounts of water.

Information/experience:
- Swedish Board of Housing, Building and Planning (2010b), http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Pasche E. (2009)
- SPUR (2011), http://www.spur.org/publications/library/report/strategiesformanagingsealevelrise_110109

5.7 Retention reservoirs

Figure 22 Storm water pond in Växjö, Sweden (Veg Tech AB, 2011)

Figure 23 Storm water pond with art (Göran Nilsson, Movium, 2011)

Small reservoirs can be designed to take care of storm water for a few hours. In combination with drainage pipes water can be infiltrated (Pasche E. 2009; Swedish Board of Housing, Building and Planning, 2010b). Also bigger reservoirs can be constructed to be able to store storm water during a period of time (SPUR, 2011). The measure can alone, or together with other measures, constitute so-called local disposal of surface water (Swedish LOD). Many small ponds may be needed to get an effect.

Generally positive: They are relatively cheap to build and with the right design also relatively easy to maintain.

Generally negative: A possible negative effect is that it may require large areas.

Geotechnical aspects: A reservoir with impervious bottom and with frequent discharge pipes may have little influence on the surrounding soil. However, the load from a heavy reservoir located inappropriately close to a slope can cause landslides. The construction needs to be adapted to local geotechnical conditions and measures might be needed to avoid subsidence and landslides. There is also a risk of extrusion (pushing up) when the reservoir is empty. In populated areas with subsiding prone soil the measure with local infiltration of storm water can reduce the risk of subsidence. These risks are in most cases not large.

Information/experience:

- Swedish Board of Housing, Building and Planning (2010b), http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Veg Tech AB (2011), www.vegtech.se
- Pasche E. (2009)
- SPUR (2011), http://www.spur.org/publications/library/report/strategiesformanagingsealevelrise_110109

5.8 Multifunctional area/ Flooding area/ Green surface

Figure 24 An area that can be used to collect storm water (Courtesy Fairfax County, 2011)

Figure 25 A park with a small stream in Lomma, Sweden (Lomma Municipality, 2011)

A flooding area could be an area that is allowed to be flooded without permanently changing the area's main function (Pasche E. 2009). You can select areas in a town that can be allowed to be flooded if the water levels rise or it rains heavily. The surface can be either a natural green area that normally is used for other purposes (park, soccer field, etc.), but if needed may be infiltrated with water to a certain degree of saturation. Infiltration works better in sandy soils than clay soils and having plants on the ground makes the water more easily drained and prevents water logging (Swedish Board of Housing, Building and Planning, 2010b). Surfaces can also be designed to serve various purposes, both with and without water, e.g. underground parking lots (SPUR, 2011). The measure can alone, or together with other measures, constitute so-called local disposal of surface water (Swedish LOD).

Generally positive: It is an area that can fulfil two or even three purposes. If it is a green area in a city the greenery is considered to be mostly positive, it also contributes to a more consistent climate and can compensate for temperature variations. The third purpose is that you learn to live with water by seeing the impact of precipitation in the area.

Generally negative: To dispose water on surfaces that would otherwise be used for other things prevents the normal function of the surfaces, e.g. park or football field for some time after the flooding. There is also a possibility that the storm water is polluted and therefore might leave pollutions on the surface or in the soil after the water has retreated from the area (SPUR, 2011).

Geotechnical aspects: The geotechnical risks and advantages are much the same as for reservoirs that are described in previous section.

Information/experience:
- Dahlman M. (2011), Kristianstad municipality has in their physical planning discussed flooding areas. http://www.kristianstad.se/upload/Bo_bygga/Samhallsplanering/PDF/Kristianstad%20v%C3%A4xer/FOP_Forutsattningar_sid26_40.pdf
- Inhabitat (2010b). A flooding pond has been constructed in Rotterdam. http://www.inhabitat.com/2009/11/30/waterpleinen-rain-reserviors-a-dynamic-public-spaces/
- Swedish Board of Housing, Building and Planning (2010b), http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Pasche E. (2009)
- SPUR (2011) http://www.spur.org/publications/library/report/strategiesformanagingsealevelrise_110109

5.9 Green roofs

Figure 26 Green roof (Scholtens Roofing, 2010)

Figure 27 Green roof in Sydney (Water Sensitive Urban Design, 2011)

Green roofs help to reduce storm water runoff. They also reduce spreading of contaminants. Individuals can use green roofs on their houses and sheds. It is part of the LOD technique (local disposal of water) (Swedish Board of Housing, Building and Planning, 2010b; Pasche E. 2009).

Generally positive: More greenery can give a positive feeling to the residents. In winter the roofs provide insulation and in summer they can reduce overheating.

Generally negative: Plants can be unreliable and are affected by the surrounding environment. Their life length is uncertain and they require maintenance.

Geotechnical aspects: The building in it self must of course be situated in a stabile way.

Information/experience:
- Swedish Board of Housing, Building and Planning (2010b), http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Veg Tech AB (2011), www.vegtech.se
- London Climate Change Partnership (2006)
- Pasche E. (2009)

5.10 Land plants

Figure 28 Design of Helsinki (Helsinki Municipality, 2010)

Forest and plants can, under the right conditions, help to absorb water and stabilize the soil. Both the individual homeowner and the municipality may contribute to the LOD technique (local disposal of water) by planting more trees and plants and avoid the use of impervious paved surfaces (Swedish Board of Housing, Building and Planning, 2010b).

Generally positive: More greenery in a city is considered to be mostly positive. It also contributes to a more consistent climate and can compensate for temperature variations.

Generally negative: Plants can be unreliable and are affected by the surrounding environment. The life length is uncertain and the plants require maintenance.

Geotechnical aspects: Land plants are a measure that doesn't affect the geotechnical conditions. Land plant's roots bind the soil and can usually decrease erosion.

Information/experience:
- Swedish Board of Housing, Building and Planning (2010b), http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- London Climate Change Partnership (2006)
- Veg Tech AB (2011), www.vegtech.se

5.11 Wetlands

Figure 29 Board walk in wetland area (Chesco, 2011)

Figure 30 Wetland in USA (National Park Service, 2011)

Wetlands are relatively shallow, vegetated surfaces that constantly keep large amounts of water and have the capacity to temporarily delay water. Storm water pipes and soil drainage may be headed to the wetlands. The area can also receive sludge and purify water before it flows out of the wetland (Swedish Board of

Housing, Building and Planning, 2010b) (Pasche E. 2009). Wetlands can be a natural barrier between a city and open water (SPUR, 2011).

Generally positive: Wetlands also serve as a nutrient trap and thus help to reduce problems of eutrophication**.** The areas act as pollution traps and can enhance biodiversity. They also contribute as a recreational area.

Generally negative: Wetlands require much space and as a barrier between water and a city much area is needed.

Geotechnical aspects: Wetlands are located on low lands adjacent to rivers and other water areas. They themselves don't increase the probability of landslides. Conversely, they can improve conditions at other locations by letting water accumulate in the wetland instead of possibly being transported to places with unstable soil.

Information/experience:
- Swedish Board of Housing, Building and Planning (2010b), http://www.boverket.se/Global/Webbokhandel/Dokument/2010/Mangfunktionella_ytor.pdf
- Pasche E. (2009)
- SPUR (2011) http://www.spur.org/publications/library/report/strategiesformanagingsealevelrise_110109
- Examples in Sweden, (Swedish Board of Housing, Building and Planning, 2010b):
  - *Myrsjöns våtmarkspark* Nacka municipality
  - *Vallentuna våtmarkspark* Vallentuna municipality
  - *Slottskogens dammar* Göteborgs municipality
  - *Vattenparken* Enköping municipality

6 Measures to prevent landslides and erosion

Figure 31 Lomma Municipality (Photo: R Bergman, SGI, 2010)

Figure 32 Lomma Municipality (Photo: R Bergman, SGI, 2010)

Much rainfall and high water levels can cause erosion and instability in the ground. Examples of additional measures to stabilize the soil which can be a complement to the above measures are the following:

- Erosion protection
- Excavation
- Filling
- Sheet piling
- Soil nailing
- Filling and "culverting" of a water course
- Lowering of water table
- Soil reinforcement

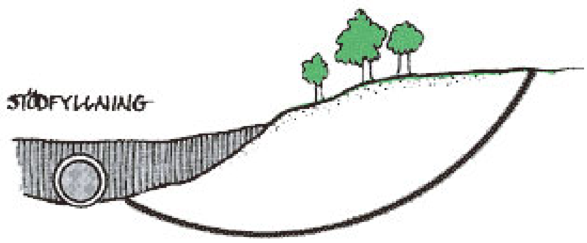

Figure 33 A culvert covered with filling (MSB, 2011a)

More examples can be found on the MSB website[1] that describes measures to prevent erosion and landslides. A selection of examples can be read about in the Swedish Board of Housing, Building and Planning's report on climate change adaptation in planning and building (Swedish Board of Housing, Building and Planning, 2010a) and the SGI Varia 608 (Rydell et al., 2011).

In general for all the above measures the following advantages and disadvantages and geotechnical aspects apply.

Generally positive: Some of these measures could be quite inexpensive but prevent big consequences where both houses and lives otherwise directly can be harmed.

Generally negative: Measures could in some cases be needed along a long stretch of the affected coast. Maintenance and control are also needed.

Geotechnical aspects: As with all complex and heavy structures these measures, which in themselves are carried out to improve the conditions of stability, require well-thought-out design (see page 10).

Information/experience:

- SGI, Swedish Geotechnical Institute, www.swedgeo.se
- MSB (2011) http://www.msb.se/sv/Forebyggande/Naturolyckor/Skred-ras-och-erosion/Forebyggande-atgarder-/
- Swedish Board of Housing, Building and Planning (2010a), http://www.boverket.se/Global/Webbokhandel/Dokument/2011/Klimatanpassning-i-planering-och-byggande-webb.pdf

7 Prevention of ravines in moraine and other coarse-grained soils

Heavy precipitation can in more coarse-grained soils cause gullies that bring large masses of soil off rock edges. The most common methods to protect buildings and sites along and below the gullies from the moraine landslides and debris flows are erosion stairs, diversion dams, sedimentation dams and channeling. Here follows a short description of each method. In general for all the measures the following advantages and disadvantages and geotechnical aspects apply.

Generally positive: The measures are intended to reduce the debris flows' energy, divert debris flows from buildings that are at risk and capture soil from a debris flow.

[1] http://www.msb.se/sv/Forebyggande/Naturolyckor/Skred-ras-och-erosion/Forebyggande-atgarder-/

Generally negative: The measures are costly and may damage or affect valuable nature or existing development. The measures should therefore be equally compared to the alternatives: evacuate and relocate or demolish the existing settlement. During development one should consider an alternative location of the planed settlement. If a sedimentation dam has been built also an access road must be built to the dam to allow access of vehicles to the dam so the dam rapidly can be drained from soil when a debris flow has occurred.

Geotechnical aspects: The described preventive measures against moraine landslide and debris flows are in many cases constructed in steep terrain, and / or transportation of heavy building materials for the measures is done in steep and partially sensitive terrain. This means that the actual construction process can trigger moraine landslide and / or debris flows. Necessary removal of natural vegetation and deep traces of heavy work vehicles will lead to changes in the runoff conditions on the slope, which also can increase the risk of triggering moraine landslide and / or debris flows. A prudent and careful planning is therefore required.

7.1 Erosion stairs

Erosion stairs are constructed to reduce erosion along the ravine bottom and reduce the debris flow's kinetic energy. The number of erosion stairs, locations and size are chosen so that they sufficiently can slow any debris flows, so that they do not reach the threatened buildings.

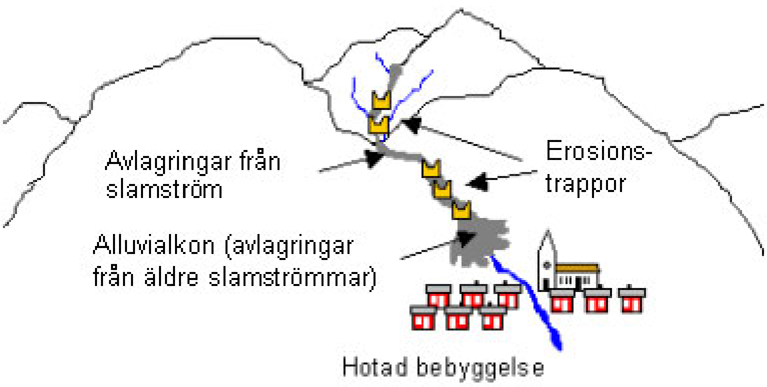

Figure 34 The yellow markings show where erosion stairs could be placed (MSB 2011b).

Figure 35 Energy reducing stair, Östlienbäcken, Åre Municipality. Photo: S. Edsgård, MSB

7.2 Diversion dam

The consequences of debris flows can be reduced by constructing dams that can steer the sludge flows away from the buildings.

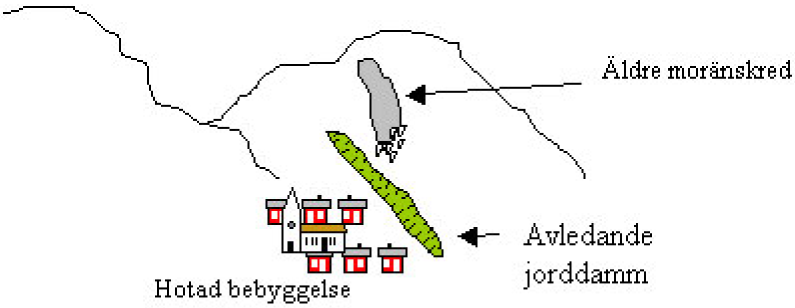

Figure 36 A diversion dam (green) is placed between a possible debris flow and threatened buildings (MSB, 2011c)

Figure 37 Vegetated diversion dam, Neudorf, Ötz, Austria. Photo: J. Fallsvik, SGI

7.3 Sedimentation dam

Sedimentation dams are built to intercept debris flows, thus restricting them from reaching the settlements in the valley lying below. The dams are built below the ravine in the upper part of the so-called alluvial cone, which is composed of deposits from repeated past debris flows. Most dams are built with a barred opening. The grid captures the coarse material (logs, gravel, stone and bricks), while the finer material and the water can pass through. Sedimentation dams are not designed to store all the calculated debris flow volume.

Figure 38 Sedimentation dam in Ahrnbach, Austria. Photo: S. Sauermoser, WLV, Schwaz

7.4 Channeling

Channeling of a current mainstream is performed in order to prevent erosion, prevent the outflow of water and soil outside the regular stream and to be able to control a stream along a possible new direction. It is common to construct channeling downstream sedimentation dams and through alluvial cones.

Figure 39 Channeled stream with erosion stairs in Åre. Photo: J. Fallsvik, SGI, 2000

8 Domestic measures

8.1 Structural

8.1.1 Small pump in the home

Having a small pump at home pumping water out faster than water flows in can be an important safety measure. However, one should think of the pressure between outside and inside so that the water-saturated soil outside doesn't press too much at the empty cellar floor and defects the floor. One should check if the floor is well adapted to withstand water pressure before installing a pump (MSB, 2010b) (Aviva, 2011).

8.1.2 Barrier around windows, doors and air intakes

Barriers that are fitted and ready to be put in place at threat of flooding (Aviva, 2011).

8.1.3 Silicone sealant around windows, doors and other openings

The small gaps may need to be sealed so that no water seeps into under e.g. a door. However, if the water is deep outside the house (>1m) the water should be allowed to enter if the pressure could otherwise destroy the building (Aviva, 2011), but this depends on the construction of the house.

8.1.4 Beams can be protected by chemical moisture protection

The chemical reduces the risk that water is sucked into the beam (Aviva, 2011).

8.1.5 Replace materials in the home with water-resistant material

Particle board can be switched to concrete or treated wood, carpets to tiles, plaster to lime or concrete. The interior of a kitchen and bathroom can be replaced with plastic or steel. Wood doors and window frames can be replaced with plastic and isolation material that doesn't rot (Aviva, 2011).

8.1.6 Unidirectional valves for sewage in house/stopper for the drain

If flooding threatens you can put plugs for drains and toilets so that no water flows in that way. The stopper can be a wooden plug or an expanding rubber seal. You can also install one-way valves (MSB, 2010b) (Aviva, 2011).

8.1.7 Place some objects in secure places

Some sensitive items do not need to be in the basement/ground floor. Outdoor furniture and other things can be moved so that they do not float away with the water and cause plugs in passages where water flow is needed (MSB, 2010b). Important documents and other sensitive material can be placed on a higher area (MSB, 2010b) (Aviva, 2011).

8.1.8 Electrical outlets can be placed higher up

(Aviva, 2011)

8.1.9 Raise the floors

(Aviva, 2011)

8.1.10 Permeable asphalt/coating in the driveway

(Swedish Board of Housing, Building and Planning, 2010b)

8.2 Non-structural

8.2.1 Keep track of water levels and weather forecasts

If you keep track of what normal water level is it will be easier to see when the water rises. To know if the area you live in has been flooded earlier can give you a chance to prepare yourself better. During radio/TV weather forecasts, warnings can be read which can be important information (MSB, 2010b).

8.2.2 Home insurance

It could be important to review the terms of the home insurance and see if flood damage is covered. The damages should be photographed and receipts for purchases related to the injury should be saved (MSB, 2010b).

8.2.3 Turn off power and gas

When flooding occurs you can mitigate potential impacts by turning off power and gas (MSB, 2010b).

8.2.4 Be careful with excavations and dirty water

Pits with water and other cavities, unstable soil and dirty water can cause injuries if you are not careful when a flood hits the area (MSB, 2010b).

8.2.5 Have supplies at home/be prepared for evacuation

If you live in an area where there is a risk of natural disaster you can be prepared and have a box of essential supplies tucked away. You can have toiletries, first aid and medicines. A radio, flashlight and batteries are practical to have access to. Faced with a possible evacuation, these items are packed in a bag together with important documents. In the home there can also be canned food and other foods with long durability, maybe also a camping stove and fuel. Blankets, rain gear, boots, candles and matches can ease the situation. Water cans may need to be replenished in order to secure drinking water (MSB, 2010b). If food or other things that can be ingested gets in contact with water due to flooding, it must be boiled before consumption. Medicine that has been in contact with water may need to be discarded to avoid risks posed by contaminated water.

More tips of what to do in case of flooding:

- MSB, http://www.msb.se/sv/Forebyggande/Sakerhet-hem--fritid/Skydda-dig-mot-oversvamning/
- U.S. Department of Homeland security, http://www.fema.gov/hazard/flood/fl_after.shtm

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37. *Vegetated diversion dam,*
Neudorf, Ötz, Austria. Photo: J. Fallsvik, SGI

38. *Sedimentation dam*
Ahrnbach, Austria. Photo: S. Sauermoser, WLV, Schwaz

39. *Channeled stream with erosion stairs*
Åre, Sweden. Photo: J. Fallsvik, SGI, 2000

CLIMATE PROOF AREAS
TIME TO ADAPT

European Union The European Regional Development Fur

The Interreg IVB North Sea Region Programme

Investing in the futu
by working for
a sustainable and
competitive region