Scenarios and Sustainability

A Swedish Case Study of Adaptation Tools for Local Decision-Makers

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Sammanfattning

Att anpassa sig till ett förändrat klimat innebär stora osäkerheter och långa tidsperspektiv, vilka båda är utmaningar för beslutsfattare. Som en hjälp att hantera dessa utmaningar har ett antal verktyg utvecklats inom forskningsprogrammet Climatools. I den här rapporten redovisas resultaten från testen av två verktyg för kommunal klimatanpassning: Socioekonomiska scenarier och Hållbarhetsanalys. Syftet med testen var att undersöka om verktygen kan underlätta kommunal klimatanpassning. Resultaten från en fallstudie i Botkyrka kommun visar att kommunala handläggare anser att verktygen är relevanta och användbara, men att de behöver vidareutvecklas.

Idag råder vetenskapligt konsensus kring att klimatet är på väg att förändras till följd av människans utsläpp av växthusgaser. För att minska konsekvenserna av de oundvikliga effekterna av utsläppen måste samhället anpassas.

Forskningsprogrammet Climatools syftar till att ta fram verktyg som kan hjälpa samhällsplanerare och beslutsfattare att fatta bra klimatanpassningsbeslut, det vill säga beslut som underlättar samhällets anpassning till ett förändrat klimat. Målet är i första hand att kunna erbjuda kommunala planerare och beslutsfattare en uppsättning verktyg för lokal klimatanpassning. I den här rapporten testas två av de verktyg som utvecklats inom Climatools, Socioekonomiska scenarier och Hållbarhetsanalys, i en fallstudie i Botkyrka kommun. Forskningsprogrammet finansieras av Naturvårdsverket mellan 2006 och 2011.

VERKTYGET SOCIOEKONOMISKA SCENARIER

Verktyget Socioekonomiska scenarier (scenarioverktyget) är ett hjälpmedel för att inkludera förändrade socioekonomiska förhållanden som förändrad befolkningsstruktur (till exempel fler riktigt gamla människor i befolkningen) och förändrade ekonomiska villkor (till exempel högre kommunala vattentaxor) i det lokala klimatanpassningsarbetet.

Eftersom det är osäkert hur samhället kommer att se ut i framtiden är det en fördel att studera ett antal olika, men möjliga, framtidsbilder. Med utgångspunkt i en konkret frågeställning kring klimatanpassning underlättar scenarioverktyget utvecklingen av ett mindre antal (tre-fyra) olika framtidsbilder.

De socioekonomiska scenarierna kan användas för att öka insikten hos planerare och beslutsfattare om vilka utmaningar samhället står inför med anledning av klimatförändringarna. De kan också användas för att studera olika framtida samhällens förmåga till klimatanpassning, men också för att värdera olika anpassningsåtgärder mot olika framtida samhällsförhållanden.

VERKTYGET HÅLLBARHETSANALYS

Verktyget *Hållbarhetsanalys* är ett systematiskt verktyg för att planera och välja klimatanpassningsåtgärder. Givet en eller flera alternativa anpassningsåtgärder kan verktyget användas för att identifiera de miljömässiga, sociala och ekonomiska konsekvenserna av att genomföra de olika åtgärderna.

Verktyget består av tre delar, en grundläggande del och två valbara delar. Den grundläggande delen innebär att beslutsfattaren med hjälp av en checklista identifierar (och om möjligt kvantifierar) potentiella konsekvenser av anpassningsåtgärder i de tre hållbarhetsdimensionerna (social, ekonomisk, miljömässig). De två valbara delarna, kostnadsnyttoanalys och målkonfliktsanalys, bygger vidare på analysen i den grundläggande delen.

Kostnadsnyttoanalys är ett ekonomiskt verktyg som på ett systematiskt sätt jämför en åtgärds kostnader (både ekonomiska och andra negativa förändringar) med dess nyttor (både ekonomiska och andra positiva förändringar). Kvantifieringen av konsekvenser som sker i verktygets grundläggande del utgör grund för att beräkna kostnader och nyttor uttryckta i kronor och ören av de konsekvenser som uppstår av en anpassningsåtgärd.

Målkonfliktsanalys ställer de identifierade konsekvenserna i relation till mål inom de områden som hållbarhetsbegreppet omfattar. Denna del av verktyget hjälper till att identifiera synergier och konflikter mellan anpassningsåtgärder och mål inom andra områden.

FALLSTUDIEN

Scenarioverktyget och hållbarhetsanalysen testades tillsammans i en fallstudie av Tullinge vattentäkt i Botkyrka kommun i december 2010 och januari 2011. Tullinge vattentäkt förser omkring 15 000 invånare i kommunen med dricksvatten. Vattentäkten är reservvattentäkt för de omkringliggande kommunerna och bedöms av VAS-rådet (Rådet för vatten- och avloppssamverkan i Stockholms län) som högprioriterad för långsiktiga skyddsåtgärder, främst mot markanvändning och verksamheter som begränsar användningen av vattnet.

Tullinge vattentäkt ligger i ett område med bebyggelse bestående av industrier och bostäder samt kommunikationer i form av järnvägar och vägar. Det råder ett stort exploateringstryck på marken i området. Två företag använder i dagsläget Tullingeåsen som naturgrustäkt. Sammanlagt innebär det att Botkyrka kommun måste balansera flera och motstridiga intressen – utöver klimatförändringar – vid planeringen av klimatanpassningsåtgärder för Tullinge vattentäkt.

I fallstudien användes två grupper av klimatanpassningsåtgärder, tekniska och samhällsplanerande (administrativa). Varje grupp bestod av tre enskilda åtgärder som utvecklats i samarbete med Botkyrka kommun och Tyréns (ett konsultföretag verksamt inom samhällsbyggnadsområdet) innan själva testen av verktygen genomfördes. Alla åtgärder bedömdes som relevanta men de skiljer sig åt i något avseende, till exempel med avseende på genomförandekostnader.

Testen av verktygen genomfördes under två halvdagsmöten i Botkyrka i december 2010 och januari 2011. Deltagarna bestod av ett tiotal handläggare från olika kommunala förvaltningar.

På det första halvdagsmötet bestod deltagarnas uppgift av att identifiera de socioekonomiska faktorer som de ansåg viktigast och osäkrast för att kunna bedöma de föreslagna klimatanpassningsåtgärdernas lämplighet. Resultaten från detta halvdagsmöte användes sedan för att konstruera fyra olika framtidsbilder; två för 2030 och två för 2060.

På det andra halvdagsmötet bestod deltagarnas uppgift av att identifiera och, om möjligt, kvantifiera konsekvenserna av de olika tekniska och samhällsplanerande klimatanpassningsåtgärderna, mot bakgrund av de fyra olika framtidsbilderna. Resultaten från detta halvdagsmöte användes sedan för att genomföra en enkel kostnadsnyttoanalys. Kostnadsnyttoanalysen visar entydigt att värdet av att skydda Tullinge vattentäkt överstiger de kostnader som de enskilda åtgärderna innebär. När det gäller målkonflikter kom det fram att det var möjligt att identifiera konflikter och synergier mellan de identifierade konsekvenserna och såväl kommunala mål som nationella miljömål. Målkonfliktsanalysen gav emellertid inte kommunen någon direkt vägledning för valet mellan olika klimatanpassningsåtgärder eftersom många av målkonflikterna gav upphov till avvägningar som enbart kan baseras på lokala värderingar och prioriteringar. Verktyget hjälper dock beslutsfattaren att belysa de synergier, konflikter och valmöjligheter som finns.

På det andra halvdagsmötet genomfördes också en enkel enkät där deltagarna fick möjlighet att kommentera arbetet under halvdagsmötena och verktygens användarvänlighet. Sammanfattningsvis bedömde de flesta deltagare att båda verktygen är användbara men att de måste vidareutvecklas för att bli mer användarvänliga och mindre tidskrävande.

Abstract

Adaptation to climate change often involves long time frames and uncertainties over consequences of chosen adaptation measures. In this study, two tools developed for assisting local decision-makers in adaptation planning were tested: socio-economic scenarios and sustainability analysis. The objective was to study whether these tools could be of practical relevance to Swedish municipalities and foster local level climate change adaptation. We find that the municipal civil servants who participated in the testing generally considered the tools to be useful and of high relevance, but that more time was needed for using the tools than provided during the test process.

Keywords: climate change; adaptation; socio-economic scenarios; goal conflict; cost-benefit analysis

Contents

1. Introduction

In Sweden, climate change adaptation planning has increased since the middle of the last decade (Glaas et al., 2010; Ds 2009:63). The main responsibility for planning for climate change adaptation lies with Sweden's 290 municipalities, with support from the 21 county councils (Ds 2009:63). The municipalities are responsible for social and contingency planning, rescue services, physical planning, and for the technical provision of infrastructure, such as drinking water and sanitation, energy use and waste management.

However, municipal adaptation to climate change involves decision-making characterized by uncertainty and complexity. First, there are uncertainties regarding the cause-effect chain from emissions of greenhouse gases to actual impacts (Schneider, 2001; Reilly et al., 2001), which means that predicting how and when climate change will impact municipalities is even more difficult than predicting impacts on a global level. Second, there are long time lags between decisions and outcomes which extend the policy/learning cycle and reduce the space for experimentation, feedback and iteration, adding an unusual dimension to municipal decision-making. Third, municipal climate adaptation at the local level will require cross-sectional decisions, which is in contrast to the Swedish current practice.

Given the prevailing responsibilities, uncertainties and complexities, the municipalities should be equipped with sufficient resources and tools to be able to handle a range of climate adaptation issues. Nevertheless, a municipal survey by the Swedish Association of Local Authorities and Regions (SALAR), finds a profound need for climate adaptation planning tools (SALAR, 2009). Thus, there appears to be a gap between the municipal responsibilities and the municipal means. This paper presents the testing of two tools that aim at alleviating at least a part of this gap.

To support the municipalities in addressing the climate adaptation challenge a number of decision tools have been developed internationally[1] to be used at different stages in the climate adaptation process; from identification of risks to *ex ante* and *ex post* evaluation of climate adaptation options. This article focuses on two climate adaptation decision tools, developed under the auspices of the Climatools[2] programme; a Swedish research programme aimed at providing local decision-makers with a better basis for developing strategies for adapting to climate change. Within the programme, a 'toolbox' of methodologies to support climate adaptation planning at the local and regional level in Sweden is developed. A key tenet of the programme is that the tools are developed in close collaboration between researchers, who develop prototypes, and practitioners, who test the tools which are then further refined.

The two tools described in this paper, scenario planning and sustainability analysis, are intended for *ex ante* evaluation of adaptation options and both contain a mix of new and well-known elements to municipal planners. The tools were tested in a case study in the Botkyrka municipality within the Stockholm metropolitan area. The aim was to study if the tools could be used to support municipal decision-making in prioritizing between different climate adaptation measures for protecting a groundwater aquifer

1 See, for example, UNFCCC Secretariat (2008) for an overview of different methods and tools. See also the UKCIP Adaptation Wizard (www.ukcip.org.uk).

2 www.climatools.se

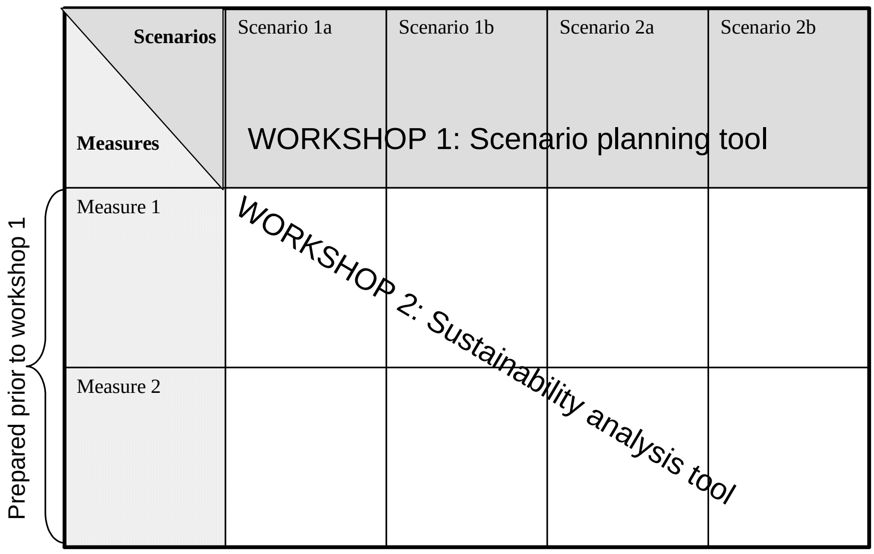
within the municipality. The test process was designed to mimic a real process, although this was not an on-going planning issue in Botkyrka. The case in itself is realistic and the aquifer might require real adaptation measures in the near future. The test process involved participatory workshops in which civil servants from various parts of the organization of Botkyrka municipality took part. The workshops were supplemented by back-office work where scenarios were constructed and a rough cost-benefit analysis was carried out.

In the test process, the tools were used in a complementary fashion, although they can be used separately. The guiding idea of using the tools in combination was to utilize the first tool, scenario planning, as a means for providing a suitable background for the second tool, sustainability analysis. That is, the scenario planning tool gives different scenarios, i.e., brief descriptions of future socio-economic and climatic states of the municipality, in which various climate adaptation measures are carried out (one at a time) to protect the aquifer. These adaptation measures give rise to several environmental, social and economic consequences, depending on the scenario, which need to be identified in order to provide a broad decision support, which is the aim of the sustainability analysis tool.

In this paper we will present the two tools and how they intend to aid municipal decision-makers, illustrated through the case study of a groundwater aquifer in Botkyrka municipality. In Figure 1, we give a brief overview of the test process and show how the tools co-operate. The first column on the left (shaded grey) presents the different measures (described in section 3.1) for adapting the aquifer to climate change. As this was not an on-going planning issue in the municipality, these measures were developed before the first workshop in co-operation with the civil servants of the municipality. The top row (grey) gives the different scenarios, which were developed from the results of the first workshop (workshop 1). The other rows and columns (white) of the matrix were elaborated on under and after the second workshop (workshop 2).

In the next section, we present the two tools. In section 3, we describe the case and the test process. In section 4, we conclude the paper with a discussion.

Figure 1. The tools and the test process.



2. The tools

This section provides a description of the two tools. Emphasis is placed on describing how the tools offer a systematic solution to the uncertainties and complexities described above.

2.1 Scenario planning

Climate change adaptation is not about adapting society to a changing climate, but to the *impacts* of a changing climate. The Intergovernmental Panel on Climate Change (IPCC) recognizes climate change impacts as the *"[…] difference […] between socio-economic conditions projected to exist without climate change and those projected with climate change"* (Carter et al., 1994; 2007). The Swedish Commission on Climate and Vulnerability (2007), on the other hand, digressed from this definition and imposed future climate conditions on a present day socio-economic context. The Commission however acknowledged that the impacts from changes in socio-economic contexts would most likely be larger than the impacts from climate change (Swedish Commission on Climate and Vulnerability, 2007). Arnell et al. (2004) argue that it might be acceptable to study impacts of future climate change on today's society for near-time assessments but for longer time horizons such an approach is not adequate. It is, therefore, necessary to cope both with climatic change and future socio-economic uncertainties when adapting to climate change.

There are a number of different methodologies for coping with future socio-economic conditions (cf., Börjeson et al., 2006). Within climate modelling, as well as in impacts, adaptation and vulnerability analyses, scenario planning has become widely utilized (Kahn and Wiener, 1967; Wack 1985a, 1985b; Huss and Honton, 1987; van der Heijden, 2005; Bradfield et al., 2005; Nakićenović et al., 2000). The main aim of scenario planning is to inform decision-makers in the face of deep uncertainty, i.e., in situations where predictions are not reliable within the time-frame of relevance to the planning issue at stake (Dreborg, 2004). This is operationalized in several ways. The scenarios can reveal challenges, both opportunities and threats, related to different directions of development for society. Furthermore, the scenarios can be used as a test bed for potential adaptation measures but they may also stimulate ideas of new adaptation measures by highlighting potential future conditions. A workshop-based approach is often utilized for the development of the scenarios, involving representatives of the intended scenario users.

During the last three years a scenario planning tool for local climate change adaptation has been developed and tested within the Climatools programme (Carlsen and Dreborg, 2008; Carlsen et al., 2009; Mossberg Sonnek and Hörnsten Friberg, 2009). The scenario planning tool of Climatools intends to provide an easily accessible methodology for incorporating socio-economic development paths into local climate change adaptation work. In the first phase of using the scenario planning tool it is important to define a clear focus: For what purpose are the scenarios developed? The scenario tool supports three modes of application: *i)* Identification of climate change induced opportunities and threats; *ii)* Identification of adaptation strategies; and *iii)* Assessment of adaptation strategies. In the second phase, the actual scenario construction takes place. The process ends with the utilisation of the scenarios in one (or a combination) of the three modes of applications.

The scenario planning tool of Climatools share many characteristics with other frameworks for the utilisation of socio-economic scenarios in the IAV communities, e.g. the socio-economic scenarios developed within the UK Climate Impacts Programme (UKCIP, 2001; Berkhout et al., 2002) and the Finnish project FINADAPT (Carter et al., 2005). However, there are two important differences. First, the scenario planning tool of Climatools does not emphasize the link between the socio-economic development at the *global* level and that at the *local* level. As a motivation, we use a model developed by Emery and Trist (1965).[3] In general, a planning entity, *P* (e.g. a Swedish municipality) is embedded in two layers of environments: the contextual environment (*C*) and the transactional environment (*T*). The contextual environment *C* affects *P,* while *P* does not have any effect on *C*. For a Swedish municipality this could for example be the exchange rate for the Swedish krona (SEK), which influences the municipality but is not affected by decisions within the municipality. With *T* there is however an interaction with *P*. Within *T* we find, for example, factors such as decisions taken by the county council to which the municipality belongs. In most scenario planning exercises, in general as well as in connection with climate change adaptation (e.g., UKCIP and FINADAPT), the focus is on external socio-economic scenarios, i.e., scenarios describing the development in the *T* and *C* environments. However, during the development of the Climatools scenario planning tool, we found that the

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[3] For a thorough treatment of this model and its implications for long range planning, see Eriksson and Dreborg (2011).

influence of global factors (i.e., in *C*) on local and regional climate change adaptation is generally weak. Instead, the most important socio-economic factors were found to be in *P* or *T*. Hence, the Climatools approach to scenario planning focuses on describing the development of *P* itself and *T* with only minor influence from *C*.

Another difference between the Climatools' scenario tool and most other approaches is a lack of *general* national level socio-economic scenarios. The guiding idea is that, in order to facilitate relevance of the socio-economic scenarios and stakeholder engagement, it is necessary to develop a *unique* set of scenarios specifically tailored for each planning situation. In the Climatools' framework there is no middle layer between the global scenarios (e.g. the storylines associated with the SRES[4] scenarios) and the scenarios developed at the local level; when necessary, the national level is described from the point of view of the actual focal issue.

When developing socio-economic scenarios for adaptation planning it is vital to relate this work to climate change scenarios. Due to considerable inertia of the climate system the uncertainty with regard to anthropogenic climate change is relatively small in the short time-perspective (Meehl et al. 2007); the climate change expected the coming one or two decades is relatively independent of the socio-economic development. Therefore, for these time-scales, there is a wide range of socio-economic developments that are consistent with the projected climate change. This also implies that for shorter time-scales (i.e., one or two decades), the climate outcome is insensitive to the choice of emission scenario and hence there is no need to consider multiple climate scenarios. On these time-scales, the focus should instead be on exploring socio-economic uncertainties, i.e. to consider multiple socio-economic scenarios. However, when considering longer time-scales the climate outcome will be dependent on the socio-economic development and associated emission paths and it will, therefore, be important to consider multiple emission scenarios.

In this case study we aim at investigating whether Climatool's scenario planning tool could be utilised in municipal climate adaptation planning. More specifically, could scenario planning be used as tool for structuring the future socio-economic context in which a sustainability analysis could be conducted?

2.1 Sustainability analysis

It is often difficult for decision-makers to predict all the consequences from the different adaptation options in the choice set and, therefore, often ends up satisficing rather than optimizing, i.e. to deciding on sufficiently satisfactory alternatives rather than "optimal" ones (Simon, 1972; Simon, 1956; March and Simon, 1958). To illustrate the difference March and Simon (1958:141) compare optimizing to satisficing with "searching a haystack to find the *sharpest* needle in it and searching the haystack to find a needle sharp enough to sew with". Satisficing could especially be the case when planning for sustainability, where the decision-maker has to cope with three divergent policy dimensions, social, environmental and economic, and resolve con-

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[4] The Special Report on Emission Scenarios (SRES) published in 2000 by the IPCC contains families of scenarios ("the SRES scenarios") used for making projections of possible future climate change. The SRES scenarios have been used both in the IPCC's third and fourth assessment reports (TAR, 2001 and AR4, 2007).

flicts amongst them, given the prevalent uncertainties and complexities (Campbell, 1996).

The tool *sustainability analysis* offers a systematic way of identifying the economic, social and environmental (i.e., the three dimensions of sustainability) consequences of adaptive measures and relating them to each other, thus increasing the probability of improved decision-making. The tool bears resemblance to existing decision tools that integrates environmental, social and economic considerations in local decision-making, such as "sustainability appraisals" in the UK (Carter et al., 2003), and France's "RST_{02} grid", which can be used to inform decision makers about the strong and weak points of a project on the basis of sustainable development criteria (Certu, 2009). The tool, as developed within Climatools, consists of one basic part and two optional parts (A and B), is useful when a number of alternative adaptation measures are considered. In its basic part, the short and long-run consequences (positive as well as negative) of each alternative are identified and, if possible, quantified. In the two optional parts, which can be used separately or in combination, the consequences are (A) monetized and used in cost-benefit analyses and/or (B) mapped out in order to indicate potential goal or value conflicts. If all parts are carried out, decision-making should be considerably facilitated through a broad and detailed decision support.

2.2.1 SUSTAINABILITY ANALYSIS, BASIC PART

The basic part of the tool consists of a checklist with questions that aim at identifying the potential environmental, social and economic consequences of different adaptation options (for a general version of the checklist, see Appendix A). The checklist is simple and can be used almost without any preparation to get a comprehensive view of the potential consequences of the adaptive measures. The questions are open-ended, which makes the checklist easy to implement in municipalities of different sizes and with different (financial, personal or other) capacities. The different sustainability dimensions – environmental, social and economic – are specified through questions related to each of the different dimensions. In, for instance, the case of social consequences, the checklist focuses on questions about human health, safety and equity. Focusing the identification of consequences to more detailed sub-dimensions is a way of enabling the municipal planner to, in a systematic way, gain deeper insights into the sustainability of an adaptation measure. The checklist could, and should, however be tailored for its specific purpose to make sure that the questions posed are relevant.

After identifying the consequences by going through the checklist, it is desirable to, at least approximately, estimate the magnitude of consequences. If the magnitudes can be ascertained decision-making trade-offs are considerably facilitated and more transparent. In quantifying the consequences, even tacit knowledge about the magnitudes is important. That is, even ordinal measures (e.g., low, medium and high) can prove to be useful.

2.2.2 SUSTAINABILITY ANALYSIS, OPTIONAL PART A: COST-BENEFIT ANALYSIS

Cost-benefit analysis (CBA) is a decision support tool that has been used since the end of the 1960's for public decisions within the areas of environment, transport and health (Hanley and Spash, 1993; Fuguitt and Wilcox, 1999; OECD, 2008). CBA is a method in which the different options are evaluated by the consequences they give rise to. The idea is to weigh the costs of an option against its benefits and choose the option that maximizes the difference between the two.

In governmental decision-making the use of CBA is common (e.g., infrastructural decisions), but CBA appears to be more sparsely used in municipal decision-making. Results from the municipal survey performed by SALAR (2009) mentioned earlier, show that the municipalities experience difficulties especially in making the benefits of adaptation measures tangible. In the survey, more than 70 percent of the municipalities stated that they have "very little" or "nothing" of the tools they needed for making local CBAs. In only four percent of the municipalities, CBA was not considered to be a relevant planning tool. Thus, there is a need for planning tools to facilitate municipal CBA.

In this case study we seek tentative answers to a number of CBA related questions. First, does the outcome of a municipal CBA case study have the potential of significantly affecting policy recommendations or decision-making? If so, how data intensive is the exercise? Is it worth the cost? Second, is it possible that the development of a user-friendly interface would lead to a more widespread use of CBA – despite possible trade-offs with the precision of the results?

2.2.3 SUSTAINABILITY ANALYSIS, OPTIONAL PART B: GOAL CONFLICTS AND SYNERGIES

Because the concept of sustainability incorporates three different dimensions, there is a risk that these areas of planning might conflict with each other. This presents a challenge to municipalities' often sectional structure and way of planning. It is particularly challenging in climate adaptation planning, where different municipal sectors and competences must work together in order to come up with long-term sustainable solutions to a complex and multi-faceted decision problem.

Adaptation measures ought to be sustainable in the sense that they effectively reduce vulnerability to climate change (or exploit beneficial opportunities) without compromising the achievement of other environmental, economic, and social goals (McKenzie Hedger et al., 2008). In actual practice, however, goal conflicts frequently arise in climate adaptation (Edvardsson Björnberg and Svenfelt, 2009). Actions taken in response to climate change can conflict with goals concerning the preservation of natural, cultural, or recreational values, such as when hard coastal defenses – erected to protect against flooding – pose threats to biodiversity, change the landscape and render beach leisure less attractive. At other times adaptation measures conflict with mitigation targets, such as when using air-conditioning to lower indoor temperatures increase energy use and, hence, carbon dioxide emissions. Occasionally, measures to reduce the vulnerability in one location (or at one point of time) can increase the vulnerability in some other location (or at some other point of time), such as when flood defenses erected on one side of a river increase the risk of flooding on the opposite side of the river (Mitchell, 1981). Ideally, synergies between goals should be sought, i.e., when a consequence from an adaptation measure facilitates goal attainment of other goals within the sustainability dimensions.

The optional part B focuses on mapping out potential conflicts and synergies between the consequences identified in the basic part of the tool and the municipal goals set within the areas covered by the tool. By using goals from divergent areas as a primary source for analyzing the appropriateness of an adaptation measure the decision-maker will get a comprehensive view of how the consequences of an adaptation measure holds against other municipal plans.

In this case study the main focus concerning goal conflicts was under what conditions optional part B could be used (e.g., did it benefit from a cross-sectional approach)? The identified goal conflicts were also analyzed to investigate in what way the results could facilitate decision-making, and if further analyses of the goal conflicts were required.

3. The case study

Drinking water of good quality is vital for survival. The potential negative consequences from climate change on drinking water are therefore an urgent issue in municipal planning. Underscoring the urgency is IPCC's devotion of one of its six technical papers to the link between climate change and freshwater resources (Bates et al., 2008). In general, water quality is expected to be affected due to changes in floods and droughts and increased water temperature. Groundwater in particular is expected to be negatively affected by increased salt-water intrusion resulting from sea level rise (Bates et al., 2008). In Sweden it is estimated that both water endowments (freshwater in lakes, streams and groundwater aquifers) and water quality will experience more microbiological and chemical contaminations, increased salt-water intrusion, humus and undesired algae blooms, as well as more damages to the distribution net (Swedish Government Official Report 2007:60, Appendix B 13).

Nevertheless, the interest for climate change's impacts on the drinking water has been shallow in Sweden, possibly because the water supply traditionally has been abundant (Swedish Government Official Report 2007:60, Appendix B 13). Groundwater aquifers are perhaps especially vulnerable because they are invisible and, therefore, easy to ignore. Furthermore, water purification provided through water silting through layers of sand and gravel, is an intangible ecosystem service often taken for granted.

3.1 The Tullinge aquifer in Botkyrka

Botkyrka municipality is situated south of Stockholm, adjacent to Lake Mälaren in the Stockholm metropolitan area. There are approximately 80,000 inhabitants in the municipality. The Tullinge aquifer and the moraine in which it is situated are judged to be of *high priority* for the regional water supply according to the Stockholm County Water- and Sewage Council (VAS-council, 2009). The aquifer provides drinking water to approximately 15,000 people in the municipality, but it also works as a substitute aquifer for several neighbouring municipalities. There is, thus, a great demand for drinking water extracted from the aquifer and there are, consequently, significant incentives to protect the aquifer from the negative impacts of climate change. The Tullinge water aquifer is presently safeguarded by a water protection zone, depicted in Figure 2, in which land use is regulated.

Figure 2. Water protection area surrounding the Tullinge water aquifer (used with the permission of Botkyrka municipality, www.botkyrka.se)

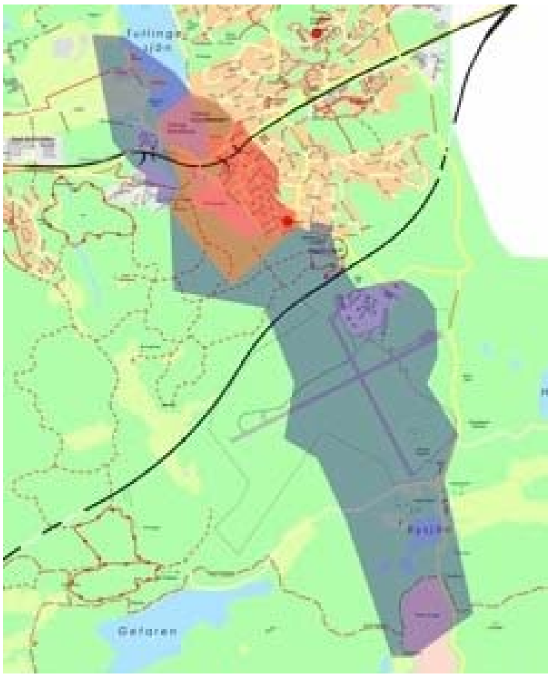

Figure 2 shows that the aquifer is located at the intersection of different uses, needs and interests. In the aquifer's vicinity there are roads, railways, enterprises and households. These different uses, needs and interests can both benefit from and pose threats to the Tullinge aquifer. At present, two companies extracting gravel from pits in the Tullinge valley glacier pose the most serious threat to the aquifer. Gravel extraction is authorized by the Stockholm county council a few years ahead of time. Although gravel extraction is important for, e.g., building and road construction, the gravel is in itself vital for the water purification. A too extensive extraction of gravel risks harming the Tullinge aquifer in the long run.

The roads and railways adjacent to the aquifer are used by both heavy and light vehicles, as well as for passenger and freight transports. If the use of roads and railways is restricted, the traffic flows will be negatively affected with potentially severe consequences for local industry and business. On the other hand, if transports of dangerous goods on rails and roads are prohibited, traffic accidents pose less of a threat to the aquifer.

Furthermore, since taxed inhabitants provide the municipality with income, there is an economic incentive to attract new inhabitants, e.g., by building new housing in proximity to the aquifer. These developments and other land uses also have negative effects on the aquifer.

Altogether, the municipal planners in Botkyrka municipality need to deal with several disparate and complex interests in addition to climate change when planning for adaptation of the Tullinge aquifer.

In this case study, we use two broad categories of adaptation measures; technical and administrative (see Table 1). Each category consists of three different measures. The measures were developed from discussions with the municipal planners and in co-operation with a consultancy firm specialized in social structuring[5] before the actual testing (the municipal planners did, however, not have to consent to the measures). The measures were selected on basis of relevance, but it was also desirable to have measures with a large variation in characteristics. Thus, even though all measures aim at protecting the Tullinge aquifer, they differ in e.g., terms of ease and cost of implementation.

Table 1 The different measures used to protect the Tullinge aquifer in the case study

1. Technical measures	2. Administrative measures
1.1 Seal dikes by roads and railways	2.1 Limit exploitation
1.2 Robust stormwater systems	2.2 Limit permits for gravel extraction
1.3 Membrane filtering in water works	2.3 Prohibit dangerous goods on road and rail

3.1 The test process

In order to dissolve some of the municipal planning complexities described in the introduction, the testing was performed in a participatory fashion, involving civil servants from different municipal sectors. This was a way of including multiple perspectives on the adaptation of the Tullinge aquifer to climate change. The process consisted of four phases which are described below.

3.1.1 PHASE I: WORKSHOP ON "SCOPING OF SCENARIOS"

The purpose of using the scenario planning tool in conjunction with the sustainability analysis tool was to provide a context in which the sustainability analysis could take place. Hence the *scoping* of the scenarios was relatively clear: they had the ambition of being used as a background to the identification and quantification of consequences, and to the CBA and goal conflicts analysis. In relation to the description in section 2.1 above, the application of the scenario planning tool was in accordance with mode three, Assessment of adaptation strategies.

The first workshop consisted of seven civil servants from different municipal sectors, primarily from the administrations of social service, city planning, health and environment as well as from the secretariat to the council and the executive board. In order to come up with building blocks for the socio-economic scenarios, the participants were faced with the following focal question: *"What variables are important for assessing and evaluating the appropriateness of the proposed adaptation measures?"*. These variables were generated in a structured brainstorming facilitated by a researcher from Climatools. In this phase, each participant came up with non-criticised proposals. During the next phase participants assigned votes to the different proposals on two aspects: *i)* how important is a variable for the focal question?; and *ii)* how uncertain is the future development of a certain variable? Because the scenarios should explore critical uncertainties, the variables voted most important and most uncertain were then further analysed in a group work session.

5 Tyréns AB (www.tyrens.se)

3.1.2 PHASE II: BACK-OFFICE WORK ON CONSTRUCTION OF SCENARIOS

The construction of the scenarios during phase II served the purpose of acknowledging that adaptation to climate change will have different consequences depending on different future socio-economic and climatic conditions. In this study two planning horizons, 2030 and 2060, were used. As discussed in section 2.1, for the shorter planning horizon it suffices to study only one climate scenario, while the socio-economic development is in general very uncertain. Hence, in the time frame 2030, one climate and two socio-economic scenarios were constructed. For the longer time frame 2060 two climate scenarios, one assuming medium climate change and one assuming severe climate change, were constructed. Of course, the uncertainty with regard to the socio-economic development is even higher for the longer time frame, but in order to limit the complexity of the process, only one (less detailed) socio-economic scenario was constructed for 2060.

The climate scenario 2030 and the medium climate scenario 2060 were based on the climate modeling of the Swedish Meteorological and Hydrological Institute (SMHI, 2011). Starting with a global climate model, SMHI performs calculation with a finer resolution over Europe. The more severe climate scenario for 2060 was based on Strandberg (2007) and used a higher emission scenario. In short, the future climate in the Stockholm region will be warmer and experience more precipitation. The increase in mean temperature will be higher during the winter than in the summer. For example, in the scenario for 2060, the mean temperature increases with 5.5° C compared to the reference period 1961-1990.

The starting point for constructing the three socio-economic scenarios was the results from the first workshop. For each of the prioritized variables (e.g., infrastructure and norms/values), a number of associated future states were assigned. In some cases these states were tangible, e.g. the variable "infrastructure" was related to the implementation or non-implementation of certain projects. In other cases, e.g. the variable "norms/values", the states were less tangible. A socio-economic scenario is defined as one state for each variable included. In the back-office work, numerous combinations of states, i.e., scenarios, were assessed with regard to plausibility and relevance. In this way three scenarios describing possible future socio-economic conditions of relevance for the issue of adapting the Tullinge aquifer to a changing climate, were constructed. One of the socio-economic scenarios for 2030 described a global and market-oriented society with an urban centre around the aquifer, whereas the second socio-economic scenario for 2030 depicted a small, local society characterised by downshifting and environmental concerns. The socio-economic scenario for 2060 described a future Botkyrka in a dematerialized economy with a scarcity of freshwater resources in many areas of the world.

The output from phase II, the scenario architecture depicted in Table 2 (cf., Figure 1), was used as a background to the second workshop in the test process. For each socio-economic scenario a narrative storyline was developed and distributed to the workshop participants before the second workshop.

Table 2 The scenario architecture with two time frames

Type of measures	2030		2060	
	Climate scenario		Socio-economic scenario	
	Socio-economic scenario ”Market oriented”	Socio-economic scenario ”Local society”	Climate scenario Medium	Climate scenario High
Technical measures				
Administrative measures				

3.1.3 PHASE III: WORKSHOP ON SUSTAINABILITY ANALYSIS

All the participants from the first workshop, as well as two additional civil servants, participated in the second workshop devoted to testing the tool sustainability analysis.[6] After a general presentation of the different scenarios and the different adaptation measures (see section 3.1), the participants were split into two groups, each working with one of the time horizons 2030 or 2060.

The identification of consequences was initially done individually. Each participant was given a form to fill out the environmental, social and economic consequences imagined from implementation of the (six) different technical and administrative measures – given a specified time horizon and the accompanying climate and socio-economic scenarios. This work was performed through a purpose-made version of the checklist which focused on very general questions about each sustainability dimension (see Appendix A for the general version). Then everyone presented his/hers consequences to the others. The consequences that were most unanimously agreed upon were then quantified, i.e., given an approximate magnitude (a low, medium or high increase/decrease).

The second workshop concluded with all participants identifying goal conflicts in relation to the consequences they had previously identified. In order to have some goals by which to compare the identified consequences, a political document summarizing long-term sustainability goals in Botkyrka was used. The document *A Sustainable Botkyrka* (Botkyrka, 2007) contains goals to be reached within a time-frame of 30 years and covers areas such as employment, health (both healthcare and recreational activities), education, public trust and co-operation, and greenhouse gas emissions abatement. The goals are formulated as visions but are specified through sub-goals that are followed-up and revised annually, and are hence designed to practically guide local planning.

Among the synergies identified by the participants were the administrative measures protecting the area surrounding the aquifer and meeting goals in areas of biodiversity, coastal defense and recreational activities. It was also claimed that these consequences could have educational value for nearby schools. Furthermore, the participants believed that limiting the permits for gravel extraction would be followed by a decrease in heavy traffic near the aquifer, which would have a positive effect on climate mitigation goals. Conflicts, on the other hand, primarily related to limiting land use and hence to the administrative measures. This, it was agreed, always brings goal conflicts to the fore. The area surrounding the aquifer is for instance attractive for constructing housing and a municipality that puts restrictions on permits and land use risks being viewed as too arduous to deal with, probably restraining new investments. On the

[6] The second workshop took place less than two months after the first workshop.

other hand, attaching weight to protecting the aquifer could also generate a positive image of the municipality. Upon further analysis after the workshop it was possible to identify more detailed accounts of conflicts and synergies between the consequences and goals on both municipal as well as national levels concerning health, traffic and sustainability.

3.1.4 PHASE IV: BACK-OFFICE ON SUSTAINABILITY ANALYSIS, OPTIONAL PART A

Thus, in workshop 2 the participants were asked to identify and (if possible) to quantify the consequences of the different climate adaptation measures proposed. This exercise mainly resulted in general, qualitative judgements, most likely because of the different measures' generality. For instance, the measure "robust stormwater systems without infiltration close to the aquifer" can, in itself, consist of a number of different technical measures (e.g., green roofs, percolation, creeks, wetlands) each associated with its own costs and benefits (Stahre and Geldof, 2003).

To estimate a total economic value of the Tullinge groundwater aquifer, we need to estimate the values of the benefits derived from the aquifer. The main benefits from the Tullinge aquifer are use-values (extraction values) derived from the supply of water for drinking, irrigation and industry. There are also non-use values (*in situ* values, i.e., non-extraction values), such as ecological and recreational benefits, and option values, such as the value of water's potential uses (e.g., buffer), attached to the Tullinge aquifer. The total value of the Tullinge aquifer is defined as the sum of all the identified values (Johansson et al., 2002).

In calculations by Sterte (2010)[7], the total economic present value of the Tullinge aquifer is estimated at SEK 1,800 million using a time horizon of 300 years and a time-declining discount rate.[8, 9] This value is of course very hard to verify. However, another Swedish study (Göransson, 2008) verifies that substantial economic values are involved when estimating the value of an aquifer (in a less populated area) at SEK 510 million. Furthermore, assuming that a new water source is available at a reasonable distance, the cost of constructing a new water work is estimated at SEK 200-400 million (2007 prices) for an average sized city (Swedish Government Official Report 2007:60, Appendix B 13). Thus, there appears to be great values at risk if refraining from protecting the aquifer.

The costs of protecting the aquifer can be divided into forgone profits and costs of lost employment and protection measures (Sterte, 2010). The forgone profits and the lost employment both occur if gravel extraction is prohibited at the Tullinge aquifer. Since gravel is a finite resource, gravel extraction is a time-restricted activity. Using a time horizon of ten years for gravel related costs and 300 years for protection costs, in conjunction with a time-declining discount rate, Sterte (2010) estimates the present value of the costs of protecting the Tullinge aquifer at SEK 60 million. Thus, according to Sterte (2010), the net present value, i.e., the difference between the discounted benefits and costs of protecting the Tullinge aquifer, is SEK 1,740 million.

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7 Not published but available from the authors upon request.

8 In 2008 prices unless otherwise stated. € 1 was on average equal to SEK 9.61 in 2008 (www.riksbank.se).

9 The time declining discount rate was 3.5 percent (years 1-20), 2.5 percent (years 21-100), 1.5 percent (years 101-200) and 0.5 percent (years 201-300).

To illustrate the idea of CBA, some costs and benefits of the proposed measures are given in Table 3. The consequences are based on the results from workshop 2, but are not exhaustive. Because the different scenarios generated a number of similar consequences differing in magnitudes, we, for simplicity, choose the worst-case scenario, the 2060 high impact climate scenario, to illustrate the idea of CBA.[10] Note that the calculations are based on a number of assumptions and that the figures are only indicative. Table 3 shows that protecting the aquifer appears to be good value for money even in the shorter time perspective of ten years (i.e., when the costs for the gravel industry occurs). However, the profitability of protecting the aquifer also depends on the magnitude of the losses from limiting exploitation and from prohibiting dangerous goods on road and rails. If these losses are large, protecting the aquifer will be less worthwhile. Nevertheless, such measures are continuous, not discrete (i.e., all or nothing) and careful limitation of both exploitation and transportation could be designed to minimize the dynamic costs of such restrictions.

Table 3 Examples of costs and benefits from the different adaptation measures in scenario 2060 High. Figures are only indicative (based on Sterte, 2010)

Measure	Costs (C)	Benefits (B)
1. Technical measures		
1.1 Seal dikes by roads and railroads	SEK 30,000 per km. Replacement every 15 years. Length of road in need of protection: 90 km. Total cost: SEK 2.7 million every 15 years	Freshwater for households and industry: SEK 32 million per year. Recreational value: SEK 1.5 million per year. Buffer value: SEK 1.5 million per year. Total benefit: SEK 35 million per year.
1.2 Robust stormwater systems without infiltration close to the aquifer[a]	SEK 30,000 per km. Replacement every 15 years. Length of road in need of protection: 90 km. Total cost: SEK 2.7 million every 15 years	See benefits above.
1.3 (Nano-)membrane in the water works	SEK 1 per m^3. Total cost: SEK 1.2 million per year.	See benefits above.
2. Administrative measures		
2.1 Limit exploitation	No direct costs, but dynamic indirect costs.	See benefits above.
2.2 Limit permits for gravel extraction	Job losses in the gravel industry: SEK 3 million per year. Forgone profits in the gravel industry: SEK 3 million per year. Total costs: SEK 6 million per year.	See benefits above.
2.3 Prohibition of dangerous goods on road and rail	No direct costs, but dynamic indirect costs.	

Note: [a] We were not able to get an adequate estimate of the cost of robust stormwater systems and, therefore, use the assumptions as for sealing roads and railroads.

10 Economizing on space we do not present all the details of the calculations. Full information is available from the authors upon request.

4. Discussion and conclusions

A vast majority of scholars in the impacts, adaptation and vulnerability community agrees that impact analysis and adaptation planning must incorporate future socio-economic conditions. There is however a worry that operationalizing this statement is far from trivial (e.g. Hughes et al. 2009; van Drunen et al. 2011). We draw the following conclusions from the test of the scenario planning tool. First, the Climatools approach seems to successfully address one common shortcoming of scenario planning, namely a lack of a clear link between the scenarios and the stakeholders' own concerns. This is, we believe, due to the fact that the scenarios in our approach are not delivered 'off the shelf' to the local decision-makers. Instead the scenarios are developed in close collaboration with the concerned municipality. Another reason is the emphasis on defining a clear focal question for *each* scenario planning exercise. Second, the proposed scenario planning approach can be used in a relatively short time and with rather small resources. A well-known barrier to using scenario planning is that it is generally considered resource intensive. The present case study was performed with relatively little resources; two half day workshops and approximately two man-month workload for preparation and back-office work. Of course, this amount of work would not suffice to reach a final answer to the question of what adaptation measure to employ. But it can provide an overview of the pros and cons of the different measures and give further directions for future work.

Furthermore, after testing the optional part A of the sustainability analysis tool, we believe that municipal use of CBA may be beneficial in major municipal decisions, i.e., decisions involving large financial (or other) costs and benefits. In such cases, at least a rough CBA is likely to be worthwhile. However, because economic analyses require a certain amount of specialist knowledge, it is probably wiser to let e.g., an economist or a qualified expert, perform the analyses than to always have the required competence "in house". If deemed to be a useful tool for the municipalities, user-friendly CBA interfaces may be developed over time. Such development is likely to be both "pull-driven" (from the municipalities) and "push-driven" (from e.g., the government or consultants). CBA is, if ambitious, data demanding and may, thus, be quite expensive. Our suggestion is, therefore, to use the tool sustainability analysis sequentially; if the basic part is performed and the decision basis is still too weak, then optional part A, economic analyses, could be considered.

When testing the sustainability analysis optional part B, it was possible to identify goal conflicts as well as synergies during the time-frame offered at the workshop, but it was difficult to determine a preferred adaptation measure based on the identified goal conflicts and synergies. It would require more analysis and more goals to compare the identified consequences with. In actual practice it will require preparations in order for the decision-maker to be informed about the relevant goals to compare identified consequences with, encouraging cross-sectional collaboration and usage. This was demonstrated by the way participants from different municipal sectors provided a wide range of goals to contrast the identified consequences with. However, even if conflicts were identified, it was difficult to determine the extent to which the consequences would impact on existing goals and how to weight such impacts. This, in part, lies beyond the tool. Deciding in a conflict between, for instance, social and environmental goals could rather be a political problem, but this tool could bring the conflict to the fore and serve as a foundation for planning.

The results from a simple questionnaire, distributed to all participants at the end of the second workshop, indicate that a majority of the participants deemed the scenario planning and the sustainability analysis tools to be very useful. Some participants appreciated the cross-sectional character of both workshops and most participants thought that the workshops were either "rewarding" or "very rewarding". Using the two tools together was seen as a strength: "*It worked well. It was easier to first think about the consequences in general and then put them into context/scenarios"* was one comment.
The main dissatisfaction concerned the lack of time and the intense schedule during the workshops. With regard to preparations, some participants wanted more information before the workshops, others wanted more, but shorter, workshops. "*The methods need to be simplified and structured – but are definitely useful"* was stated by one participant. This, together with a better focus on an actual on-going planning issue, is a natural way to proceed in future research.

References

Arnell, N., Livermore, M., Kovats, S., Levy, P., Nicholls, R., Parry M., and Gaffin, S., 2004. Climate and socio-economic scenarios for climate change impacts assessments: characterising the SRES storylines. *Global Environmental Change*, 14: 3-20.

Bates, B. C., Kundzewicz, Z. W., Wu, S. and Palutikof, J. P., eds., 2008. *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva.

Berkhout F., Hertin J. and Jordan A., 2002. Socio-economic futures in climate change impact assessment: using scenarios as learning machines. *Global Environmental Change*, 12: 83-95.

Botkyrka, 2007. *Ett hållbart Botkyrka* [A Sustainable Botkyrka] [online]. Available in Swedish from: http://www.botkyrka.se/SiteCollectionDocuments/Kommun%20och%20politik/Ett_h%C3%A5llbart_Botkyrka_digital_slutlig_version%5B1%5D.pdf [Accessed: 2011-05-18]

Bradfield R., Wright G., Burt, G., Cirns, G. and van der Heijden, K., 2005. The origins and evolution of scenario techniques in long range business planning. *Futures*, 37(8): 795-812.

Börjeson, L., Höjer, M.,Dreborg, K.-H., Ekvall, T. and Finnveden, G., 2006. Scenario types and techniques: towards a user's guide. *Futures*, 38: 723-739.

Campbell, S., 1996. Green Cities, Growing Cities, Just Cities? – Urban Planning and the Contradictions of Sustainable Development. *Journal of the American Planning Association* 62(3): 296-312.

Carlsen, H. and Dreborg, K.-H., 2008. *Dynamisk generering av socioekonomiska scenarier för klimatanpassning: metod, byggstenar och exempel* [Dynamic generation of socio-economic scenarios for climate change adaptation], FOI-R--2512--SE, Swedish Defence Research Agency.

Carlsen, H., Dreborg, K.-H., Edvardsson Björnberg, K., Rocklöv, J., Vredin Johansson, M. 2009 *Hälsokonsekvenser av extrem värme i Umeå-regionen,* [Health consequences of extreme heat in the region of Umeå] FOI-R--2811--SE. Swedish Defence Research Agency.

Carter, T. R., Parry, M. L., Harasawa, H. and Nishioka, S., 1994. *IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations*, Department of Geography, University College London UK and Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Japan.

Carter, J, Wood, C. and Baker, M., 2003. Structure plan appraisal and the SEA directive. *Town Planning Review*, 74(4), 395-422.

Carter, T. R., Jylhä, K., Perrels, A., Fronzek, S. and Kankaanpää, S., 2005. *FINADAPT scenarios for the 21st century. Alternative futures for considering adaptation to climate change in Finland*, FINADAPT Working Paper no. 2, Finnish Environment Institute Mimeographs 332, Helsinki.

Carter, T.R., R.N. Jones, X. Lu, S. Bhadwal, C. Conde, L.O. Mearns, B.C. O'Neill, M.D.A. Rounsevell and M.B. Zurek, 2007: New Assessment Methods and the Characterisation of Future Conditions. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge.

Certu, 2009. *Taking sustainable development into account in projects. The French RST_{02} evaluation grid user guide.* www.certu.fr

Dreborg, K.-H., 2004. *Scenarios and structural uncertainty : explorations in the field of sustainable transport.* Thesis (PhD), Royal Institute of Technology (KTH), Stockholm.

Ds 2009:63. *Sveriges femte nationalrapport om klimatförändringar. I enlighet med Förenta Nationernas ramkonvention om klimatförändringar.* [Swedens fifth national report on climate change. In accordance with United Nations convention on climate change] [online]. Available in Swedish from http://www.sweden.gov.se/sb/d/344/a/139741 [Accessed 2011-05-19]

Edvardsson Björnberg, K. and Svenfelt, Å., 2009. *Goal Conflicts in Adaptation to Climate Change*. Report No. FOI-R-2747-SE. Swedish Defence Research Agency: Stockholm. Available from: http://www.foi.se/upload/FOI-R--2747--SE%20Goal%20conflicts.3.pdf [Accessed: 2011-05-25]

Emery, F. E. and Trist, E. L., 1965.The causal texture of organizational environments. *Human Relations*, 18, 21-32.

Eriksson, E. A. and Dreborg, K.-H., 2011. Archetypal planning situations: A framework for selecting FTA tools for global challenges. Paper presented at the conference *Fourth International Seville Conference on Future-Oriented Technology Analysis (FTA). FTA and Grand Societal Challenges – Shaping and Driving Structural and Systemic Transformations*, Seville, 12-13 May 2011.

Fuguitt, D. and Wilcox, S. J., 1999. Cost-benefit analysis for public sector decision makers. Quorum, Westport, Conn.

Glaas, E., Jonsson, A., Hjerpe, M. and Andersson Sköld, Y., 2010. Managing climate vulnerabilities: formal institutions and knowledge use as determinants of adaptive capacity at the local level in Sweden. *Local Environment*, 15(6): 525-539.

Göransson, A., 2008. Kan grundvatten värderas? Grundvattenrådet för Kristianstadsslätten. [Is it possible to value groundwater?] [Online]. Available in Swedish from http://www.kristianstad.se/upload/Milj%C3%B6%20Energi/dokument/Grundvatten/Kan%20Grundvatten%20v%C3%A4rderas_Rapport.pdf [Accessed 2011-04-11]

Hanley, N. and Spash, C. L., 1993. Cost-benefit analysis and the environment. Edward Elgar, Northampton, MA, USA.

Huss, W. R. and Honton, E. J, 1987. Scenario planning – what style should you use. *Long Range Planning*, 20(4): 21-29.

Hughes, N., Tomei, J. and Ekins, P. 2009. Critical review of the Application of the UKCIP Socioeconomic Scenarios: lessons Learnt and Future Directions. Department of Geograhy, King's College London.

Johansson, P-O.,Djurberg, H., Gunnemyr, L., Söderqvist, T. and Collentine, D., 2002. Värdering av grundvattenresurser. Metoder och tillvägagångssätt. [Valuing groundwater resources. Methods and procedures]. Swedish Environmental Protection Agency, Report 5142.

Kahn, H. and Wiener, A., 1967. The Year 2000: A Framework for Speculation on the Next Thirty-Three Years. New York: MacMillan.

March, J. G. and Simon, H. A., 1958. *Organizations*. Wiley: New York.

McKenzie Hedger, M., Mitchell, T., Leavy, J., Greeley, M., Downie, A. and Horrocks, L., 2008. *Desk review: evaluation of adaptation to climate change from a development perspective*. Institute of Development Studies, University of Sussex.

Meehl, G. A., T. F. Stocker, W. D. Collins, P. Friedlingstein, A. T. Gaye, J. M. Gregory, A. Kitoh, R. Knutti, J. M. Murphy, A. Noda, S. C. B. Raper, I. G. Watterson, A. J. Weaver och Z.-C. Zhao, 2007. *Global Climate Projections*, i Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (red.), *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Mitchell, C. R., 1981. *The structure of international conflict*. Basingstoke: Macmillan Press.

Mossberg Sonnek, K. and Hörnsten Friberg, L. 2009. *Test av Climatools Scenarioverktyg. Utveckling av socioekonomiska scenarier inom turismnäringen på Österlen*. [Test of Climatools scenario tool] FOI-R--2798--SE. Swedish Defence Research Agency

Nakićenović, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., Gaffin, S., Gregory, K., Gruebler, A., Jung, T.Y., Kram, T., La Rovere, E.L., Michaelis, L., Mori, S., Morita, T., Pepper, W., Pitcher, H., Price, L., Raihi, K., Roehrl, A., Rogner, H.–H., Sankovski, A., Schlesinger, M., Shukla, P., Smith, S., Swart, R., van Rooijen, R., Victor, N. and Dadi, Z., 2000. *Emission scenarios. Special Report of Working Group III of the Intergovernmental Panel of Climate Change,* Cambridge University Press.

OECD, 2008. Economic aspects of adaptation to climate change. Costs, benefits and policy instruments. OECD, Paris.

Reilly, J., Stone, P. H., Forest, C. E., Webster, M. D., Jacoby, H. D. and Prinn, R. G., 2001. Uncertainty and climate change assessments. *Science*, 293: 430-433.

SALAR, 2009. Läget i landet. En enkätundersökning om klimatanpassning i den fysiska planeringen. Sammanställning och presentation av resultat. [A survey on climate change adaptation in physical planning]. Swedish Association of Local Authorities and Regions. Available in Swedish from: http://www.skl.se/vi_arbetar_med/tillvaxt_och_samhallsbyggnad/plan/klimatanpassning/nyheter_4/laget-i-landet [Accessed 2011-05-19]

Schneider, S. H., 2001. What is dangerous climate change? *Nature*, 411: 17-19.

Simon, H. A., 1956. Rational choice and the structure of the environment. *Psychological Review*, 63 (2): 129-138.

Simon, H. A., 1972. "Theories of Bounded Rationality", McGuire, C. B. and Radner, R. (eds.) *Decision and Organization*, North-Holland Publishing Company: Amsterdam

SMHI, 2011. http://www.smhi.se/sgn0106/leveranser/sverigeanalysen/ [Accessed: 2011-05-25]

Stahre, P and Geldof, G. D., 2003. New approach to sustainable stormwater planning. International Green Roof Institute, Publication No 005.

Sterte, Å., 2010. Cost benefit analysis of protecting Tullinge water catchment. Swedish University of Agricultural Sciences, 2010-11-25. Mimeo.

Strandberg, G., 2007. En jämförelse av de två klimatscenarierna A1FI och A2 med två globala klimatmodeller, underlag till Climatools, [A comparisment of the two climate scenarios A1F1 and A2 with two global climate models] SMHI Rossby Centre, november 2007.

Swedish Commission on Climate and Vulnerability. 2007. *Sweden Facing Climate Change – Threats and Opportunities*. Final report from the Swedish Commission on Climate and Vulnerability. Swedish Governmental Official Reports (SOU) 2007:60, Stockholm.

Swedish Government Official Report 2007:60. Sverige inför klimatförändringarna. Bilaga B 13 Dricksvattenförsörjning i förändrat klimat. [Sweden and climate changes] Available in Swedish from: http://www.sweden.gov.se/sb/d/8704/a/89334 [Accessed 2011-05-19]

UKCIP, 2001.*Socio-economic scenarios for climate change impact assessment: a guide to their use in the UK Climate Impacts Programme*. Oxford: UK Climate Impacts Programme.

UNFCCC Secretariat, 2008. *Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change*. [Online] Available at: http://unfccc.int/files/adaptation/nairobi_workprogramme/compendium_on_methods_tools/application/pdf/20080307_compendium_m_t_complete.pdf [Accessed 2011-04-18]

Van Drunen, M., van't Klooster, S.A., and Berkhout, F. 2011. Bounding the future: The use of scenarios in assessing climate change impacts. *Futures* 43, 488-496.

van der Heijden, K., 2005. *Scenarios: the art of strategic conversation*. 2nd. ed. Chichester: John Wiley & Sons.

VAS-council, 2009. Dricksvattenförekomster i Stockholms län. Prioriteringar för långsiktigt skydd. VAS-rådets rapporter nr 6. [The occurence of drinking-water in Stockholm county.] Available in Swedish from: http://www.lansstyrelsen.se/stockholm/SiteCollectionDocuments/Sv/miljo-och-klimat/halsoskydd/dricksvatten/RAPPORT_nr_6_Dricksvattenforekomster_i_Stockholms_lan_utan_bilagor.pdf [Accessed 2011-05-19]

Wack, P., 1985. Scenarios, uncharted waters ahead. *Harvard Business Review*, 63(5): 73-89.

Wack, P.,1985. Scenarios, shooting the rapids. *Harvard Business Review*, 63(6): 139-150.

Appendix A: The checklist (general version)

This general version of the checklist should be regarded as a gross list of questions that should be tailored to the specific purpose at hand. The list aims at covering as many aspects as possible of each dimension and, depending on the case at hand, some aspects may be of great relevance whereas others may be completely irrelevant. Thus, testers of the tool have to subtract, and possibly add, questions in order to create purposeful net lists of the questions.

Mapping the measures' consequences

A. Environmental dimension
A1. Consequences for nature and culture
Has an environmental impact assessment (EIA) been performed for the measure and its alternatives? If yes, what does it show?
In what ways does the measure affect the opportunities to achieve national and municipal environmental quality objectives? (Pay regard to both conflicts and synergies).
Can the measure be modified so that it becomes more pro-environmental? What are the obstacles for doing so?
Are there alternative measures which involve smaller conflicts with environmental issues?
What are the consequences for nature and culture from doing nothing?
Do we need more information before making a decision?
A2. Consequences for outdoor life
How does the measure affect the opportunities for outdoor life?
Can the measure be modified so that it becomes more aligned to the municipality's outdoor life commitments?
Are there alternative measures which involve smaller conflicts with outdoor life?
What are the consequences of doing nothing?
Do we need more information before making a decision?
B. Social dimension
B1. Consequences for nature and culture
Has a health impact assessment (HIA) been performed for the measure and its alternatives? If yes, what does it show?
How does the measure affect traffic safety?
How does the measure affect the possibilities for physical activities?
How does the measure affect people's social participation and influence?
What are the consequences for people's health and safety from doing nothing?
Do we need more information before making a decision?
B2. Consequences for working life and housing
How does the measure affect working life?
How does the measure affect housing and building?
How does the measure affect segregation due to housing?
Are there alternative measures which involve less conflict with people's health and safety?
What are the consequences for working life and housing from doing nothing?
Do we need more information before making a decision?
B3. Distribution and ethics
Identify the gainers. Are there some individuals or group of individuals that benefit particularly from the measure? Pay regard to the distribution of benefits over time.
Identify the losers. Are there some individuals or group of individuals that lose particularly from the measure? Pay regard to the distribution of costs over time.
Are there alternative measures which involve less conflict with distributional and ethical issues?
What are the consequences for distributional and ethical issues from doing nothing?

Do we need more information before making a decision?
C. Economic dimension
How does the measure affect (local) business and (local) growth?
How does the measure affect employment?
How does the measure affect communications and infrastructure?
How does the measure affect tourism?
Are there alternative measures which potentially involve smaller conflicts with economic and growth targets?
What consequences for the economy and growth are associated with doing nothing?
Do we need more information before making a decision?

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