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Goal Conflicts in Adaptation to Climate Change

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Goal Conflicts in Adaptation to Climate Change

An inventory of goal conflicts in the Swedish sectors of the built environment, tourism and outdoor recreation, and human health

Cover Photo: Coal Fired Power Station Cooling Towers with House, Radcliffe On Trent, Nottinghamshire, England.
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Titel	Målkonflikter i det svenska klimatanpassningsarbetet. En inventering av målkonflikter inom sektorerna byggd miljö, turism och friluftsliv samt hälsa.
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Sammanfattning

Beslut som rör anpassning till klimatförändringen innebär ofta ett val mellan olika handlingsalternativ, vilka enskilt eller tillsammans kan påverka möjligheten att nå andra samhällsmål. Ibland uppstår konflikter mellan målet om anpassning och andra samhällsmål. Det sker när genomförandet av en anpassningsåtgärd gör det svårare att nå något annat mål som beslutsfattaren själv eller någon annan vill uppnå. För att undvika negativa sidoeffekter på andra samhällsmål behöver beslutsfattaren känna till de kortsiktiga och långsiktiga (miljömässiga, ekonomiska, sociala och etiska) konsekvenserna av olika handlingsalternativ. Med andra ord, innan beslut om anpassning fattas behöver man inte bara kunna fastställa hur effektiv och kostnadseffektiv en åtgärd är utan även hur rimlig den är givet beslutsfattarens övriga mål. Idealt sett bör en åtgärd vara hållbar i den bemärkelsen att den på ett framgångsrikt sätt anpassar samhället till klimatförändringen samtidigt som den inte skapar onödiga konflikter med andra samhällsmål och värden.

Det faktum att anpassningen till klimatförändringen ofta påverkar våra möjligheter att nå andra mål visar på behovet av att kunna förutsäga de miljömässiga, sociala och ekonomiska effekterna av enskilda anpassningsåtgärder, strategier och policys i ett tidigt skede i beslutsprocessen. För att säkerställa att klimatanpassningen är förenlig med andra strävanden behövs verktyg som kan användas för att förutsäga och värdera olika utfall liksom för att väga utfallen mot varandra i de fall de inte är förenliga.

Det finns idag relativt begränsad forskning om målkonflikter i förhållande till klimatanpassning. Syftet med den här rapporten, som har producerats inom ramen för forskningsprogrammet Climatools (www.climatools.se), är att ge kunskap om vilken typ av målkonflikter svenska beslutsfattare (främst på lokal och regional nivå) kommer att behöva hantera när de fattar beslut om anpassning inom sektorerna byggd miljö, turism och friluftsliv samt hälsa.

Rapporten visar att målkonflikter är relativt vanligt förekommande i anpassningsarbetet. Ibland handlar det om konflikter mellan målet om anpassning och målet om utsläppsbegränsningar (”mitigation”), som när luftkonditionering och andra mekaniska kylsystem som används för att begränsa hälsoeffekterna av t.ex. värmeböljor även bidrar till att öka utsläppen av växthus-gaser. I andra situationer handlar det om att anpassningen gör det svårare att nå mål om bevarandet av värdefulla naturområden, som när skidanläggningar som omlokaliseras till platser med bättre snöförhållanden påverkar den biologiska mångfalden negativt. Ofta kan en och samma anpassningsåtgärd göra det svårare att nå en viss grupp av mål medan andra mål främjas. Det gör att beslut om anpassning till klimatförändringen ofta är komplexa och svåra att hantera.

Olika typer av målkonflikter kräver troligtvis olika typer av lösningar. Ett av de kanske mest uppenbara sätten att förhindra uppkomsten av målkonflikter i anpassningsarbetet är att intensifiera arbetet med utsläppsbegränsningar, vilket i förlängningen medverkar till att färre anpassningsåtgärder behöver vidtas. Andra konflikter kan undvikas genom att man väljer en annan (mer hållbar) anpassningsåtgärd, eller för det fall inga hållbara anpassningsåtgärder står till buds satsar på forskning som kan bidra till att utveckla sådana.

Som en del i det fortsatta arbetet inom Climatools kommer dessa metoder för konflikthantering, liksom andra, att studeras och preciseras i syfte att leverera användarvänliga verktyg som kan bistå planerare och beslutsfattare i deras anpassningsarbete.

Nyckelord: Klimatförändringar, anpassning, målkonflikter, fysisk planering, miljömål, byggd miljö, turism och friluftsliv, hälsa.

Summary

Decision-making concerning adaptation to climate change often involves choosing between different options, each of which can have important implications for the achievability of other goals and policies. Sometimes, conflicts arise between the goal of adaptation and other policy goals. This occurs when the implementation of an adaptation measure makes it more difficult to achieve some other goal that the decision maker aims to achieve. To avoid producing negative impacts on other goals, the decision maker must have a good understanding of the long- and short-term consequences (environmental, economic, social and ethical) of her decisions. In other words, before an adaptation measure is decided on, two things must be established: how successful the measure will be in terms of expected effectiveness and cost efficiency and how appropriate it is given the decision maker's other aims and goals. Ideally, an adaptation measure should be sustainable in the sense that it is effective in abating the negative effects of climate change (or seizing new opportunities engendered by such changes) without negatively affecting other goals and values.

The fact that adaptation decisions generally produce more than one outcome points to the need for assessing and predicting the environmental, social and economic impacts of individual adaptation measures, strategies or policies at an early stage in the decision-making process. To ensure the coherence of adaptation measures with other policy goals, there is a need for tools to assess and predict outcomes, but also to balance those outcomes and trade them off in situations where they are not easily reunited.

So far, relatively little research has been performed on goal conflicts and conflict resolution in adaptation to climate change. The aim of this report, which was produced as part of Climatools' research programme (www.climatools.se), is to provide basic data on what kind of goal conflicts Swedish decision makers will

likely have to handle as they make decisions concerning adaptation in the sectors of the built environment, tourism and outdoor recreation, and human health.

As the report shows, goal conflicts in adaptation are common phenomena. Sometimes, adaptation conflicts with mitigation efforts, such as when air-conditioning and other mechanical cooling systems used to reduce heat-related mortality also increase carbon dioxide emissions. At other times, adaptation conflicts with goals concerning the preservation of natural and cultural values, such as when ski establishments are relocated to meet snow deficits, resulting in biodiversity loss and damage to landscape integrity. Often, adaptation conflicts with some goals while at the same time benefits others, which makes choices concerning adaptation complex and difficult to manage.

Different types of goal conflicts will likely require different types of solutions. Perhaps the most obvious strategy to avoid conflicts is to make sure that they do not arise: for example, by investing in intensified action to mitigate climate change. Other conflicts can be avoided by exchanging the considered adaptation measure to an alternative (more sustainable) one. In those situations, the alternative adaptation measure may not be equally successful in preventing harm (or taking advantage of opportunities) as the former measure was but may result in better overall goal achievement and, therefore, emerge as a preferred alternative to governmental decision makers who are generally responsible for working towards many different goals.

As the Climatools research program proceeds, these methods of conflict management/resolution and others will be studied with the aim of delivering user-friendly decision tools that can assist social planners and decision makers in their day-to-day adaptation work.

Keywords: Climate change, adaptation, goal conflicts, physical planning, environmental objectives, built environment, tourism/outdoor recreation, human health.

Contents

Foreword

This report has been written within the framework of Climatools, a research programme financed by the Swedish Environmental Protection Agency, which aims to develop tools that can assist us in adapting to climate change. Climatools is run by the Swedish Defence Research Agency (FOI) in collaboration with the Royal Institute of Technology (KTH), Uppsala University and Umeå University. The research programme was initiated in 2006 and will continue until 2011.

In order to meet the challenges posed by climate change, Climatools is concerned with projects relating to program synthesis, climate change scenarios, adaptability analyses, public health, environmental objective conflicts, geopolitics and gender equality issues. The focus of the Climatools programme is on sustaining or enhancing the capacity within sectors and regions in Sweden to deliver the services that society will require in the future. The principal task is to provide a set of tools that can be used by social planners at different levels in the various sectors and regions in Sweden. Climatools is developing tools in stages and in close collaboration with a range of interested stakeholders. The tools will be tested in a variety of scenario-based case studies. The tools will also provide an insight into options for adaptation within sectors and regions given the uncertainties that exist regarding the future climate. A secondary aim of the programme is therefore to provide new knowledge about the possible adaptation measures that may be needed in Sweden. The health sector is one of several sectors that will be studied in more detail, as will the built environment, tourism and leisure. The programme will focus on three regions of Sweden: Skåne, Mälardalen and Umeå.

Assumptions about the future climate in Sweden are a common feature of the scenarios developed in the Climatools programme. The primary assumption is that climate will be affected not only by what we do but also by the way in which the rest of the world behaves with regard to the emission of greenhouse gases, as well as by how the climate reacts to the measures taken. We attempt to take full account of the uncertainties that exist regarding the future climate and see it as an important task to produce tools that can handle these uncertainties.

This report constitutes the first deliverable in Climatools' subproject on environmental goal conflicts and their solution. The study has been carried out at the Division of Philosophy at the Royal Institute of Technology (KTH) in collaboration with the Division of Environmental Strategies Research (KTH). The primary target groups for the study are the other members of the Climatools research programme and decision makers at local and regional levels.

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Any errors that remain in the following pages are the authors' responsibility.

Stockholm 9 April 2009

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1 Introduction

1.1 Background

Climate change is considered one of the most severe challenges facing humankind. The latest report of the Intergovernmental Panel on Climate Change (IPCC) establishes that warming of the climate will have profound global impacts, not only on the Earth as a physical system, but also on the well-being of humans, societies and economies in the years to come. It is expected that in the future, the living conditions of hundreds of millions of people worldwide will be affected by changes in climate, with some of the most negative impacts, such as impaired food security and water supply, concentrated in the most vulnerable populations. Also developed countries will suffer from the direct and indirect effects of climate change. Many European regions, including Scandinavia, will, for example, experience higher mean temperatures and more frequent periods of hot weather, more drastic flooding, and more severe coastal erosion (IPCC, 2007, p. 14). In addition, many mountainous areas will experience significant glacier retreat, reduced snow cover, and extensive species losses.

Two fundamental policy approaches exist to reduce the environmental, economic and social threats posed by climate change: mitigation and adaptation. Whereas it has long been acknowledged that mitigation (reduction of greenhouse gas emissions) is needed in order to combat climate change, adaptation (responses to coming climate changes) has traditionally received much less attention (Pielke, 1998). Adaptation policies have been far more politically controversial than mitigation policies, since they seem to imply at least partial surrender in the battle against harmful greenhouse gas emissions (Parry *et al.*, 1998). However, the negative attitude toward adaptation has subsided over the last couple of years as scientists and decision makers have come to realise that changes in climate are unavoidable, even if we succeed in reducing greenhouse gas emissions considerably. To an increasing extent, adaptation is considered the only way of coping with the climate change impacts that inevitably will occur over the next few decades (Stern, 2007).

Compared to mitigation, a larger proportion of the changes that the adaptation process has to address will take place on a local and regional level. This means that many important adaptation decisions will have to be taken by actors operating at these levels, such as individuals, households, businesses, and local and regional governmental institutions. It also means that to be successful, adaptation measures will generally have to be adjusted to fit local conditions. An adaptation policy that is appropriate given the environmental and socio-economic conditions of one community need not be equally suitable in some other community or at some other point in time.

Adaptation often involves a choice between different options, each of which can produce more than the effect that it was initially intended to achieve. To avoid unwanted side effects, the decision maker must have a good understanding of the long- and short-term consequences (environmental, economic, ethical, etc.) that a particular adaptation measure could give rise to, as well as the extent to which those consequences obstruct the achievement of other goals and values that he or she wishes to safeguard. In other words, before an adaptation measure is decided on, the decision maker must establish not only how successful the measure is in terms of expected effectiveness, but also how appropriate it is given the other goals that he or she has adopted.

The fact that adaptation measures often produce more than one outcome points to the need for assessing and predicting the social, environmental and economic impacts of individual adaptation measures, strategies or policies at an early stage in the decision-making process. To ensure the coherence of adaptation measures with other policy goals, there is a need for tools that can be used not only to assess and predict outcomes, but also to balance or trade off these outcomes in situations where they are not easily reunited (Lim & Spanger-Siegfried, 2004). This report, which was carried out within the scope of the Climatools research programme (www.climatools.se), is a first step towards developing such tools, as it provides basic data on goal conflicts to be used in the development process.

1.2 Aim and scope

The overall aim of this report is to provide examples of goal conflicts that decision makers encounter concerning adaptation in the sectors of the built environment, tourism and outdoor recreation, and human health. More specifically, the report aims to provide a systematic answer to two questions: (1) What adaptation measures have been proposed for the three designated sectors? (2) Given that those adaptation options are implemented, what goal conflicts could they give rise to? Since the answer to the second question is largely dependent on what the future holds in terms of climatic and socioeconomic conditions—conditions that are to a significant extent surrounded by uncertainty—the findings in this report should be considered preliminary. They should not be taken as a blueprint for what will happen in the future, or as tacit advice concerning the adaptation measures that decision makers ought to take within their respective fields of competence.

The primary target group of the report are the decision makers at the national, regional and local governmental levels in Sweden. However, the report is also expected to be of some interest to the international research community on adaptation and governmental decision makers in countries that face adaptation challenges similar to Sweden. Moreover, it is hoped this report will benefit other projects in Climatools by providing examples of goal conflicts that can serve as inputs to the scenarios and tools that are developed as part of the programme.

1.3 Method

The investigation on which the report is based was conducted in two stages. The first stage consisted of an inventory of possible adaptation measures in the three focus sectors. This part of the investigation was carried out through a desk-based review of available information from governmental institutions in Sweden, most notably the 2007 report of the Swedish Commission on Climate and Vulnerability (henceforth 'SCCV, 2007'), and from governmental institutions in developed countries that face similar adaptation challenges to Sweden. Information about possible adaptation measures was also collected from a number of research institutes and research programmes focusing on adaptation, among them Finadapt, UKCIP and ESPACE. A list of the research institutes/programmes that have been consulted is available in Table 1.1. The searchable database "Adaptation Actions" (www.ukcip.org.uk), which contains examples of adaptation actions taken by UK organizations, proved to be particularly useful in this part of the investigation.

Next, the identified adaptation measures were categorised according to the climate change impact they are expected to counteract. They were also categorised into one of the following broad (and sometimes overlapping) types of adaptation measures:

1. Technical measures
2. Physical planning and infrastructure development
3. Policy and regulatory measures
4. Communication and education

For each of the three focus sectors, the results of this categorization were then represented in a matrix: Table 2.1 (built environment), Table 3.1 (tourism and outdoor recreation), and Table 4.1 (human health).

The second stage of the investigation consisted of an analysis of potential goal conflicts related to the adaptation measures that were identified during the first stage. Goal conflicts were identified based on literature studies combined with interviews with relevant staff from national and local authorities and field experts. Goals from four public policy fields were considered: environmental goals, goals concerning human health, recreational goals, and social justice goals (see section 1.5).

1.4 Goal conflicts in adaptation

In simple terms, a goal conflict arises when actions that are performed to achieve one goal make it more difficult to achieve some other goal that the decision maker wants to achieve (Edvardsson Björnberg, in press). Translated into the context of climate change adaptation this means that a goal conflict arises when a measure that is taken "in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" obstructs the achievement of some other goal that the decision maker has set. In this report, we refer to these conflicts as goal conflicts, although in reality they are perhaps more properly described as conflicts between measures.

A goal conflict can be *intra*personal or *inter*personal, i.e., it can exist between goals held by one agent or between goals held by different agents (Wilensky, 1983).[1] Interpersonal goal conflicts are very common and have been systematically studied by game theorists at least since von Neumann and Morgenstern's monumental *Theory of Games and Economic Behavior* (1944). These conflicts are not the primary object of study here. Instead, as the definition above indicates, this report deals mainly with *intra*personal goal conflicts, as in the case of a local authority deciding on an adaptation measure that makes it more difficult to reach some other goal that the authority is responsible for achieving.

Although simple enough in theory, the distinction between intra- and interpersonal goal conflicts can be blurred in practice. This can happen, for example, in the public sector where the goals of different governmental agencies sometimes stand in conflict with one another. As an example, in the Vellinge district (in the southwestern part of Sweden) there is an ongoing conflict between the local authorities and the county administrative board of Skåne concerning the protection of the Falsterbo peninsula. The local authorities in Vellinge want to protect vital economic interests at the peninsula from flooding and erosion through additional sand supply. Sand and sediments are available at the peninsula so no transport would be required. However, the sand would have to be taken from areas that are protected through Natura 2000—areas that the

[1] Sometimes, conflicts between goals held by different agents are referred to as conflicts of interest. For example, Axelrod (1967, p. 87) defines a conflict of interest as "the state of incompatibility of goals of two or more actors."

county administrative board of Skåne is responsible for protecting. This means that there is a conflict between the local authorities' goal of moderating harm associated with climate change (by constructing sand walls) and the county administrative board's goals of nature protection and conservation at the Falsterbo peninsula.

Goal conflicts of this type are seemingly interpersonal, since the agencies (in this case the local authorities and the county administrative board) are separate entities responsible for achieving different goals. However, both agencies are responsible for protecting the public interest. Therefore, what the situation boils down to is a conflict between the public's desire to protect vital economic interests (infrastructure and buildings, service, commerce, technical supply, etc.) safeguarded by the local authorities and the public's desire to protect vital ecological and cultural interests safeguarded by the county administrative boards. Whether or not such a conflict should be regarded as an intrapersonal or interpersonal one depends on whose perspective is considered.

Goal conflicts can be divided into *apparent* and *real* goal conflicts (Wandén, 1997; 2003; 2007). *Apparent* goal conflicts are conflicts that are due to some kind of inefficiency, for example, the inefficient use of resources or a poorly designed management system, and conflicts that can be solved by using better technology (Wandén, 2003). *Real* goal conflicts are conflicts that cannot be solved within a reasonable space of time by redesigning the management system, allocating further resources (financial or otherwise) or by introducing improved technologies. Instead, these goal conflicts mean that some kind of trade-off has to be made.[2] A council that has enough money to fund either a football field or an ice-hockey rink cannot reasonably compromise and spend half the sum on a field and half the sum on a rink. Arguments can be put forward to defend either goal, but ultimately the decision maker must prioritize between the goals and choose which of the measures to invest in. The same reasoning can be applied to conflicts that relate to adaptation policies.

Support relations, or synergies, are the opposite of goal conflicts. Such relations also exist between adaptation goals and other public policy goals. This holds true when a measure that is taken to adjust society to climate change also benefits the achievement of some other public policy goal, such as when establishing green roofs to slow run-off and protect against flooding also serves to enhance biological diversity. In this report, the primary focus is on goal conflicts in adaptation. However, it should be kept in mind that many of the identified adaptation measures also entail important synergies that deserve

[2] As is pointed out by Wandén (2007), the distinction between the various types of goal conflicts is not clear cut. For example, goal conflicts that can be solved by introducing new technologies can be real goal conflicts or even dilemmas depending on one's time perspective.

theoretical attention in their own right. In this report, synergies are briefly touched on at the concluding part of sections 2-4.

1.5 System boundaries

The field of goal conflicts in adaptation is vast, and any investigation into the subject must be clearly defined. This section describes the most important delimitations that have been made.

Adaptation by whom?

Adaptation decisions are taken by many different actors—governmental institutions, the private sector in industry, business and commerce, community groups, organizations, and private individuals. In this study, the primary focus is on planned adaptation in an institutional and policy-driven context, i.e., adaptation directed at collective needs that is initiated and implemented by national, regional and local governments (Levina & Tirpak, 2006). However, some adaptation actions taken by private actors are also analysed, mainly in section 3 on tourism and outdoor recreation.

In the sector of the built environment, adaptation decisions are taken at multiple levels. At local and regional levels, local authorities (kommuner) and county administrative boards (länsstyrelser) are important. At the national level, the National Board of Housing, Building and Planning (Boverket) is the main actor. Decision-making concerning adaptation in this sector also involves many private actors, such as building and property management companies and municipally owned companies, such as local water purification plants.

In the sector of tourism and outdoor recreation, adaptation decisions are mostly taken by private tourist operators and entrepreneurs, such as campsite and ski lift owners, sometimes in collaboration with tourist organisations and local authorities.

In the health sector, adaptation decisions are also taken by many different agents, mainly the county councils (landsting) and their subordinate agents, but also by national authorities such as the Swedish Institute for Infectious Disease Control (Smittskyddsinstitutet), the National Board of Health and Welfare (Socialstyrelsen), and the Swedish National Institute of Public Health (Folkhälsoinstitutet) (Waldau, 2007).

Adaptation based on what scenario?

Which adaptation measures will be required and implemented in the future depends on several factors. Two important ones are Sweden's socioeconomic development and the severity of climate change. In a longer span of time, such as 80 to 100 years, for instance, it makes a great difference for the choice of adaptation measures if we are expecting a 1.4°C or 5.8°C rise in global mean temperature. In a similar fashion, future socioeconomic conditions will have a bearing on the choice of adaptation measures. In a society distinguished by a strong central administration, slow economic growth, and a strong readiness for personal sacrifices to save the environment, different adaptation measures will probably be considered more readily than in a society distinguished by fast economic growth, a high rate of consumption and a low acceptance of public interference in personal lifestyles.

This assessment does not focus on any particular climate or socioeconomic scenario (or set of scenarios) in the identification and analysis of adaptation measures. It should be noted, however, that some of the identified adaptation measures might prove themselves less appropriate options over the long term, given that we will in fact experience considerable changes in climate.

Which goal conflicts?

Adaptation measures could give rise to negative (and positive) consequences for many different public policy goals—goals of the labour market, housing policy goals, energy policy goals, regional development goals, environmental goals, and economic policy goals. In this report, only goals from four public policy fields are considered, namely environmental goals, goals concerning human health, recreational goals, and social justice goals. This means that many important goals that are likely to be affected by adaptation decisions, such as employment goals and goals concerning regional growth, are not covered in this report.

In Sweden, environmental policy is operationalised through a set of national environmental quality objectives that were adopted by the Parliament in the late 1990s (Gov. Bill 1997/98:145; 2000/01:130; 2004/05:150).[3] The 16 objectives and their respective sub-goals define the environmental quality that Sweden should aim for within a generation (for most objectives the target years are from 2020 to 2025). The objectives also specify concrete measures to be taken and

[3] Table 1.2 contains a list of the environmental quality objectives. Detailed formulations of the sub-goals can be found at the Environmental Objectives Portal (www.miljomal.nu).

timescales for goal implementation. The overall environmental objectives of the Swedish government are to contribute to sustainable development as it is defined in the Brundtland report and to hand over to the next generation a society in which the central environmental problems have been solved.

The goal to improve and safeguard human health is partly operationalised through a set of national public health objectives adopted by the Parliament in 2003 (Gov. Bill 2002/03:35). The overarching aim for the national public health objectives is to create social conditions that will ensure good health, on equal terms, for the entire population. The 11 objectives cover aspects such as participation and influence in society, economic and social security, healthy living environments, the provision of safe products, and the reduction of the spread of infectious disease. The protection of human health is also furthered by the environmental quality objectives, most notably the objectives *Clean air*, *A non-toxic environment*, *A safe radiation environment*, and *A good built environment*.

Recreational values are today protected by the environmental quality objectives; most notable among these are the objectives *Flourishing lakes and streams*, *A balanced marine environment, flourishing coastal areas and archipelagos*, *Sustainable forests* and *A magnificent mountain landscape*.

Social justice considerations are incorporated into many different policy areas. This study focuses on a particular set of social justice goals, namely the national gender equality goals (Gov. Bill 2005/06:155). The overall goal of the Swedish government's policy for gender equality is "to combat and change systems that preserve the gender-based distribution of power and resources at the societal level" and "to create the conditions for women and men to enjoy the same power and opportunities to influence their own lives" (author's translation) (Gov. Bill 2005/06:155). The overall goal is operationalised through four sub-goals concerning, among other things, equal access to positions of power and influence and equal pay for equal work (as well as work of equal value). Among the other social justice goals that are discussed in the report, although not in a systematic fashion, are the national disability goals and goals concerning the equal distribution of economic resources.

Many of the above-mentioned objectives and their sub-goals are cross-sectoral and constitute a framework for continued definition, operationalisation and adjustment in geographic terms. This means that environmental goals, health and recreational goals, and gender equality goals are often incorporated into policies and plans developed at regional and local levels. In this report, regional and local goals are not specifically considered, although there is reason to believe that many of the conflicts identified in relation to national goals also pertain to goals set at lower administrative levels.

1.6 Definitions

In this section, definitions are provided for the terms that are most frequently used in the report.[4]

Mitigation

In response to climate change, a reduction of greenhouse gas emissions is required. This process is referred to as climate change mitigation. Mitigation is needed to decrease the rate of climate change and the magnitude of the consequences (Lemmen & Warren, 2004). However, mitigation will not avoid every negative climate change impact that occurs but has to be combined with a process of addressing those impacts.

Adaptation

Adaptation is defined by the IPCC as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2001, Annex B). The goals of adaptation can be to alleviate current impacts, to reduce the sensitivity and exposure to effects of climate change, and to increase the adaptive capacity, and hence resilience, of the systems in question (Warren & Egginton, 2008).

Vulnerability, adaptive capacity and resilience

The vulnerability of a system depends on the impacts of climate that the system is subject to, how sensitive it is towards those impacts, and its ability to adapt to the impacts (Lemmen & Warren, 2004). The IPCC defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2001, Annex B). A system can be sensitive to climate change impacts but have sufficient capacity to adapt and cope with those impacts, and hence not be vulnerable to them. When this holds true, the system has adaptive capacity.

[4] An excellent specification of key adaptation terms and concepts used by the climate change community and other institutions is provided by Levina and Tirpak (2006). The UKCIP homepage (www.ukcip.org.uk) also provides a useful glossary of words and terms used frequently in the climate change literature.

Adaptive capacity is closely related to resilience, which is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state (Holling, 1973). These terms are sometimes used interchangeably. A resilient system can deal with impacts and restore itself without significant declines in important functions. Loss of resilience can make the system more sensitive to smaller disturbances, thus increasing the risk that the system will change into a different state (Walker & Salt, 2006). Change and dynamics are inherent properties of ecosystems; therefore, coping strategies should not aim to eliminate change, but rather to develop the adaptive capacity to avoid crossing the threshold into undesirable states (Gunderson & Holling, 2002). If resilience is lost, capacity to adapt is lost.

Anticipatory and reactive adaptation

One can distinguish between anticipatory adaptation and reactive adaptation, and between autonomous and planned adaptation. Anticipatory (proactive) adaptation measures are taken before the impacts of climate change are observed, whereas reactive adaptation measures are taken in response to climate change, i.e., after a particular climate change impact has been observed (Smith, 1997). Although the distinction may seem intuitively clear, it can be difficult in practice to differentiate between anticipatory and reactive adaptation. Climate change is a continuous process that usually gives rise to gradual changes in the environment, and it is often hard to determine the particular point in time when a climate change impact actually occurs (Fankhauser *et al.*, 1999). Moreover, developing an appropriate adaptation strategy is seldom a 'one-shot' deal; instead it is perceived as "an iterative, continuous learning process" (Lim & Spanger-Siegfried, 2004, p. 185).

Autonomous and planned adaptation

Autonomous adaptation occurs spontaneously and is not a conscious response to climatic stimuli but is instead triggered by ecological changes in natural systems and by market or welfare changes in human systems (Levina & Tirpak, 2006). Planned adaptation is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that actions are required to either return to or achieve a desired state. According to Lemmen and Warren (2004), adaptation in unmanaged natural systems is mainly reactive and autonomous, while in managed systems it has the potential to be anticipatory and planned.

The distinction between autonomous (spontaneous) and planned adaptation is not crystalline. As an example, agriculture is commonly regarded as a sector in which private individuals, i.e., the farmers themselves, spontaneously adapt to changes in the climate; for example, growing crops that are more heat resistant as the annual mean temperature increases from year to year. At the same time, the choice sets of these farmers are often influenced by collective action at the public institutional level as well as public policies such as international trade agreements, taxes and subsidies, which are often designed to influence farmers' actual choices (Adger *et al.*, 2003).

There are also other important relationships between autonomous and planned adaptation. For example, the extent to which autonomous adaptation is expected to reduce the harm caused by climate change defines the need for planned policy interventions (Stern, 2007).

1.7 Disposition and reading instructions

In the following sections, adaptation measures and goal conflicts are identified and analysed in the following order: built environment (section 2), tourism and outdoor recreation (section 3), human health (section 4). Section 5 contains a brief account of the ways in which the proposed adaptation measures can obstruct Sweden's gender equality goals. Section 6 provides some concluding remarks on ways of managing goal conflicts in adaptation. The discussion in this section is preliminary and will be developed further as the Climatools research programme proceeds.

Some of the adaptation measures that are analysed in relation to one of the three sectors also constitute adequate responses in the other sectors. This holds true in particular for adaptation measures discussed in the sector of the built environment, which are often effective means of preventing harm to human health. Whenever an adaptation measure is relevant to more than one sector, cross-references are provided.

2 The built environment

2.1 Effects of climate change on the built environment

Climate change is expected to have significant consequences for the built environment. Threats against buildings and developments will increase due to more frequent extreme weather events, such as storms and landslides, and from flooding and erosion caused by the rising sea level and increased precipitation. Higher mean temperatures and increased humidity will cause buildings to deteriorate faster, will threaten the health of building occupants due to the increased mould that grows in a warm, moist environment, and will warrant reconstructions in building design.

Flooding and sea level rise

Flooding poses particular threats to buildings and developments in low-lying and coastal areas. In the future, flooding will occur more often in areas that already have problems today with high water flows (SCCV, 2007, p. 261). In other areas, high water levels are expected to occur less often and the risk of flooding will decrease or remain unchanged. The change in sea level, which will occur by the end of the century along large parts of the coast, will vary between a rise in land level of a metre to a rise in sea level of 80 cm depending on scenario and region.[5] For example, along the Svealand coast there may be anything from a drop in sea level of about 0.5 metre to a rise of the same amount (SCCV, 2007, p. 150).

Flooding and sea level rise will damage infrastructure, buildings and the environment, especially in the coastal zone and other areas that are situated close to lakes and water courses. Increasing flows are particularly troublesome, since people generally tend to live in high-risk areas.[6] The severity of the impacts on

[5] Some researchers have a much more pessimistic view on sea level rise. They argue that global sea level rise will be several metres in business-as-usual scenarios, because of rapid disintegration of the ice-sheets (e.g., Hansen, 2007).

[6] As an example, more than 30 percent of the total number of buildings in Sweden are in the coastal zone (which extends up to five kilometres from the shoreline) (SCCV, 2007, p. 262), and along 10 percent of the coastline there are developments within 100 metres of the shore (SCB, 2003).

society and the environment will largely depend on how successful the mitigation efforts will be and on the adequacy of adaptation measures that are implemented.

Besides causing damage to buildings and developments, flooding and other extreme whether events can jeopardize human safety (see also section 4) and result in immense losses to property owners and inhabitants of buildings. There are of course financial losses but also other kinds of suffering. Flood disasters can have severe social, physical and/or psychological health effects as people’s lives are disrupted and their homes are damaged (Caroll *et al*., 2007).

Increased precipitation

Climate scenarios indicate that there will be an increase in the amount, frequency and intensity of precipitation (SCCV, 2007, p. 263). The total annual precipitation will increase, and a redistribution of rain to autumn, winter and spring will occur. More intense rainfalls can cause an increased load on sewage systems and lead to possible backflows. If overloaded, excess water from sewage systems can cause flooding in built-up areas and increase the risk of water contamination. Since this is untreated sewage water, although diluted, flooding from sewage overflows means increased health risks due to microbes. Toxic moulds and bad indoor air quality following the flooding of buildings and basements can cause additional health problems (Chiotti & Mills, 2002).

In the future, the depth and duration of the snow cover is expected to decrease (see also section 3.1). The content of water in snow will change, and in some areas, most notably in the southern parts of the country, there will at times be high values of water content in the snow (SCCV, 2007, p. 313). In many of these areas, increased snow loads may pose threats to building constructions, since buildings are generally not designed to endure heavy snow loads (Boverket, 2007).

Increased precipitation can bring with it more frequent occurrences of horizontal rain. Horizontal rain entails increased risk of damage to buildings caused by moisture (Boverket, 2007). The rain wears out building materials, such as windows and wooden facades. As facades turn moist, there is also a risk that water is transferred to underlying materials where it can lead to odour and growth of mould.

Erosion and landslide

Increased precipitation and changed ground water levels can contribute to soil instability and erosion. For example, it can cause landslide, ravine formation, boulder clay landslide and mud flows (SCCV, 2007, p. 279). The risk of landslide is expected to increase in areas that are already deemed high-risk, such as around Lake Vänern, the Göta Älv river, in eastern Svealand and along the east coast. It is estimated that ca 200,200 buildings will be located in risk areas towards the end of the century (SCCV, 2007, p. 477).

Coastal erosion is also expected to be more severe in the future, predominantly in areas with mobile soil or sand, such as Skåne, Halland, Öland and Gotland. Coastal erosion affects the shoreline and has an impact on ecosystems, buildings and developments. More than 1,135 km^2 of different kinds of developments (low development, holiday homes, high development, industry, farmland) and 152,900 existing buildings could be affected or threatened by coastal erosion until 2100 (SCCV, 2007, p. 292).

Increased temperature and humidity

According to scenarios developed by the Rossby Centre, the average temperature in Sweden could rise approximately 2°C by 2020 and about 2-3°C by 2050 (SCCV, 2007, p. 127). Higher temperatures and increased precipitation mean increased humidity. In northern Sweden, humidity will increase to the point where it will be a year–round occurrence, whereas in southern Sweden, humidity is expected to drop during the summer. Increased humidity will cause corrosion, increased risk of frost erosion in plastered facades (in the north), and faster degradation of exterior building materials (SCCV, 2007, p. 311). Moisture and high temperatures will also cause an increased risk of structural damage due to growth of mould, rot and insect attacks (SCCV, 2007, p. 311).

High temperatures in combination with long periods of low precipitation can decrease groundwater supplies. As noted above, precipitation is expected to increase in most parts of Sweden. However, parts of southeast Sweden could experience a decrease in annual precipitation and run-off (SCCV, 2007, p. 253). In these areas, decreases in precipitation could cause ground water deficit and lead to a shortage of drinking water. A decrease in groundwater levels could also cause damage to buildings. In Canada, for example, damage to buildings has been observed as a result of the dry, hot summers there; this climate causes the clay soils to dry out, which then leads to destabilization (Bourque & Simonet, 2008).[7]

Increased wind load

Extreme wind loads can cause severe storm damage to buildings, such as trees falling onto buildings and roofs being blown away (Boverket, 2007). The wind can also cause air currents to flow in and out of the building if the building is not dense enough, thus transporting hot air to the outside. This could result in the increased need for heating during periods of cold weather.

2.2 Adaptation in the built environment

2.2.1 Flooding and increased precipitation

Technical measures

Elevating buildings and developments in relation to surrounding bodies of water is a proactive and planned adaptation measure that prevents flooding. The adaptation measure has already been implemented in the planning of large infrastructure projects in Denmark, where some metro stations have been constructed 30 cm above the original street level in order to avoid flooding (Fenger & Frich, 2002). It is also common that buildings in locations that are regularly flooded are built on stilts. This is, for example, the case in the Florida Keys.

In the absence of sufficient proactive adaptation, more acute measures, such as *pumping out water* and *temporary damming*, are necessary to protect buildings against flooding. Flood event damages will also require extra measures to be taken such as *increased maintenance and repair of buildings, ventilation* and *drying up* with the use of fans.

As precipitation increases in frequency, intensity and quantity, water conduits can temporarily be overloaded. To protect buildings from backflow of storm water, conduits can be equipped with *non-return valves or pumps*. *Increasing*

[7] This risk has not been discussed in relation to Swedish buildings (Maxe, personal communication).

pipe diameters, and regularly *cleaning and inspecting drainage and sewage systems* are other important means of preventing blockages and possible backflows (SCCV, 2007, p. 313). *Rainwater harvesting* can be used to capture and divert rainwater before it reaches the pipes (Shaw *et al*., 2007).

If snow loads increase, *building constructions may have to be strengthened*; an example of this would be using reinforced roof beams. Existing buildings that have not been adapted already or cannot be adjusted for increased snow loads could be equipped with *warning systems for sagging roof beams*.

Physical planning and infrastructure development

The most effective way to avoid flooding is to reduce exposure. The most effective way to do this is to *abstain from building in risk areas*. Here, physical planning at the local level plays an important role. The Swedish Planning and Building Act (Plan- och bygglagen, PBL) (1987:10) states that developments shall be localised to land that is best suited to the purpose. Since 2008, the Act also requires flooding and erosion risk to be considered in municipal detail planning and when issuing building permits (bygglov) (Gov. Bill 2006/07:122).

Avoiding building in risk areas is an option that is available when new developments and buildings are planned. However, measures also need to be taken in existing developments. Here *relocation*, i.e., moving developments further from the shore, may come out as an alternative adaptation measure. Other measures include making space for water by establishing more *green areas* (parks, green roofs, etc.) and *waterways* (see section 4). Green and blue areas have an absorbent function in the city and decrease the vulnerability towards flooding. Urban greening measures have been tried, for example, in Central Europe and Finland (Peltonen *et al*., 2005).

To reduce water flows, *water courses can be regulated* by different methods. Water can, for example, be transferred and discharged into other areas. By using alternative discharge areas it is possible to increase the retention and storage of surplus freshwater caused by excessive precipitation or overflow of rivers. This avoids flooding and can build up reserves of stored freshwater (Nillesen & van Ierland, 2006). The capacity for storing water can also be increased, for example, by remodelling dams (SCCV, 2007, p. 226ff.).

Modifying the use of buildings is another way of avoiding damages from flooding (SCCV, 2007, p. 272). For example, cellars and basements in high-risk areas can be used for purposes not susceptible to flooding and not for human habitation. In the future, it will be particularly important *not* to locate vital social services, such as emergency service centres and emergency rooms, in premises that are at risk of flooding. Several incidents of bad weather in Göteborg during the last year show that flooding can cause great damage to technical equipment that is kept in basements (in a fire station basement, in this example) (Sveriges Radio, 080302).

Policy and regulatory measures

Extreme weather events, such as floods, storms and landslides, can cause significant damage and large costs for building owners and/or insurance companies. As a response, insurance companies may raise their insurance rates for properties in risk areas or even decline to insure such properties. This means that in the future, as the climate changes, there is a risk that people who are not economically well off will be more vulnerable towards the effects of flooding, landslide and erosion, since they will not be able to pay for protective adaptation measures or increased insurance premiums.

Protective measures at the individual building level are today primarily taken by the property owners themselves. In the resent system, municipalities can apply for some funding via the Swedish Rescue Service Agency, but there is a long waiting time and not all property owners will be granted funding (Rydell, personal communication). Proposals have been raised from several political parties in Sweden to have the increased costs and financial risks shared among the entire population. The SCCV (2007, p. 604) confirms that there are deficiencies in insurance protection against natural disasters, but it also emphasizes that no special government assistance is needed. Instead, the Commission argues that private insurance coverage needs to evolve.

In other countries, *public funding/compensation schemes* for natural disaster damages, including climate change events, have been implemented (e.g., the Norwegian Natural Perils Pool). From a social justice perspective, it could be argued that society should intervene and assist property owners who are likely to suffer financially from climate change. This could, for example, be done through financing flood defences or by providing subsidised insurance, as in the case of the United States Federal Flood Insurance Program (Cooper & McKenna, 2008).

Communication and education

Building capacity in stakeholder groups involved in flood risk management is imperative for successful adaptation.[8] For example, stakeholder groups must have an understanding of the problems, roles and distribution of responsibilities involved in flood risk management (Ashley *et al*., 2007). Case studies have been carried out in the City of Bradford Metropolitan District Council, where capacity to respond to increased flood risk has been built through, for example, the establishment of local flood action plans (FLAP). Small community groups focused on the interest of the community have been formed to assist in alleviating flooding (Bradford Metropolitan District Council, 2008). *Regional cooperation* on issues concerning flooding, such as the regulation of flows or specific watercourses and other proactive measures against flooding, is also needed (SCCV, 2007, p. 274).

The SCCV (2007, p. 314) argues for additional *research on snow factors* to establish the need for changes to maximum snow load requirements for new buildings. However, since many buildings in Sweden were constructed according to older building codes, more active systems will be required, such as *warning systems for structures that will be negatively affected* (e.g., roof structures).

2.2.2 Erosion and landslide

Technical measures

Several technical measures exist for preventing erosion and landslide. Among the measures considered by the SCCV (2007, p. 284f.) are *soil nailing* and *planting vegetation*, which can be used along the sides of watercourses to strengthen the existing ground. Other measures include lowering *or limiting ground water pressure* and *draining moist areas* in order to decrease risk of landslide.

Technical measures that can be used to prevent coastal erosion include *creating barriers between the water and beach matter* that is susceptible to erosion, which can be accomplished by planting vegetation and using revetments (structures lining the shore to absorb the energy of incoming water); *controlling water movement and sediment flows* (e.g., using fins on the sea bed to direct

[8] Presumably, building capacity in stakeholder groups is also important when it comes to managing risks associated with erosion and landslide, increased temperatures and humidity and increased wind load.

water flows); and *reducing the energy of waves and currents* (e.g., by using breakwaters) (SCCV, 2007, p. 294ff.). Placing *artificial reefs* in the sea along the coastline is another measure that reduces the energy of waves and, hence, protects against coastal erosion. For example, reefs on strategic points have been considered for the Dutch coastline and are believed to drastically reduce erosion and even compensate for sea level rise (Nillesen & van Ierland, 2006).

Another considered measure is to *replace the sand that has eroded*. The sand will then be transferred from other areas or from the seabed. Transferring sand is a measure that is already taken in several countries, including Sweden, Holland and Denmark. According to a report from the municipality of Ystad, it is a measure that is expected to be used more frequently in the future (Ystad kommun, 2004).

Physical planning and infrastructure development

The SCCV (2007, p. 285) stresses physical planning as an important measure for adapting to and avoiding the negative impacts on human health and property of land collapse, landslide and erosion. As was noted in the case of flooding, a large part of this physical planning by local authorities could include *abstaining from building* in areas that are susceptible to these climate change impacts. *Relocation* is another alternative.

Regarding coastal erosion, the SCCV (2007, p. 295) emphasizes that adaptation must be viewed in a wider perspective based on the interests of society: “The point of departure ought to be that nature has its way in areas where there are no private or public interests or values at threat.” Hence, *letting nature has its way* is a possible response when no valuable assets are threatened, such as infrastructure, developments, and other areas worthy of protection.

Policy and regulatory measures

Supplementing the Planning and Building Act with an explicit mention of landslide as well as accidents, flooding and erosion is a way of making it easier to take the risk of landslide into account at an early stage of the planning process. Another regulatory measure that can be used to avoid material damages caused by coastal erosion is to *increase the shoreline protection area*. This adaptation measure has been implemented in Denmark, where the shoreline protection area has been increased from 100 to 300 metres (Fenger and Frich, 2002).

2.2.3 Increased temperature and humidity

Technical measures

Elevated temperatures and the resultant increased humidity run the risk of causing damage to buildings due to rot and mould, and will warrant *more frequent and thorough maintenance and repair* of buildings. This will probably involve higher maintenance costs. One way of keeping long-term costs down is to *use building materials that require little maintenance*, and alternatively, *developing new building materials*.

To reduce damage caused by moisture, *barriers to vapour* can be used to protect new buildings and when refurbishing existing ones. Another way of preventing moisture damage is to *check the moisture ratio regularly* during construction work. To counteract damage caused by mould, which can cause allergic reactions (see section 4), adequate *ventilation* is needed and *building foundations can be heated* with indoor air or fan heaters (Roberts, 2008; Boverket, 2007).

Higher temperatures increase the need for cooling, which introduces the risk of increasing greenhouse gas emissions if electrical cooling systems are used. To counteract this goal conflict, *window blinds* could be used to shade building interiors from the sun’s heat and glare. *Planting trees*, using *reflective surfaces* on buildings, using *shutters*, *green roofs* and *low energy cooling systems* are other options (Bourque & Simonet, 2008) (see also section 4.2.1). The need for mechanical cooling can also be reduced by *cutting internal loads*, i.e., the density or power output of lights and machines, and possibly by *lowering the density of occupants* (Roberts, 2008).

Policy and regulatory measures

Adaptation measures to meet a deficit in ground water levels and, hence, drinking water supply, include *temporal bans for use of water for irrigation* at times of water stress, *retrial permits for water use*, measures that *decrease water consumption*, and measures that *increase the number of water resources* (SCVV, 2007, p. 255; Maxe, personal communication). *Rainwater harvesting* is another useful method for conserving water by capturing rainwater that can then be used for irrigation or toilet flushing (Shaw *et al*., 2007).

2.2.4 Increased wind load

Technical measures

Increased wind loads will require preventative *reinforcement of buildings*. To endure storms, buildings need to have strong wall systems, solid roof constructions and surface materials that are readily attached to the construction (Roberts, 2008).

One possible measure to prevent damages from storm felling is to *plant deciduous trees* rather than coniferous trees near buildings. This could have a risk-reducing effect, since most storms occur in the October to March period of the year when evergreen coniferous trees typically cause more damage than deciduous trees if they are felled in a storm (Boverket, 2007).

2.2.5 Measures on an overarching level

Physical planning and infrastructure development

Many different actors are involved in the planning and management of buildings, and breakdowns in communication are common along the actor chain. To counteract such communication failures, the Three Region Climate Change Group (the tree regions of London, the east and the southeast of England) (2008) suggests that a *clear leadership* for adapting existing homes to climate change is needed. For example, policy makers, planners and businesses should play an active role in adapting households through campaigning and disseminating information about relevant adaptation measures.

Bourque and Simonet (2008) suggest that in the future, various *climate scenarios* should be considered when designing infrastructure. This is especially relevant since infrastructure projects such as buildings, often have a long life span and, hence, little flexibility and adaptability.

Policy and regulatory measures

The SCCV (2007, p. 571) proposes that the National Board of Housing, Building and Planning create *guidelines for the planning, location and elevation of new buildings and developments*, including sewer systems, with respect to the risks of flooding, landslides and erosion in a changed climate. The SCCV also suggests that the Board should *review central building regulations and alterations advice* so that they are adapted to climate change.

Communication and education

An important means of increasing the municipalities' knowledge about climate change and the effect it has on built environments is to *include issues concerning climate change into basic technical university and college education instruction* (SCCV, 2007, p. 610). Imparting such knowledge to university students will also contribute to future sound decision-making concerning mitigation and adaptation.

Early warning systems are of great importance in immediate adaptation responses. The SCCV (2007, p. 551) states that the possibilities of creating early warning systems for flooding, heat waves, oncoming droughts, storm-felling and intensive rainfall should be investigated by relevant authorities in collaboration with the Swedish government agency for weather forecasting and warnings (SMHI) (see also section 4).

In order to plan for adaptive measures maps should also be used. Hence, areas at risk of flooding, landslide and erosion should be surveyed; both general *mapping* and detailed mapping are needed (SCCV, 2007, p. 529ff.).

2.3 Goal conflicts

2.3.1 Technical measures

Technical adaptation measures to avoid flooding that involve the *elevation of buildings* from street levels, can compromise accessibility for disabled persons and thus make it more difficult to reach Sweden's national disability policy goals. However, since considerations for the disabled are included in existing building regulations, most notably the Planning and Building Act and the Act on Technical Requirements for Buildings etc., conflicts of this type are expected to be managed at an early stage in the adaptation planning process.[9]

[9] 3 kap 15 § Plan och bygglagen (1987:10) and 2 § lagen (1994:847) om tekniska egenskapskrav på byggnadsverk m.m. (BVL).

The elevation of buildings could also be problematic, at least theoretically, from a mitigation perspective. Elevating buildings could necessitate the installation of more elevators, which could increase energy use. If this holds true, the adaptation measure could conflict with the goal *Reduced climate impact* and the goal of reducing energy use (*A good built environment*).

Technical measures that protect buildings in the event of acute flooding, such as *pumping* and *damming*, and measures that are taken after a flood event has occurred, such as *restoring* and *renovating*, require energy and materials. Increased energy and material use can impose on the climate mitigation goal *Reduced climate impact*.[10] Restoration measures that include using fungicides can also impose on goals for reducing emissions to air and water, such as the goal *A non-toxic environment*.

Temporary *damming*, in order to prevent flooding of buildings, can be constructed by using sandbags or other materials. However, this practice may impose on goals concerning decreased extraction of natural gravel (one of the sub-goals of the environmental objective *A good built environment*). This potential conflict is not discussed in the latest evaluation of the sub-goal (Arell, 2007), but further competition over this resource could pose threats to target fulfilment. According to Karin Grånäs at the Geological Survey of Sweden (SGU) (personal communication), conflicts could arise depending on the location and amount of extraction. Furthermore, sandbags that have absorbed floodwater can pose a risk to human health, since they may be contaminated with sewage and other toxic substances. To avoid the spread of infection, sandbags must be properly disposed of after a flood event has occurred, and they cannot be reused on location (English Heritage, 2004).

Some structures for protection against coastal erosion, namely structures that are located at the beach to keep the sand in place (e.g., boulder-filled nets, cement carpets), can impede accessibility to the beach area and, hence, infringe on tourism and recreational values (Ystad kommun, 2004), thus negating the objective *A balanced marine environment, flourishing coastal areas and archipelagos*. Cooper and McKenna (2008) point at the negative effects of coastal defence structures for beaches and beachgoers; when the wide, sandy beaches that denote relaxation and enjoyment become compartmentalized, they are perceived as ugly and uninviting.

Some protective measures, such as *groins* (i.e., a pier-like structure built perpendicular to the shore), may increase sand accumulation but are expensive to build (Ystad kommun, 2004). Structures for reducing wave energy, such as

[10]A Swedish insurance company has calculated that on water damage events in buildings, on average 300 kg CO2 is emitted (per damage event) (ByggaBoDialogen, 2008).

artificial reefs, can have a negative effect on shipping and fisheries, but the inshore water effect may on the other hand promote tourism and recreational values (Nillesen & van Ierland, 2006).

The *replacement of sand* to counteract coastal erosion is a measure that needs to be taken repeatedly. Hence, there is a potential conflict with the goal *A good built environment* concerning decreased extraction of natural gravel. Furthermore, this measure is associated with high transportation costs, and thus implementing it could counteract GHG reduction targets, thereby negatively affecting the goal *Reduced climate impact*. Adding sand to coastal areas may also have negative effects on local benthic communities (Nillesen & van Ierland, 2006) and, hence, conflict with the objectives *A rich diversity of plant and animal life* and *A balanced marine environment, flourishing coastal areas and archipelagos*.

Measures that protect against erosion along watercourses often include using different technologies for preserving the shoreline. According to Morneau *et al.* (2001, as cited in Bourque & Simonet, 2008), bank protection methods that have been implemented in Québec (Canada) could cause significant environmental impacts as they alter sedimentation and increase erosion in unprotected areas. This is, or can also be, the case in Sweden. Ystad municipality has noted that protection measures against coastal erosion in one area (Löderup) may have caused the accelerating erosion in a close-by-area (Hagestad) (Ystad kommun, 2004).

If protective measures are implemented in a narrow planning perspective, this could have a negative effect on other goals and interests. For example, if individual lots are protected without adequate geographical considerations, this could cause increased erosion elsewhere and, hence, conflict with goals concerning the preservation of natural and recreational assets for that area (e.g., *Flourishing lakes and streams*, *A balanced marine environment, flourishing coastal areas and archipelagos*, and *A rich diversity of plant and animal life*) (Rydell, personal communication). This can also be said for protection against landslide; a too narrow perspective can cause problems for other environmental and recreational goals and conflict with the interests of neighbouring lots (Rydell, personal communication).

Measures that protect against erosion and landslide, such as *soil nailing* and *planting vegetation*, can be problematic if they involve intrusion on protected areas. In those situations, the measures can have negative consequences for goals concerning biological diversity and the protection of cultural heritage values (e.g., *A rich diversity of plant and animal life* and *A magnificent mountain landscape*).

Measures for controlling moisture in buildings include using heating and fans. These measures could increase energy use and thus conflict with the goal of climate mitigation (*Reduced climate impact*) and goals concerning energy use (*A good built environment*).

2.3.2 Physical planning and infrastructure development

Physical planning may be a successful way to avoid the consequences of flooding, erosion and landslide in built areas, but it can also make it more difficult to realize certain other goals and interests. Flood risk areas, as well as areas prone to erosion and landslide, are often close to rivers, lakes and the sea—areas that are usually considered attractive from an aesthetic and recreational perspective. Hence, abstaining from building in risk areas is a measure that could conflict with municipality development goals as well as the aesthetic and recreational interests of individual residents.[11]

However, just because shoreline developments are considered attractive and are typically inhabited by high-income residents does not mean this will always be the case. In the future, the opposite may hold true as flood risks are increasingly taken into consideration in the real estate market. Properties in risk areas may be less attractive and entail high insurance costs. For example, in some UK areas, the proportion of deprived residents who live in tidal floodplains (i.e., in potential flood risk areas) is higher than elsewhere (Walker *et al*., 2003). A development in which floodplains and other high-risk areas are inhabited mainly by low-income or otherwise deprived residents has important environmental justice implications. If governments choose not to subsidise the costs for damages or for insurance, then the inhabitants in risk areas are more exposed to risk, which can be in conflict with social justice goals (Cooper & McKenna, 2008). On the other hand, Cooper and McKenna (2008) argue that the issue can also be seen from a larger perspective. If risk areas are not abandoned, and the costs for protecting properties from flooding will be more expensive as sea-levels increase, the burden of these costs will be laid on future generations. Furthermore, future generations might be faced with the problems of abandoning these areas.

Directing flows to discharge areas in order to avoid overloaded sewage systems is an adaptation measure that could increase competition over land. Land is needed to satisfy the demand for food, fibres and energy, as well as for the fulfilment of environmental and recreational goals. Furthermore, directing flows

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[11] The present trend among municipalities is to be aggressive in developing shoreline areas, which is clearly in conflict with the need to avoid developments prone to flooding (SOU 2005:77).

to discharge areas could pose threats to natural and cultural elements that are considered valuable, and it could create conflicts with attaining environmental goals such as *Sustainable forests, A varied agricultural landscape and A rich diversity of plant and animal life*. It could also impose on the availability of areas for outdoor recreation and thus render it more difficult to accomplish public health goals concerning increasing physical exercise among residents.

2.3.3 Policy and regulatory measures

A *retrial of permits for water use* in order to counteract deficits in ground water levels means that actors are allowed to use less water for industry and irrigation. This can create conflicts with agricultural production and, hence, make it more difficult to reach environmental objectives relating to agriculture (*A varied agricultural landscape, A rich diversity of plant and animal life*). In addition, leading water through pipes requires energy and can counteract climate mitigation goals (*Reduced climate impact*).

2.4 Summary

Adaptation in the built environment is a complex area that involves decision-making by actors at multiple levels. As in the case of environmental decision-making generally, decision-making concerning adaptation in the built environment is complicated by a number of factors. Decisions often have to be made despite incomplete and uncertain scientific knowledge; furthermore, they have long planning horizons and sometimes have irreversible, or lock-in, effects.

Due to the uncertainties involved, decision makers may deem it preferable to postpone adaptation decisions until more information and knowledge have been obtained. However, such an attitude could produce irrational and unethical results; for example, if the particular climate change impact at issue is irreversible or catastrophic, or if subsequent adaptations are likely to be very expensive. Another argument that speaks in favour of taking immediate adaptive action is that several of the considered adaptation measures are expected to have important synergy effects for other public policy areas. Before proceeding with the next section, a few of them will be pointed out:

- At the building scale, decision makers can exploit synergies between flood risk management and energy conservation (Shaw/*et al/*., 2007). For example, green roofs can be used not only to store water and reduce the risk of flooding; they can also be used to regulate indoor temperatures and decrease the need for mechanical cooling.

- Abstaining from building in high-risk areas, such as areas that are close to the water, could make it easier for everybody to enjoy the coastline, thus benefiting goals and values associated with outdoor recreation.
- Taking action to combat landslides and coastal erosion is complex and involves many different types of knowledge. This could provide employment opportunities for many people and, therefore, contribute to the goals of the labour market.

3 Tourism and outdoor recreation

3.1 Effects of climate change on the tourism industry

Tourism is considered a highly climate-sensitive economic sector similar to agriculture, energy and transportation (UNEP, 2008).[12] Together with socio-economic factors, such as regional growth and transportation costs, future climate factors will shape tourists' choices of activities and destinations and contribute to creating international tourist flows that significantly affect the profitability of individual tourist enterprises (SCCV, 2007, p. 387). This holds true in particular for tourism linked to outdoor activities, such as swimming, walking, skiing and snowmobiling. The primary focus of this investigation is on nature-based tourism and outdoor recreation, and many important tourist activities, such as recreation linked to business travel and conference participation, are not explicitly dealt with.

In Sweden, adaptation measures will primarily be required to mitigate the negative effects of higher winter temperatures on the skiing industry and to take advantage of improved business opportunities resulting from higher temperatures in the summer. In the future, higher winter temperatures will affect the depth and duration of the snow cover and adversely affect the conditions for skiing and snowmobiling. Up to the 2020s, this climate change impact is projected to be most distressing for cross-country skiing and snowmobiling in low altitude areas, but over a longer span of time, all snow-based activities and all destinations are expected to suffer from the predicted decrease in snow cover.[13]

[12] In the literature, the terms 'tourism' and 'recreation' are usually given different interpretation. The UN World Tourism Organization defines tourism as "the activities of persons travelling to and staying in a place outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited" (www.world-tourism.org). Tourism is separated from recreation in that tourists often travel longer distances from home and usually spend one or several nights at their destination (Browne & Hunt, 2007).

[13] The minimum snow depth for cross-country skiing is around 10 cm. For some areas in Svealand and southern Norrland, by the 2020s, the snow depth is predicted to be less than 10 cm for more than half of the total number of days with snow cover (SCCV, 2007, p. 391).

In addition, summer temperatures (air and water) will be higher in the future. By the end of the century, September is expected to have around the same monthly average temperature as August has today (SCCV, 2007, p. 388). The water temperature in the Baltic Sea is predicted to be 2-4ºC higher during the summer than at present. Higher air and water temperatures significantly improve the conditions for outdoor activities, such as swimming, golf and camping. This means that there will be good opportunities for expanding the Swedish summer tourism industry in the future. This prediction is further supported by the expected future change in tourist flows from the Mediterranean to the Baltic region during the hottest months of the year.

Although adaptation in the summer tourism industry is primarily about taking advantage of improved opportunities, there are also potential threats that have to be taken into consideration. As the climate changes, there is an increased risk of coastal erosion and beach destruction, particularly in the south of Sweden (see section 2.1). Furthermore, higher water temperatures risk causing deteriorations in water quality, including more severe problems with algal blooms and bacteria in the water (see section 4.1). Finally, larger tourist flows could involve an increase in visitor pressure and result in crowding, heightened conflicts between different tourist activities and participants, and increased wear and tear on sensitive natural and cultural environments. If grave enough, these scenarios could significantly reduce the opportunities associated with climate change in the tourism sector.

3.2 Adaptation in the winter tourism sector

Technical measures

In the short term, *artificial snow production* is the dominant adaptation strategy for the winter tourism industry (OECD, 2007). Artificial snowmaking has been an integral part of the alpine ski industry for many years where it is used to supplement natural snow and to extend the skiing season. Around 65% of Swedish skiing establishments, except those in the most northern parts, already produce artificial snow (SLAO, 2008). Basically, artificial snow is produced by forcing water and pressurized air though a technical device—a snow cannon—onto ski slopes. Effective snow production requires access to large water pumps and air compressors that can be used to transport water from nearby lakes and watercourses to the snow cannon.

Snow grooming involves manipulating snow (such as moving and compacting it) by using a snow groomer vehicle (pistmaskin). Snow groomers are used after snowfalls or when snow has been dispersed through snow-making devices. The vehicle is then used to maintain and improve the status of ski slopes and trails by grooming the snow on them.

Instead of producing artificial snow, *ski establishments can be relocated* to higher altitudes or to areas further north in Sweden. Alternatively, ski establishments can be relocated so that they face north instead of south or south-west.

The production of artificial snow is primarily a means of adapting alpine skiing to climate change. For cross-country skiing and snowmobiling, artificial snow production is considered economically and technically impossible (Scott & Jones, 2006; McBoyle *et al*., 2007). Artificial snow can be used at specific locations and for limited periods, but it cannot be used to compensate for lack of snow in larger areas and during the entire winter season. For cross-country skiing, at least at professional levels, *ski tunnels* come out as a more realistic adaptation option. Since the temperature in a ski tunnel is constantly kept at a few degrees minus Celsius, ski tunnels make it possible to go cross-country skiing any time during the year. Today, there is only one ski tunnel in Sweden—the *Fortum Ski Tunnel* in Torsby.

As an alternative to ski tunnels, *cooltracks* (kylspår) can be used. Cooltracks are outdoor tracks that are made of artificial snow and kept at a temperature where the snow does not melt by using cooling coils in the ground. This means that it is possible to go cross-country skiing even when the temperature rises above zero Celsius degrees. Today, cooltracks can be found in Torsby and in Högbo/Sandviken.

Reduction in suitable snow conditions could motivate a *substitution of snowmobiles for all-terrain vehicles* (ATVs) (Scott *et al*., 2002). An ATV is like a motorcycle but with four wheels, which provides more stability at slower speeds. ATVs can be equipped with snow tires, making them operational in the winter season. In Sweden, ATV driving in the country is prohibited according to terrängkörningslagen (1975:1313), although exemptions can be granted by the county administrative boards. As an adaptation measure, substitution of snowmobiles for ATVs is therefore expected to be of limited significance in Sweden.

Ski tracks and ski slopes can be *sprinkled with road salt* to create good skiing conditions during mild weather. Salt can only be sprinkled during wet conditions, since if used at low temperatures the opposite effect will result; the salt will contribute to melting the snow (as in the case when roads are sprinkled with salt in the winter). Sprinkling can be used to keep exposed parts of a track or slope intact, for example, before a major skiing competition. However, this is not considered a realistic adaptation option for larger areas or for long-term use.

Physical planning and infrastructure development

An alternative way of adapting to climate change in the winter tourism industry is to develop new business models: for example, to *diversify tourist activities* or invest in year-round tourism. In mountain regions, where a large part of the Swedish skiing industry is based, there are good opportunities for offering alternatives to alpine and cross-country skiing. In this paper, three such alternatives are analysed: mountain biking, horse riding and wildlife watching. However, there are many other activities that could supplement the skiing industry, such as kayaking and canoeing, hiking, recreational fishing, rafting and hunting, etc.

Mountain biking is riding a bicycle, usually a specially equipped mountain bike, off-road, for example down a mountain slope. Among the most common types of mountain biking are downhill, cross-country, and trails riding. Sweden’s mountain areas already have biking trails, such as those in Sälen, but they are expected to become much more common and used more frequently in the future.

Many tourist operators are already offering *horse riding* in and outside mountain areas as a summer activity (e.g., www.ridiammarnas.com). Horse riding is sometimes combined with camping or an overnight stay in a hotel.

Wildlife watching is essentially an observational activity distinguished from other wildlife-based activities, such as hunting and fishing (UNEP/CMS, 2006). Many Swedish tourist operators already offer wildlife watching as part of their tour packages (Dagens Nyheter, 2007*a*). Most of these operators are offering tours where carnivores, for example, bears, wolves and eagles, are tracked and observed (e.g., www.swedenwildlife.se).

Policy and regulatory measures

Weather insurance and weather derivatives are financial instruments that are developed to reduce risks associated with ‘bad weather’ (for example, lack of snow and other unexpected weather conditions).

An alternative method of reducing the financial vulnerability to climate change in the winter tourism sector is to introduce *monetary compensation schemes* administered by the state. These compensation schemes could be uniquely tailored to individual tourist businesses so that when unfavourable weather conditions negatively threaten their profitability, these businesses would be granted monetary compensation (Bodén, 2007).

Communication and education

In the future, skiing conditions are expected to be even worse in the Alps than in the Swedish mountain areas. This provides an opportunity for the Swedish skiing industry to attract tourists that otherwise would have spent their vacation in the Alp regions. To take advantage of this opportunity, tourist operators and organizations could allocate further resources to *marketing Sweden as a tourist destination* abroad.

3.3 Adaptation in the summer tourism sector

As was pointed out above, adaptation of the summer tourism industry is primarily about taking advantage of the increased opportunities for regional development and economic growth that climate change involves. In the future, there will be plenty of opportunities for expanding the summer tourism industry. The discussion in this section is limited to adaptation measures associated with two such tourist activities, namely beach recreation and golf.

Technical measures

In order for the beach recreation and golf tourism industries to flourish there are a few areas of concern that must be addressed. Sea level rise in combination with more frequent weather events will increase the risk of coastal erosion and beach destruction. Successful development of beach recreation tourism requires that measures be taken to address these problems. Among the technical measures that can be taken to combat coastal erosion and beach destruction are creating physical barriers between the water and the beach matter, controlling water movements and sediment flows, and reducing the energy of waves and currents (see section 2.2.2).

In some places along the Swedish coast, long-term sustainable development of beach recreation tourism also requires that measures be taken to address deteriorations in water quality caused by more frequent algal blooms. Obviously, many different types of measures are required to combat leakage of nutrients and to *reduce algal blooms*. In Sweden, measures to address this problem are partly coordinated through the ‘40 Million Programme’ (40-miljonersprogrammet), which consists of 10 specified areas of action (Miljödepartementet, 2007). Among the measures that are proposed in the programme are restoration of marine environments through oxygenating, fishing out the European sprat (*Sprattus sprattus*) and restoring migration paths.

The golf industry is likely to benefit substantially from a warmer climate, with a prolonged golfing season and increased investment opportunities. However, the warmest climate change scenarios could produce challenges for the golf industry. Higher temperatures are likely to cause greater demand for *irrigation* to keep turf grass in shape. Warmer and more humid climate conditions could also contribute to greater problems with insect pests and turf-grass diseases, particularly in the summer months (Scott & Jones, 2006). To avoid these problems, *pesticides* (insecticides, fungicides, herbicides, etc.) may have to be used.

Physical planning and infrastructure development

In the future, competition for water resources is expected to cause severe conflicts of interest between different sectors in Europe (EEA, 2007). The tourism industry will be involved in these conflicts, since many tourist activities require access to clean water. Higher summer temperatures and less precipitation in the south-east of Sweden will create a greater need for irrigation of parks, golf courses and other recreation areas, which is likely to render it more difficult to achieve other goals whose realization are heavily dependent on access to water. Consequently, *measures that handle increased competition for water resources* will be required in the future. Efficient *land-use planning* is one measure that can reduce the risk of conflict surrounding diminishing water resources.

Policy and regulatory measures

In addition to land-use planning, policy and regulatory measures can be introduced to handle increased competition for water resources. Examples of such measures are *water pricing policies* and the *integration of water-related concerns into sectoral policies* (European Commission, 2007; see also section 2.2.3).

Communication and education

Allocating funds for marketing Sweden as a tourist destination could provide greater financial opportunities in the summer tourism sector. The international marketing of Sweden as a tourist destination could be accomplished through Visit Sweden or one of the other organisations by giving them overall responsibility for providing information about Sweden to other countries; examples of such organisations are the Swedish Government Offices (including the Foreign Ministry), the Swedish Institute, and the Swedish Trade Council.

Marketing measures could also be taken by local municipalities and private tourist businesses.

3.4 Goal conflicts

3.4.1 Technical measures

Artificial snow production is in many ways a problematic adaptation measure (OECD, 2007; Rixen *et al*., 2003). Water pumps and air compressors require large amounts of energy (electricity or diesel fuel). Depending on what source of energy is used, this could conflict with the environmental quality objective *Reduced climate impact*.

Furthermore, artificial snow production plants require water. Water can be pumped up from lakes and rivers in the vicinity or from ponds and high-altitude reservoirs that have been built close to the ski slopes. However, this practice is problematic because it runs the risk of negatively affecting the living conditions in the sources from which water is being pumped. Therefore, artificial snow production also conflicts with the objectives *Flourishing lakes and streams*, *A magnificent mountain landscape* and *A rich diversity of plant and animal life*.

Artificial snow production also runs the risk of adversely affecting human health and the conditions for outdoor recreation. Building new ponds and reservoirs on mountains could increase the risk of erosion, landslides and floods (Wahlström Novakovic, 2007), thus putting the health and safety of humans at risk. It also causes noise that could be disturbing for people living close to the snow production plants and for tourists who have travelled to the area to enjoy silence, thereby rendering it more difficult to satisfy goals concerning human health and the recreational values expressed in the goal *A magnificent mountain landscape*.

The practice of *snow grooming* has similar problems. For example, researchers argue that the compaction involved in snow grooming could reduce the porosity, permeability and water-holding capacity of mountain slopes (Fahey & Wardle, 1998). This, in turn, could produce longer and deeper frost penetration into the soil and have a negative impact on the underlying tussock.

Relocating ski establishments further north in Sweden, to higher altitudes, or to areas that face northwards could have negative consequences for biodiversity, landscape integrity, safety and outdoor recreation. For example, terrain modification during slope construction can encourage soil erosion, which inhibits or delays re-establishment of vegetation (Mosimann, 1985). Furthermore, the felling and removal of trees can alter flow conditions and increase the risk of erosion and avalanches (Pettersson & Svensson, 2005; SCCV, 2007, p. 394). Hence, the adaptation measure could conflict with the environmental objectives *A magnificent mountain landscape* and *A rich diversity of plant and animal life*, and with goals concerning human health and safety.

The management of ski tunnels and cooltracks is mainly problematic from a mitigation perspective. *Ski tunnels* require (artificially produced) snow and lighting—measures that could conflict with the objective *Reduced climate impact* if the required energy is produced through the combustion of fossil fuels.

Substituting snowmobiles with ATVs is in many ways a problematic adaptation measure. First, ATV driving is associated with land degradation, erosion and significant destruction in many ecosystems.[14] The tires of ATVs are constructed to be operational in rocky and muddy terrain. This means that they can easily damage snowmobile trails and other recreational trails, drain bogs and increase sedimentation in streams. In this way, ATV driving obstructs the achievement of the environmental objectives *Flourishing lakes and streams*, *Sustainable forests* and *A rich diversity of plant and animal life*. Furthermore, ATVs are run on fossil fuel, which means that using them makes it more difficult to reach the mitigation objective *Reduced climate impact*. Finally, ATV driving is associated with noise pollution, which could conflict with the objective *A magnificent mountain landscape*. The noise pollution and trail erosion caused by ATV driving also render it more difficult to reach recreational values safeguarded by that environmental objective.

Salt sprinkling is an adaptation measure that is intended to be used only to a limited extent, such as before important ski competitions. This speaks against it having severe negative impacts on the environment. However, should it be used in greater quantities, the increased soil salt levels could have negative effects on vegetation and groundwater. An example of a similar environmental impact can be seen in how the exposure to salt from roads has changed the composition of species in ditches (Scott & Davison, 1982; Vägverket, 2003). There is also evidence to support the claim that road salt can have negative effects on groundwater (Blomqvist *et al*., 2001). Hence, there is a theoretical possibility that this adaptation measure could render it more difficult to reach environmental objectives such as *Flourishing lakes and streams*, *Good-quality groundwater*, *A magnificent mountain landscape* and *A rich diversity of plant and animal life*.

[14] A comprehensive bibliography on the environmental and social effects of ATVs can be found in Stokowski and LaPointe (2000).

3.4.2 Physical planning and infrastructure development

A diversification of recreational activities could give rise to a number of ecological impacts that render it more difficult to reach the environmental quality objectives. Among the negative ecological impacts caused by mountain biking and horse riding are trampling and habitat disturbance, destruction, and fragmentation (Dale & Weaver, 1974; Weaver & Dale, 1978; Törn *et al*., 2009). Horse riding can also affect the composition of plant species and alter soil fungal regimes by adding urine and faeces to the environment (Newsome *et al*., 2002; Törn *et al*., 2009). These impacts could make it more difficult to reach the environmental objectives *A magnificent mountain landscape*, *Sustainable forests* and *A rich diversity of plant and animal life*.

On a general level, *diversification of recreational activities* linked to mountain areas could create severe conflicts of interest over land use (SCCV, 2007, p. 390). As the climate changes and the areas above the tree level decrease, so will available land for different activities diminish. This may increase the risk of conflict on many levels; conflicts may arise between individuals (who merely want to satisfy their personal recreational goals), the tourism industry (which needs to reach its economic goals), and reindeer herders (who have a unique set of economic goals of their own that need to be met).

The wildlife-watching tourism industry can have adverse effects on wildlife, thereby making it more difficult to reach the environmental quality objectives *A magnificent mountain landscape* and *A rich diversity of plant and animal life*. Unless properly managed, wildlife watching can cause physiological and behavioural changes in animals. For example, increased levels of stress hormones in the blood have been observed in wildlife that is subject to these types of tourist activities (UNEP/CMS, 2006). Among the behavioural changes observed are that animals spend less time on feeding and resting and more time on trying to escape disturbance.

Extensive investments in beach recreation activities could give rise to a number of goal conflicts as well as conflicts of interest. To begin with, an expansion of the tourist industry in coastal areas and lakesides causes enhanced pressure on sensitive natural and cultural environments, which could obstruct achievement of the environmental objectives *Flourishing lakes and streams*, *A balanced marine environment* and *A rich diversity of plant and animal life*. On a more general level, an expanding summer tourism industry consumes energy and natural resources and generates additional quantities of waste, which could inflict on the objective *A good built environment*.

A development of some types of water-based activities could render it more difficult for participants in other types of activities to reach their personal recreation goals. The development of motor boat driving could for example make it more difficult for fishers and paddlers to satisfy their personal recreation goals (Gramann & Burdge, 1981).

An expansion of the golf industry, which necessitates adaptation measures such as increased irrigation and the widespread use of pesticides, could have negative effects on the natural and cultural environment. Given below is a list of negative implications for the natural environment with the objectives that each result possibly negates in parentheses (Svenska Golfförbundet, 2000):

- increased emissions of CFCs from cooling systems and air conditioners, which could contribute to depleting the ozone layer (*A protective ozone layer*)
- increased emissions of nitrogen and sulphur dioxide from combustion and use of machines, which could contribute to increased acidification of land and water courses (*Natural acidification only*)
- increased emissions of nitrogen and phosphorus compounds from artificial manure of golf courses, which could contribute to increased eutrophication (*Zero eutrophication*)
- the frequent use of pesticides against fungi, weed and insects, which could have negative implications for human health and biological diversity (*A non-toxic environment*)
- more intense irrigation of golf courses, which is energy consuming and could have negative implications for groundwater quality (*Reduced climate impact*, *Good-quality groundwater*)
- more severe consequences of inadequate handling/disposal of waste, e.g., grass and other organic material, which could contribute to an increased leakage of nutrients and damage vegetation (*Zero eutrophication*, *A rich diversity of plant and animal life*)

3.4.3 Communication and education

Marketing Sweden as a tourist destination abroad could be a problematic adaptation measure from a mitigation perspective, since larger tourist flows cause increased emissions of carbon dioxide and thus make it more difficult to reach international and national mitigation targets (*Reduced climate impact*). This holds true in particular for tourists travelling longer distances by air.

3.5 Summary

It is clear that many of the adaptation measures that are under consideration within the tourism and outdoor recreation sector could give rise to goal conflicts if they were to be implemented. However, the opposite also holds true. Several of the suggested adaptation measures could support the achievement of the (environmental and social) goals that are under consideration in this report. Before turning to the next section, a few such synergies will be discussed briefly:

- On a general level, nature-based tourism, such as hiking, canoeing and wildlife watching, can increase public knowledge of and respect for natural and cultural environments and for animal life, thus affecting people's behaviour in such a way that it becomes easier to achieve the environmental quality objectives.
- Tourist activities, such as horse riding, can help to keep agricultural landscapes and old trails open. By doing so, biological diversity can be further protected and enhanced.
- Golf courses have been shown to enhance biological diversity such as by hosting small biotopes that contain dead wood, which can be used as food and shelter for many species (Berntsson & Lindström, 2006). Ponds and other constructed watercourses also provide a good living environment for a number of species that are protected by the law, such as Triturus (*vattensalamandrar*) and Odonata (*trollsländor*) (Dagens Nyheter, 2007*b*).
- Participation in recreational activities can help to promote human health and well-being, which makes it easier to achieve Sweden's national public health goals. In the future, the tourism sector must be suitably adapted to continue providing these benefits.

4 Human health

4.1 Effects of climate change on human health

In Sweden, climate change will affect human health primarily in two ways.[15] To begin with, one of the direct effects climate change will have on people's health will be in exposing them to health risks, such as heat waves, floods and other extreme weather events. Secondly, climate change will have indirect effects on people's health through altered dispersion patterns for infectious diseases, deteriorations in water quality and increased air pollution. Besides these direct and indirect effects on human health, the social and economic effects of climate change in other parts of the world, such as altered migration patterns, could have resulting effects on the Swedish healthcare infrastructure.

In the future, heat waves and other extreme weather events are expected to become more common, causing increased mortality and morbidity particularly among vulnerable groups. Among the groups that are most at risk are the elderly, people who suffer from pulmonary diseases, cardiovascular diseases or impaired kidney function, and people who are on particular medications.

Extreme weather events such as floods and hurricanes are also expected to become more frequent in the future, causing more numerous deaths and more severe injuries and psychological traumas. Extreme weather events will probably create more severe problems for healthcare and medical treatment, since damaged infrastructure (e.g., blocked roads and damaged electrical power lines) can paralyse ambulance transports and other emergency services. Among the groups that are particularly vulnerable to the direct and indirect effects of extreme weather events are elderly people living alone and people who are physically and/or mentally disabled.

Higher temperatures and altered patterns of precipitation could give rise to a longer and more intense pollen season. It could also result in new pollen producing plants spreading in Sweden. As a result, there is an increased risk of developing allergies toward pollen in the future. In addition, more frequent flooding could cause enhanced moisture load indoors, which could result in the proliferation of dust mites and microbes in air ventilations systems. This would

[15] Section 4.1 is largely based on the report of the Swedish Commission on Climate and Vulnerability (2007) and Rocklöv *et al.* (2008).

then cause an increased risk of developing allergies, asthma and other breathing problems.

Higher temperatures and increased precipitation could alter dispersion patterns for infectious diseases and cause the spreading of water-, food- and vector-borne diseases. For example, toxic algal blooms, which benefit from higher water temperatures, are likely to occur more frequently in lakes and watercourses, causing gastrointestinal problems and skin infections. Higher temperatures in the summer are also expected to increase the number of cases of food poisoning, as microorganisms generally grow more rapidly in food products that are not properly refrigerated.

In the event of floods and landslides, drinking water, bathing water and water for irrigation could be contaminated through the spread of toxic chemical substances and infectious agents. This could lead to more frequent outbreaks of water-borne diseases, such as VTEC (EHEC), Campylobacter and Giardia.

Higher temperatures in the winter are likely to benefit the survival rate for species that spread infections. It could also make it easier, for example, for ticks to find host animals, which would then enable them to increase exponentially. In Sweden, vector-borne diseases, such as Lyme disease and TBE, are among the diseases that will produce the greatest risks to human health because of climate change. Other vector-borne diseases that could spread to Sweden as the climate changes are visceral leishmaniasis and West Nile virus.

4.2 Adaptation in the human health sector

4.2.1 High temperatures

Technical measures

Air-conditioning is an effective means of keeping indoor temperatures comfortable. It is already widely used in the US to reduce heat-related morbidity and mortality (IPCC, 2007, p. 418). In the future, measures that decrease indoor temperatures, such as air-conditioning, will have to be taken in Sweden as well. Air-conditioning will be particularly important at hospitals, nursing homes, and other premises where elderly or ill people are staying, and should be introduced as standard in emergency, intensive care and cardiac departments (SCCV, 2007, p. 431). In other European countries, air-conditioning policies for institutions where the elderly and ill are staying are already under consideration. As an example, the French government recommends that institutions for the elderly be equipped with at least one air-conditioned room (Michelon *et al.*, 2005).

Awnings that are attached to the exterior walls of buildings are an alternative means of mitigating heat stress. Awnings prevent the sun from shining through windows and help to maintain a comfortable indoor temperature. This effect can also be reached by *planting trees* that shade exterior walls and windows.

Another way of mitigating the negative effects of higher temperatures is to use *cool roofs* and *cool pavements* (Akbari *et al*., 1999; Akbari, 2003). Cool roofs are roofs built from materials with high solar reflectance and high thermal emittance. On hot sunny days, they absorb and store less solar energy than ordinary low reflectance roofs do and are consequently not major emitters of heat into the urban atmosphere at night. In this way, they mitigate the urban heat island effect. Cool roofs also contribute to creating comfortable indoor temperatures, since they reduce the transfer of heat to the upper floors of buildings (Greater London Authority, 2006). By doing so, they also reduce the demand for mechanical cooling systems.

Cool pavements (parking lots, urban roadways, etc.) are pavements comprised of material with good water permeability and high solar reflectivity. As with cool roofs, they can be used to reduce urban temperatures. In addition, cool pavements can have ancillary environmental and safety benefits by acting as filters that improve water quality, by helping to reduce tire noise, and by increasing traction and enhancing visibility at night (thus enhancing safety) (Cambridge Systematics, 2005).

Urban heat island effects can also be mitigated through the construction of *green roofs*. As with cool pavements, green roofs have a number of ancillary environmental and health benefits. For example, green roofs:

- help to retain storm water and reduce runoff, and they have been shown to improve urban air quality by absorbing volatile organic compounds and other particles (Banting *et al*., 2005);
- provide valuable habitats for spiders, birds, butterflies and other insects (Johnston & Newton, 2004);
- insulate for unwanted noise and produce desired, natural ‘white’ noise, such as the sound of the wind moving through branches and leaves (Peck *et al*., 1999);
- make the urban environment more aesthetically pleasing, relieve stress, and in other ways foster psychological well-being for those who live or work close to them or in other ways have access to them (Banting *et al*., 2005).

Physical planning and infrastructure development

Tall buildings and narrow streets contribute to the urban heat island effect as they create ‘canyons’ that prevent heat from escaping at night. *Open spaces between buildings* help to reduce the urban heat island effect and can be used as a means of mitigating the negative health effects associated with high temperatures (Smith & Levermore, 2008).

Promoting *green and blue infrastructure* in the construction of individual buildings and neighbourhoods is another means of reducing urban temperatures and therefore mitigating the negative health effects of heat stress (Gill *et al*., 2007; see also section on green roofs). Green areas also provide storage and infiltration capacity during extreme weather events and play an important role in the mitigation of climate change (McEvoy *et al*., 2006).

Policy and regulatory measures

Having *adequate emergency response services* in force is of central importance in reducing the negative health effects of heat waves (and extreme weather events). A successful emergency response programme can provide individuals and communities with appropriate health care and social services during and after the occurrence of a heat wave. For such a programme to be successful, however, the existing health infrastructure may have to be retrofitted. For example, the number of staff and beds available in hospitals during heat waves, flooding, etc. may have to be raised and training may have to be provided for health care service personnel.

Another important risk-reducing measure during heat waves (and other extreme weather events) is to *check up on vulnerable groups* of people, particularly elderly people living alone and people with physical and mental disabilities. Established contact schemes for vulnerable individuals can, for example, be part of an extreme weather alert plan administered by the state (see below), but it can also be a measure that is taken by non-profit-making organizations on a voluntary basis.

During heat waves and other prolonged periods of hot weather, *working schedules may need to be adjusted* to avoid exposure to heat stress. This is particularly important for workers who are directly exposed to heat and sunshine. Other measures that can be taken to avoid exposure to heat stress include *waiving user fees* for beaches, pools, etc. and *extending opening hours* for libraries, shopping centres, community centres and other facilities where people can cool off during hot weather.

Communication and education

A *heat-wave warning system* is a system that uses meteorological forecasts to initiate public health interventions designed to mitigate the harmful effects of high temperatures on human health (Kovats & Ebi, 2006). *Heat-wave emergency plans* usually describe different interventions depending on the confidence of the heat-wave forecast, ranging from issuing general advice to the public and health care professionals to distributing fans and keeping in contact on a daily basis with at-risk individuals living at home. Heat-wave warning systems and heat-wave emergency plans have already been adopted in several other countries (Table 4.2).

Public education campaigns and other risk communication activities can give citizens the necessary tools to handle the health risks of climate change in a well-informed way. Among the benefits of risk communication are improved individual and collective decision-making and increased coordination between different levels of government and between diverse interest groups. In the case of extreme temperatures, public education campaigns could involve publicizing precautions to take during heat waves, such as wearing lightweight clothing and drinking lots of water (Health Canada, www.hc-sc.gc.ca).

4.2.2 Extreme weather events

Technical measures

To counter the negative effects of extreme weather events on human health, many different adaptation measures will have to be taken at different points in time. To begin with, short-term emergency measures will have to be taken in situations where there is substantial risk of harm to human health and property (see also sect. 2.2.2). For example, *sandbags* (i.e., sacks that are filled with soil or sand) may have to be used to control flooding. In the event of storms, *storm shelters* can be opened. Storm shelters are particularly important for people whose homes run the risk of being severely damaged during extreme weather events and for homeless people who may have nowhere else to go.

In addition, more long-term technical adaptation measures will have to be taken, such as the *construction of seawalls*, the *strengthening of building constructions*, and the *reinforcement of drainage and sewage systems*. Section 2.2 contains a thorough discussion of seawalls and other technical adaptation measures that can be used to mitigate negative effects of flooding and erosion.

Physical planning and infrastructure development

Wetlands reduce society's vulnerability to the negative effects of climate change by helping to filter pollution, recharge groundwater and water supply, and control erosion (Hartig *et al*., 1997). Wetlands are also important buffers against flooding (SCCV, 2007, p. 397). For example, wetlands in the form of mangrove forests can protect freshwater from saline intrusion and maintain the resilience of natural coastal defences in tropical areas (www.wetlands.org). Hence, *developing new wetlands* and protecting already existing wetlands through policy and regulatory measures could be a means of increasing society's resilience to flooding and other negative climate change effects.

As was noted in previous sections, *green and blue infrastructure* can also be used to moderate the negative effects of flooding by providing storage and infiltration capacity during heavy rainfalls.

In the case of flooding and landslide there is an increased risk of harmful pollutants such as metals, organic substances and contagions being dispersed in the environment (SCCV, 2007, p. 315). An important step towards preventing floods and landslides from causing negative effects on people's health is to *chart animal graves, industrial lands and known dumps* that are infected with anthrax.

Policy and regulatory measures

Section 2 contains a discussion of the policy and regulatory measures that may have to be taken in response to flooding and other extreme weather events, such as restrictive land use zoning and modification of building codes.

Communication and education

As with heat-wave warning systems, *extreme weather warning systems* can be used to maximize the probability that people at risk will take appropriate measures to protect themselves (Health Canada, 2008). Several international conferences have emphasized the importance of well-functioning early warning systems for reducing the health risks associated with extreme weather events, for example, the Third International Conference on Early Warning (www.ewc3.org) in 2006. Early warning systems not only reduce mortality and morbidity; they also reduce the negative impacts on central economic sectors, such as agriculture, construction and shipping.

Extreme weather warning systems can be found in many parts of the world. For example, Canada has a federal thunder and lightning warning system in force. Whenever there is a risk of severe storms, Environment Canada issues a weather warning (Health Canada, 2008). In the UK, the Environment Agency provides flood warnings online 24 hours a day.[16] The Agency's online Flood Warning Service shows the current flood-warning situation for England and Wales. The agency also administers a 'Floodline' and offers a free service—Floodline Warnings Direct—that provides flood warnings directly to people via telephone, mobile, email, SMS text message, fax or pager.

As in the case of heat waves, *public education campaigns* concerning extreme weather events enable people to take informed decisions concerning risk-taking and risk exposure. Education campaigns can include information about natural disasters as well as publication of precautionary actions, such as what to do in the event of flooding or landslide.

4.2.3 Altered air quality

Technical measures

One of the most important adaptation measures that will have to be taken to counter the negative health effects associated with enhanced moisture load indoors is *ventilation*. Ventilated air is primarily delivered through a mechanical system that heats, cools, humidifies or dehumidifies the air inside a building. However, air can also be delivered to an indoor space by natural means (natural ventilation).

Physical planning and infrastructure development

As noted above, *urban greening* measures (e.g., the establishment of green roofs) can be used to reduce the negative health effects that are associated with poor air quality.

Policy and regulatory measures

In the future, different materials may have to be used in housing and workplaces to manage moisture problems. According to the SCCV (2007, p. 438), the

[16] More information about the UK Flood Warning Service is available at: http://www.environment-agency.gov.uk/subjects/flood/

National Board of Housing, Building and Planning should *take into account the problem of moisture when issuing building regulations and recommendations*. Section 2.2.3 contains a more thorough description of the adaptation measures that may have to be taken to counter the problem of increased moisture loads indoors.

Communication and education

Air pollution is expected to increase slightly because of climate change (Rocklöv *et al*., 2008). However, it is a little uncertain whether this slight increase in air pollution will require any particular adaptation measures. Should air pollution become a more serious threat to human health in the future, one possible adaptation measure could be to adopt *smog alert warning systems* and *smog alert response plans* that reduce risk in much the same way as heat-wave warning systems and extreme weather warning systems (Health Canada, www.hc-sc.gc.ca).

Smog alert warning systems are already in force outside Sweden. For example, in Ontario, there is a notification service called "The Smog Alert Network" that provides warnings of poor air quality.[17] The service issues three kinds of smog notifications: smog watch (issued when there is a 50 per cent chance that smog levels will be high within the next three days), smog advisories (issued when there is a strong probability that high smog levels will occur within the next 24 hours) and termination notices (when the smog advisory is over).

Public education campaigns can be used to inform the public about the dangers of smog, just as they are for heat waves and extreme weather events. These air quality campaigns can include the distribution of information about what precautions to take during a smog event or during pollen seasons.

4.2.4 Spread of infection

Technical measures

To counteract the increased risk of spread of infection, more *effective treatment of drinking water* may have to be introduced, such as multiple barrier approaches with emphasis on source-water protection.

[17] More information about The Smog Alert Network is available at http://www.airqualityontario.com/alerts/signup.cfm

One way of managing vector-borne diseases spreading through mosquitoes is to *control disease vectors* through biological or chemical larvacides (Health Canada, 2008). Since mosquitoes need water to breed, another mosquito management technique is to reduce the existence of standing waters, for example, by large-scale engineering and management of marsh water levels or by simple actions such as regularly emptying the water in rain barrels, birdbaths and fountains.[18]

Measures to counter toxic algal blooms are considered in section 3.3.

Physical planning and infrastructure development

Appropriate *land use and management of livestock* are important means for reducing the contamination of water and thus eliminating water-borne diseases in humans. Examples of good agricultural practices are to prevent run-off from fields and not to apply slurry when rain is expected. Establishing greater distances between bathers and grazing animals, fencing livestock away from streams and providing them with alternative sources of water are other means of preventing the spread of certain water-borne diseases (SCCV, 2007, p. 445).

Climate forecasting offers an opportunity for local and regional planners to design and manage water infrastructure (e.g., reservoirs, floodways and sanitation systems) in a way that proactively addresses the health risks associated with extreme weather events and spread of infection.

Policy and regulatory measures

In the future, *agriculture may have to be managed differently* in order to mitigate the negative effects of climate change on food safety. As competition over water resources escalates, re-using wastewater for irrigation will probably become a more common agricultural practice (IPCC, 2007, p. 418). This could have severe implications for human health, since irrigation is an important determinant of the spread of infectious disease. To prevent negative effects on human health, *stricter water-quality guidelines* for wastewater irrigation will be needed.

The increased risk of the spread of infectious diseases will also require *stricter surveillance policies and regulations*. More frequent testing and monitoring of

[18] More information is available at: http://www.epa.gov/pesticides/health/mosquitoes/index.htm.

beaches is a step that can be taken toward managing the health risks associated with higher water temperatures and more precipitation.

Vaccination can be a way of preventing mortality and morbidity associated with infectious diseases. For some diseases (e.g., Lyme disease), vaccines are already available, but for others they need to be developed and tested. For some diseases that could become more frequent as the climate changes, risk information and vaccine recommendations may need to be updated.

Communication and education

Warning systems can also be developed for algal blooms. Warning systems that predict the timing and magnitude of algal blooms are particularly useful for coastal managers, health officials, fishers and tourist operators. However, they are also useful for private individuals, such as when they plan their holidays and other recreational activities.

Engaging in public health education activities can be a means of preventing the spread of infection through food. Such activities can include *information to consumers about basic hygiene and food handling* and information to producers about food production and food storage processes (Commonwealth of Australia, 2007).

Public health messages containing advice as to how to dress and behave to avoid mosquito bites is a way of preventing people from catching vector-borne diseases from that insect. Wearing clothes, avoiding outdoor activities at dusk and dawn, and using mosquito repellents are efficient means whereby people can protect themselves from these diseases. Tick bites and tick-borne infections can be similarly avoided by checking for ticks on the body and on one’s clothing after being in tick habitats (Health Canada, 2008).

Permanent residents and summer residents with private water supplies will likely need more *information about the risks of poorer water quality* to avoid contracting water-borne diseases. In Sweden, such information can be supplied by the National Board of Health and Welfare and the Geological Survey of Sweden (SCCV, 2007, p. 445).

Personnel within the healthcare field and veterinary personnel may need further *training* concerning infectious diseases. As in the case of heat waves and extreme weather events, education and training are important means of strengthening the public health infrastructure.

4.3 Goal conflicts

4.3.1 Technical measures

Using *air-conditioning* and other mechanical cooling facilities could lead to an increase in carbon dioxide emissions to the atmosphere, for example, if electricity is supplied by coal-powered plants (Hacker *et al*., 2005). This also holds true for *mechanical ventilation systems*. Air-conditioning and mechanical ventilation are therefore problematic adaptation measures from a mitigation perspective (*Reduced climate impact*). Mechanical cooling also produces waste heat to the environment surrounding the building, which could intensify the urban heat island effect and make it harder to reach goals concerning human health and well-being (Smith & Levermore, 2008).

Widespread use of air-conditioning and other mechanical cooling facilities also places an increased strain on the existing energy supply infrastructure (Greater London Authority, 2006). Theoretically, introducing air-conditioning on a large scale could cause electricity shortages in other sectors and could render it more difficult to reach environmental, economic and social goals that can only be achieved by consuming electricity.

Installing and running air-conditioners could be expensive, depending on the current price of electricity. This could raise some important social equity issues, since people in poor quality buildings may not be able to afford to buy and run an air-conditioner (Greater London Authority, 2006). To avoid enforcing social segmentation, municipalities may have to assure that economically less advantaged people have access to supplementary adaptation measures; alternatively, the local government may have to provide some form of economic assistance to those in need of air-conditioning installation.

To avoid negative effects on the goal of mitigation, other technical adaptation measures can be chosen, such as using awnings, planting trees, using reflective surfaces on buildings, using shutters, green roofs and low energy cooling systems (Bourque & Simonet, 2008). The need for mechanical cooling can also be reduced if summertime heat gains to spaces are limited. This could, for example, be accomplished by reducing the power output density of lights and machines and possibly by lowering the density of occupants (Roberts, 2008).

Although *awnings* and sun screening are energy-efficient alternatives to air-conditioning, they are associated with other problems. In some built areas, particularly those that have a high historic value, awnings and other facilities attached on the walls or roofs of buildings are not allowed or are only allowed as an exception. As an example, according to a proposed building regulation (byggnadsordning) for the city centre of Visby, awnings should be avoided to the greatest extent possible (Gotlands kommun, 2008). The proposed building regulation requires that whenever awnings are considered necessary as sun visors they should be placed over individual windows and not over the entire front of a building. As the example illustrates, using awnings in adaptation could inflict on cultural heritage values expressed through the environmental objective *A good built environment*.

As described above, *cool* (high-albedo) *pavements* absorb less heat than darker pavements and therefore stay cooler. However, in places where people will be exposed to the reflected radiation for long periods (e.g., in playgrounds) they may not constitute an appropriate adaptation measure (Cambridge Systematics, 2005).

As was indicated above, *green roofs* have a wide range of beneficial effects on the environment and on people's health. However, there are also difficulties relating to the use of green roofs (see also the discussion on urban greening below). For example, green roofs can increase the risk of fire hazards, and they can contribute to increased levels of pollen, leaves and dirt on mechanical units (Peck *et al.*, 1999). Furthermore, when constructing a green roof, the relationship to other buildings in terms of wind and shading must be considered to avoid conflicts between different property owners.

There are also cost-based barriers associated with the construction and maintenance of green roofs. Savings that arise in the public health system as a result improved air quality or improved storm water containment are easily overridden by the immediate costs borne by individuals and private businesses. It can also be quite expensive in terms of money and labour to maintain a rooftop garden properly so that it continues to deliver the environmental and health benefits accounted for above.

Using pesticides and other chemicals to combat and control disease vectors can release toxins into the environment, rendering it more difficult to achieve environmental objectives such as *Clean air* and *A non-toxic environment*. Pesticides also have negative effects on human health.

4.3.2 Physical planning and infrastructure development

Arranging buildings and transportation routes in a way that allows for sufficient ventilation and the escape of excessive heat is an adaptation measure that is difficult to apply in high-density cities that have already been built. Efforts to provide *open spaces between buildings* can also make it more difficult to reach other environmental, economic and social goals. Less dense environments tend to be more scattered, creating longer distances between different city areas. Longer distances could mean longer transportation routes, which, in turn, could give rise to increased carbon dioxide emissions, more severe air pollution, and increased traffic noise. Hence, the adaptation measure could render it more difficult to reach certain environmental objectives such as *Reduced climate impact*, *Clean air* and *A good built environment*.

By creating longer distances within the city, the adaptation measure could also contribute to social fragmentation and loss of the sense of community and belonging. In sprawled living environments, people usually spend more time on travelling to work, going shopping, running errands, and thus it is more difficult for people to meet their neighbours. Sprawled living environments simply tend to be less conducive to social interactions.

Urban encroachment also tends to create land use conflicts at the urban-rural fringe. Settlements that are allowed to spread can cause loss of important farmland, rendering it more difficult to reach food and biological production goals (*A varied agricultural landscape*). They can also damage or make wildlife habitats more fragmented, which means that certain species will find it difficult to survive (*A rich diversity of plant and animal life*). Moreover, urban encroachment can inflict on important recreation values, rendering it more difficult for people to exercise or simply enjoy the nature that surrounds their living environment.

As described above, increasing the proportion of green areas in cities and other urban areas is a well-documented means of mitigating the negative health effects caused by heat waves, flooding and deteriorations in air quality. However, even *urban greening* is not a straightforward adaptive measure, since it can give rise to negative effects on other environmental goals and on goals concerning the protection of human health. As in the case of open spaces between buildings, larger proportions of green surfaces tend to create longer distances to services and facilities (Reneland, 1999), which means that this adaptation measure faces the same difficulties as the ones described above.

Another difficulty that has to be taken into consideration is that some species of trees (for example pine (Pinus spp.), oak (Quercus spp.) and willow (Salix spp.) (Bolund & Hunhammar, 1999) are associated with the emissions of ozone precursors, i.e., biogenic hydrocarbons, which lead to increased local and regional formation of ground-level ozone (Air Quality Expert Group, 2007). Whenever these trees are planted, there is therefore a theoretical possibility that they will make it harder to reach sub-goal 3 (ground-level ozone) of the environmental objective *Clean air*.

Yet another difficulty associated with urban greening measures is that green areas could harbour animals that serve as reservoirs for infectious diseases, such as Lyme disease and the West Nile virus (Daniels *et al.*, 1997). By doing so, these green areas could theoretically make it more difficult to reach goals concerning the protection of human health.

4.3.3 Policy and regulatory measures

Goal conflicts that arise due to more restrictive land use zoning, modification of building codes and regulations/recommendations that take into account the problem of moisture are discussed in section 2.3.

4.3.4 Communication and education

Heat-wave warning systems are usually considered effective in reducing deaths during heat waves if they are accompanied by specific health interventions and if they undergo continuous evaluation (IPCC, 2007, p. 416; Kovats & Ebi, 2006). However, the interventions that are prescribed in a heat-wave plan (and similar plans) could, at least hypothetically, render it more difficult to achieve other goals. For example, social equity problems could be reinforced if home outreach to vulnerable persons is mostly performed by groups of people that are themselves vulnerable or in some sense disadvantaged in society, such as elderly women or those with low income (see also section 5.3.2). This also holds true for other adaptation measures, such as extending the opening hours of libraries, swimming pools and shopping centres.

As noted above, *public education campaigns* can be used to raise awareness of health risks associated with climate change and to induce risk-reduced behaviour. However, to reach its designated ends, public education campaigns must wisely balance the risk of harm to human health against the risk of upsetting people unnecessarily. Too much information in low-risk situations can cause ‘warning fatigue’ by the time the risks have materialized (Australian Greenhouse Office, 2007). In those situations, the education campaign can become self-defeating; the more information that is provided, the less people are prepared to change their actual behaviour. When this happens, the proposed adaptation measure will in fact render it more difficult to reach the goal of protecting people’s health.

4.4 Summary

This section shows that there are close connections between adaptation in the human health sector and adaptation in the built environment. Many of the adaptation measures that are taken to protect buildings and developments from the negative impacts of climate change are also adequate responses when it comes to mitigating harm to human health. As in the case of adaptation in the built environment, adaptation in the health sector is a complex task that involves decision-making by many different actors, as well as significant uncertainties and long time lags.

Also in the human health sector, there are important synergies that could motivate decision makers to take adaptive actions. As noted in section 2.4, decision makers can exploit synergies between adaptation in the human health sector, energy conservation and flood risk management. For example, green roofs not only help to regulate indoor temperatures, facilitating the achievement of energy conservation goals and goals concerning human health and well-being. They also store water, slow run-off and protect against flooding of valuable buildings and developments. Other examples of synergies in the human health sector are:

- Development and protection of wetlands not only protects against flooding; they are also important in protecting biological diversity, and they contribute to the achievement of the environmental objectives *Thriving wetlands and A rich diversity of plant and animal life.*
- Providing adequate emergency response services to meet changes in climate provides an opportunity to revise and improve general risk management practices and methods.
- Urban greening measures not only reduce the health risks associated with high temperatures, flooding and altered air quality. They also contribute to creating more aesthetically pleasing urban environments and help to protect biological diversity in cities (thus, *A good built environment and A rich diversity of plant and animal life*).

5 Gender aspects

In general, adaptation to climate change is of great importance to people regardless of sex, ethnicity, age, religious affiliation, or any other designation. Concerning gender specifically, many adaptation measures are also equally beneficial to men and women. Sometimes, however, adaptation measures may have negative implications for gender equality that need to be taken into account when choosing between different options. Unless properly designed, adaptation measures can contribute to preserving gender-based distributions of power and thus further solidify stereotypical gender roles. When this happens, adaptation makes it more difficult to achieve the goal of gender equality. This section contains a brief discussion of the conflicts that could arise between the adaptation measures that are identified in this report and the goal of gender equality.

5.1 The built environment

Many of the adaptation measures that are proposed for the built environment have no apparent implications for gender equality. For example, this holds true for measures such as regularly cleaning and inspecting drainage and sewage systems, soil nailing, and replacement of eroded sand. However, there are measures that could affect the needs and opportunities of men and women differently and, hence, have consequences for gender equality. This applies in particular for measures involving physical planning and infrastructure development.

Physical planning is an instrument of force that has great potential to affect people’s everyday lives. Whereas some planning proposals are successful in paying attention to the needs and opportunities of women and men, and thus contribute to creating a society that is truly equal in terms of gender, others fail to do so. This applies to municipal comprehensive planning (översikts-planering) and municipal detail planning (detaljplanering). The following sections discuss two ways in which physical planning can affect gender equality: by obstructing (facilitating) women’s accessibility and by decreasing (increasing) the safety and security of women.

5.1.1 Accessibility

Because of the gendered division of labour, men and women generally use public space in different ways. Women tend to work closer to home and are more often employed part-time (SOU, 1997:35). Women also have different travel patterns to men; women generally make shorter and more frequent journeys at off-peak hours (to collect children from school, to do household businesses, etc.), whereas men make more work related travels (Carlsson-Kanyama, *et al.*, 1999). This means that, at a group level, women and men live their lives in partly separate spheres in terms of locations and activities (Andersson, 2005). Associated with these differences are divergent needs and preferences concerning the planning of the built environment and the construction and design of neighbourhoods and dwellings.

Women's lives are typically facilitated when cities are planned in a way that makes it easy to reconcile different types of activities, specifically work, domestic care and leisure. Therefore, integrating the city's many functions (funktionsintegrering) is a commonly suggested method of redressing gender inequalities in the built environment (Greed, 1994; OECD, 1995; Länsstyrelsen i Stockholms län, 2007). Different types of activities or functions within the city can be reconciled, for example, by mixing residential, industrial and commercial areas, or by building more densely so that work places and services are located closer to people's homes (Bofast 8/2006). Another way of facilitating the reconciliation of production and re-production is to plan cities according to a grid pattern, which promotes the flow-through of people and traffic and usually results in more numerous service institutions (Boverket, 2006).

Men's and women's different experiences and preferences regarding the built environment also need to be considered in adaptation planning. Before deciding on an adaptation measure, such as increasing the number of blue and green surfaces in the city or relocating a shopping centre or a bus stop, decision makers ought to consider if and how the measure works to reinforce existing gender-based power distributions. Examples of questions that planners and decision makers should reflect on as part of the adaptation decision process are as follows (Boverket, 2006):

- In what ways does the adaptation measure alleviate or reinforce the prevailing gendered division of labour?
- To what extent is the adaptation measure expected to have an impact on the travel patterns of men and women?
- In what ways does the adaptation measure affect the preferences that men and women have concerning the design and construction of their dwellings (e.g., kitchens, cloakrooms and recycling stations)?
- In what ways does the adaptation measure affect the preferences that men and women have concerning their living environments (e.g., parking lots, plantations and neighbourhoods)?

- In what ways does the adaptation measure affect the preferences that men and women have concerning green and blue infrastructure?
- In what ways does the adaptation measure affect access to vital public services, such as shopping centres, day nurseries and schools?
- To what extent does the adaptation measure obstruct or contribute to mixed forms of housing in all parts of the city?

5.1.2 Safety and security

Physical planning is also an important means of addressing gender inequalities in terms of safety and security. In general, women more often than men take safety and security precautions when engaging in outdoor activities at night (Brå, 2008). This means that a carelessly designed built environment can have a particularly limiting impact on women's freedom of movement. This fact should be taken into consideration in planning and decision-making concerning adaptation to climate change. Before deciding on an adaptation measure, such as planting trees near an office area to reduce heat stress, the measure's potential impacts on the safety and security of women need to be considered.

Examples of questions that planners and decision makers ought to reflect on as part of the adaptation decision process are as follows (Boverket, 2006):

- To what extent have safety and security aspects been discussed in relation to proposed urban greening measures?
- To what extent have open solutions and transparent materials been used when relocating old or building new elevators, stairwells, bus stops, car parks, etc.?
- To what extent have safety and security aspects been considered when adapting buildings to climate change?
- To what extent has lighting been used to reduce discomfort associated with the insecurity many women feel walking in a darkened area?

5.1.3 Equal representation in the planning process

On the assumption that equal representation in the decision-making process is a means of redressing distributional gender inequalities, the argument could be made that both men and women ought to be involved in the planning process. Today, physical planning (in particular comprehensive planning) and infrastructure development are activities that are associated with men and male interests (Boverket, 2006). Studies show that most civil servants responsible for planning are in fact male (Friberg & Larsson, 2002). Male dominance is also common in consultation processes (samrådsprocesser), which are important means of collecting viewpoints on planning proposals. Several tools and methods could be used to make sure that gender aspects are integrated into

physical planning; for example, by using checklists[19], the 3R method[20], and social/gender impact assessments (Boverket, 2006). These tools and methods could also be used to integrate gender aspects into planning and decision-making concerning adaptation.

5.2 Tourism and outdoor recreation

As in the case of the built environment, many of the adaptation measures that are proposed in the tourism and outdoor recreation sector are gender-neutral in the sense that, unless specific circumstances prevail, they have no apparent implications for gender equality. However, several of the proposed measures could have negative consequences for gender equality if they are not designed properly. Below, a few examples are provided as to how adaptation of tourist activities and destinations could work to reinforce existing gender-based distributions of power.

To begin with, adaptation could result in the exclusion of low-income groups, such as single mothers with children, from participation in certain tourist activities. Many adaptation measures in the tourism sector, such as using artificial snow and relocating ski establishments, require large financial investments. In the end, individual tourists will have to pay for the investments in the form of raised fares and increased transportation costs. To counter social exclusion (if that is considered a goal), governmental policies may have to be introduced to provide people, regardless of income status, with an opportunity to participate in tourist/recreational activities. For example, policies could address pricing by including differential fares for different groups (UNEP and UNWTO, 2005).

[19] Checklists for how to include gender aspects into physical planning have been developed by several Swedish county administrative boards: Örebro (Länsstyrelsen i Örebro län, 2004), Dalarna (Länsstyrelsen i Dalarnas län, 2001), Halland (Länsstyrelsen i Hallands län, 2004), Östergötland (Länsstyrelsen i Östergötlands län, 2005) and Skåne (Länsstyrelsen i Skåne län, 2000), and by some local municipalities, such as in Uppsala (Uppsala kommun, 2001).

[20] The 3R method is a tool that can be applied to analyse gender aspects of an organization, activity or policy proposal. The 3R method starts out by asking three questions: (1) How is gender distributed among decision makers, those who work in the organization and those who are affected by the activity/policy proposal? (Representation); (2) How are resources, such as money and time, distributed between men and women? (Resources); and (3) Why is representation and resource distribution divided between men and women in the way it is currently being done? (Realia)

Secondly, the fact that adaptation could reinforce existing gender-based distributions of power is also evident from the way in which employment opportunities are offered in the tourism sector. As in the case of other industrial sectors, women who are employed in the tourism industry generally possess the lowest positions (Forsberg, 2001). To achieve the goal of gender equality it is of vital importance to implement adaptation measures in a way that does not reinforce existing inequalities in terms of pay.

Finally, unless properly designed, marketing Sweden as a tourist destination abroad could contribute to reinforcing stereotypical gender roles and, hence, help to preserve gender-based distributions of power. In a study by Sirakaya (2000), photographs presented in state tourism promotional material were examined from a gender perspective. The analysis showed that women more often than men were stereotypically depicted (i.e., submissive, subordinate, and dependent). To avoid negative effects on the gender equality goal, it is important that tourist operators and advertisers gain an understanding of the ways in which gender is re-produced in tourism advertisements.

5.3 Human health

Many of the adaptation measures that mitigate human health risks resulting from changes in climate, such as urban greening measures, also reduce risk of damage to buildings and developments. The gender implications of these measures are largely dealt with in section 5.1. In this section, two types of adaptation measures are discussed: risk communication measures, including early warning systems and response plans, and measures that involve an enlarged service to vulnerable groups of people during heat waves and prolonged periods of high temperatures.

5.3.1 Risk communication

When developing early warning systems and response plans, it is important to recognize that different groups have different capacities to prepare for, prevent and respond to natural disasters caused by changes in climate. Women and men sometimes have different access to information in disaster situations due to their different roles in society. This is perhaps most evident in developing countries where women and girls generally have a lower education than men and more often tend to be bound to their homes. In these countries, posting warning information in public spaces may not be a particularly efficient way of communicating risks to women (Cannon, 2002). To provide adequate risk information to all people regardless of gender, ethnicity, age, and income level, it is important that early warning information, methods, and institutions be tailored to meet the needs and opportunities of everyone.

5.3.2 Enlarged services to vulnerable groups

As mentioned above, changes in climate will necessitate enlarged services to vulnerable groups, for example, contact schemes for elderly people living by themselves. When planning for such adaptation measures, it is important to reflect on who will be responsible for carrying them out. In most societies, women bear the major part of the burden of caring for the sick. Furthermore, it is usually women who work in other people's homes; for example, as health visitors, domestic workers and carers of children and the elderly. This means that when adaptation measures of this type are implemented they run the risk of placing a particular burden on women, who will be doubly affected by increased levels of sickness (Hansson, 2007). When deciding on climate adaptation policies, it is important to pay attention to the existing division of labour between men and women and to make sure that the adaptation measures that are chosen are designed so as not to further increase the double burden of women.

5.4 Summary

This section has pointed at ways in which adaptation can contribute to preserving gender-based distributions of power and resources and, hence, counteract the goal of gender equality. In many cases, it is possible to avoid conflicts by subjecting the suggested adaptation measures to a gendered analysis. Use of established methods, such as the 3R method or gender impact assessments, is a means of integrating gender aspects into planning and decision-making. These methods help to raise awareness of how gender is re-produced at the local governmental level and thus can pave the way for more just adaptation policies.

6 Conclusions and further research

In this report, examples have been given of goal conflicts that governmental decision makers will likely have to handle as they make decisions concerning adaptation in the sectors of the built environment, tourism and outdoor recreation, and human health. These goal conflicts (and others) constitute a major policy challenge for decision makers involved in adaptation. Unless goal conflicts are properly addressed in the decision-making process, there is a risk that measures for adapting to climate change will counteract the achievement of other goals and values. The measures may even fuel climate change themselves and, hence, accelerate the need for further adaptation.

As goal conflicts (and the nature of those conflicts) are identified, strategies and tools for managing them can be developed. This will be an important next step in the Climatools research programme. We now complete this investigation by providing some preliminary thoughts on how to deal with conflicts in adaptation. These ideas will be further developed as the Climatools research programme proceeds.

Making sure that goal conflicts do not arise

Perhaps the most obvious strategy to avoid goal conflicts in adaptation is to make sure they do not arise. This can be accomplished in at least two ways. To begin with, some goal conflicts can be avoided through intensified action to mitigate climate change. Given that mitigation strategies are successful in halting climate change, fewer adaptation measures will presumably need to be taken. Obviously, this reduces the risk of conflict between adaptation goals and other policy goals. However, since some climate changes will occur regardless of mitigation efforts, policy still needs to focus on adaptation. This means there will be goal conflicts that need to be dealt with even if mitigation efforts turn out to be highly successful.

A second way of avoiding goal conflicts is to focus on reducing the vulnerability in social and ecological systems by making them more resilient towards the effects of climate change. With resilience built into the systems (i.e., systems that are designed and planned to withstand changes without collapsing), the need for adaptation measures could decrease, thereby reducing the risk of conflict. At least, the need for short-term emergency responses may be relieved and goal conflicts associated with such responses can be avoided. Long-term adaptation strategies may still have to be implemented, and they may involve potential goal conflicts. However, with a longer planning horizon it is easier to detect and prepare for possible conflicts than in short-term emergency situations.

Choosing a different adaptation measure or strategy

In many situations, conflicts can be avoided by exchanging the considered adaptation measure to an alternative (more sustainable) one. The alternative adaptation measure may not be equally successful in preventing harm (or taking advantage of opportunities) as the former one, but may result in better overall goal satisfaction and, hence, come out as a preferred alternative to governmental decision makers who are generally responsible for working towards many different goals.

For many of the adaptation measures there are more or less realistic alternatives. For example, instead of installing air-conditioning, which is problematic from a mitigation perspective, other measures could be considered, such as using awnings or blinds, planting trees and constructing green roofs.

Developing new technologies

Sometimes, there are no sustainable options available when a goal conflict appears. One way of managing those situations is to suspend the implementation of the adaptation measure for some time and instead search for new alternatives that involve a lesser degree of conflict with other goals. For example, investing in research for the development of new technologies can serve adaptation by coming up with alternatives that make it possible to reconcile previously conflicting goals.

The problem with developing new technologies is that it is usually a time-consuming activity. This means that it is a less appropriate strategy in situations where the harm associated with climate change must be addressed promptly. In those situations, ethical and economic reasons may speak in favour of some adaptation measures being implemented right away. This does not preclude the decision maker from simultaneously searching for new and better options for later reconsideration of the issue, as long as the initial adaptation decision is reversible (Hansson, 1994).

Prioritizations

When goal conflicts cannot be managed, for example, by selecting an alternative adaptation option or through technological development, the decision maker has to give priority to either goal. Once the adaptation strategies or measures are defined, prioritizations can be made using various methods. According to Lim and Spanger-Siegfried (2004), four methods are particularly useful in prioritizing between adaptation strategies and measures: cost benefit analysis (CBA), cost effectiveness analysis (CEA), multi-criteria analysis (MCA), and expert judgment.[21] Each method is associated with a number of methodological strengths and weaknesses (Kågebro & Vredin Johansson, 2008). In an adaptation context, MCA may come out as a preferred option, since as an analysis tool it is particularly applicable where single-criterion approaches (e.g., cost-benefit analyses) fall short.

Multi-sector integration

Integrating adaptation policies and measures between different sectors is an important means of identifying and avoiding or limiting potential goal conflicts between proposed adaptation measures and other policy goals. Because of the multifarious interrelationships that exist between different policy sectors today, adaptation strategies need to be developed in an integrated fashion to be effective and sustainable. Developing sound adaptation measures in the human health and agricultural sectors is, for example, not feasible without considering the water sector (Lim & Spanger-Siegfried, 2004).

[21] A number of additional decision-making methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change are listed in a report by the UNFCCC Secretariat (2008).

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7 Tables

Table 1.1. A selection of the research institutes/programmes that have been consulted.

FINADAPT (www.environment.fi/default.asp?contentid=108113&lan=en)

FINADAPT was a consortium of 11 partner institutions studying adaptation to the potential impacts of climate change in Finland. Studies were carried out during 2004-2005, based on literature reviews, interactions with stakeholders, seminars and targeted research. FINADAPT addressed the following topics: climate data and scenarios, biological diversity, forestry, agriculture, water resources, human health, transport, the built environment, energy infrastructure, tourism and recreation, a socio-economic preparatory study, urban planning and a stakeholder questionnaire.

UKCIP (www.ukcip.org.uk)

UKCIP (UK Climate Impacts Programme) is a programme that is mainly funded by the Department for Environment, Food and Rural Affairs (DEFRA). The aim of the programme is to help organizations to adapt to climate change. UKCIP administers an adaptation actions database that contains information about how organizations in the UK are adapting to climate change. The database, which can be found at UKCIP's homepage, is searchable by region, sector or adaptation activity.

ASCCUE (www.sed.manchester.ac.uk/research/cure/research/asccue)

ASCCUE was a research programme run between 2003-2006, which aimed to understand the consequences of climate change on towns and cities and develop adaptation strategies though planning and urban design. ASCCUE was part of the BKCC (Building Knowledge for a Changing Climate) initiative – a consortium now being continued through network and workshop activities associated with Sustaining Knowledge for a Changing Climate (SKCC).

SCORCHIO (www.sed.manchester.ac.uk/research/cure/research/scorchio)

The overarching aim of the SCORCHIO project is to develop tools for analysis of adaptation options in urban areas, with a particular emphasis on heat and human comfort in the built environment. Work on the project began in March 2007 and will continue until early 2010.

Tyndall Centre (www.tyndall.ac.uk)

The Tyndall Centre for Climate Change Research is an organisation that brings together scientists, economists, engineers and social scientists to "research, assess and communicate from a distinct trans-disciplinary perspective, the options to mitigate, and the necessities to adapt to, climate change, and to integrate these into the global, UK and local contexts of sustainable development." The Tyndall Centre has a special research programme on adaptation.

ADAM (www.adamproject.eu)

The ADAM (ADaptation And Mitigation Strategies: supporting European climate policy) project is an integrated research project running between 2006-2009 that is funded by the European Commission and co-ordinated by the Tyndall Centre. The aim of the project is to provide research that will contribute to "a better understanding of the trade-offs and conflicts that exist between adaptation and mitigation policies."

ASTRA (www.gsf.fi/projects/astra)

ASTRA was a research collaboration between various research institutes and regional planning offices around the Baltic Sea Region that ended in December 2007. The main objective of the project was to assess regional (Baltic Sea region) impacts of the ongoing global change in climate and to develop strategies and policies for climate change adaptation.

ESPACE (www.espace-project.org)

ESPACE (European Spatial Planning Adapting to Climate Events) was a five-year project led by Hampshire County Council and funded by the European Commission's North West Europe INTERREG IIIB Programme, the ESPACE Partnership and the Department for Communities and Local Government. The aim of the project, which was completed in 2008, was to increase "awareness of the need for spatial planning systems to adapt to the impacts of climate change and to begin to provide some of the necessary policy guidance, tools and mechanisms to incorporate adaptation into systems and processes."

Table 1.2. The Swedish environmental quality objectives

Reduced climate impact

The UN Framework Convention on Climate Change provides for the stabilisation of concentrations of greenhouse gases in the atmosphere at levels that will ensure that human activities do not have a harmful impact on the climate system. This goal must be achieved in such a way and at such a pace that biological diversity is preserved, food production is assured and other goals of sustainable development are not jeopardized. Sweden, together with other countries, must assume responsibility for achieving this global objective.

Clean air

The air must be clean enough not to represent a risk to human health or to animals, plants or cultural assets.

Natural acidification only

The acidifying effects of deposition and land use must not exceed the limits that can be tolerated by soil and water. In addition, deposition of acidifying substances must not increase the rate of corrosion of technical materials or cultural artefacts and buildings.

A non-toxic environment

The environment must be free from manufactured or extracted compounds and metals that represent a threat to human health or biological diversity.

A protective ozone layer

The ozone layer must be replenished to provide long-term protection against harmful UV radiation.

A safe radiation environment

Human health and biological diversity must be protected against the harmful effects of radiation in the external environment.

Zero eutrophication

Nutrient levels in soil and water must not be such that they adversely affect human health, the conditions for biological diversity or the possibility of varied use of land and water.

Flourishing lakes and streams

Lakes and watercourses must be ecologically sustainable, and their variety of habitats must be preserved. Natural productive capacity, biological diversity, cultural heritage assets and the ecological and water-conserving function of the landscape must be preserved while recreational assets are safeguarded.

Good-quality groundwater

Groundwater must provide a safe and sustainable supply of drinking water and contribute to viable habitats for flora and fauna in lakes and watercourses.

A balanced marine environment, flourishing coastal areas and archipelagos

The North Sea and the Baltic Sea must have a sustainable productive capacity, and biological diversity must be preserved. Coasts and archipelagos must be characterized by a high degree of biological diversity and a wealth of recreational, natural and cultural assets. Industry, recreation and other utilization of the seas, coasts and archipelagos must be compatible with the promotion of sustainable development. Particularly valuable areas must be protected against encroachment and other disturbance.

Thriving wetlands

The ecological and water-conserving function of wetlands in the landscape must be maintained and valuable wetlands preserved for the future.

Sustainable forests

The value of forests and forestland for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded.

A varied agricultural landscape

The value of the farmed landscape and agricultural land for biological production and food production must be protected, even as biological diversity and cultural heritage assets are preserved and strengthened.

A magnificent mountain landscape

The pristine character of the mountain environment must be largely preserved in terms of biological diversity, recreational value and natural and cultural assets. Activities in mountain areas must respect these values and assets, with a view to promoting sustainable development. Particularly valuable areas must be protected from encroachment and other disturbance.

A good built environment

Cities, towns and other built-up areas must provide a good, healthy living environment and contribute to a good regional and global environment. Natural and cultural assets must be protected and developed. Buildings and amenities must be located and designed in accordance with sound environmental principles and in such a way that promotes the sustainable management of land, water and other resources.

A rich diversity of plant and animal life

Biological diversity must be preserved and used sustainably for the benefit of present and future generations. Species habitats and ecosystems and their functions and processes must be safeguarded. Species must be able to survive in long-term viable populations with sufficient genetic variation. Finally, people must have access to a good natural and cultural environment rich in biological diversity, as a basis for health, quality of life and well-being.

Source: Environmental Objectives Portal, www.miljomal.nu (accessed 19.3.2009)

Table 2.1. Adaptation measures for the sector of the built environment.

Adaptation measures	Climate change impacts			
	Flooding and increased precipitation	**Erosion and landslide**	**Increased temperature and humidity**	**Increased wind load**
Technical measures	Elevating buildings and developments Pumping out water/temporary damming Increased maintenance and repair of buildings Ventilation/drying up buildings Non-return valves or pumps Increasing pipe diameters	Soil nailing Plant vegetation Lower/limit ground water pressure Draining moist areas Creating barriers between water and the beach matter Controlling water movement and sediment flows	More frequent and thorough maintenance and repair Using building materials that require little maintenance Developing new building materials Barriers to vapour Regularly check the moisture ratio Ventilation	Reinforcement of buildings Planting deciduous trees

	Regular cleaning and inspection of drainage and sewage systems Rainwater harvesting Reinforcement of building constructions Warning systems for sagging roof beams	Reducing the energy of waves and currents Artificial reefs Replacing eroded sand	Heating of building foundations Sun blinds Planting trees Reflective surfaces Shutters Green roofs Low energy cooling systems Cutting internal loads Lowering the density of occupants	
Physical planning and infrastructure development	Abstaining from building in risk areas Relocation	Abstaining from building in risk areas Relocation	Clear leadership Climate scenarios	Clear leadership Climate scenarios

	Green areas and waterways Regulation of water courses, e.g., alternative discharge areas, remodelling dams Modifying the use of buildings Clear leadership Climate scenarios	Letting nature have its way Clear leadership Climate scenarios		
Policy and regulatory measures	Public funding/compensation schemes Guidelines for the planning, location and elevation of new buildings Review of building regulations/advice	Supplement the Planning and Building Act Increase the shoreline protection area Guidelines for the planning, location and elevation of new buildings Review of building regulations/advice	Temporary bans for use of water for irrigation Retrial permits for water use Measures that decrease water consumption Measures that increase the number of water resources	Review of building regulations/advice

			Rainwater harvesting Review of building regulations/advice	
Communication and education	Building capacity in stakeholder groups Research on snow factors in relation to building constructions Warning systems for building constructions affected by snow loads Regional cooperation Include issues concerning climate change into basic technical university and college education courses Early warning systems Mapping	Building capacity in stakeholder groups Include issues concerning climate change into basic technical university and college education courses Mapping	Building capacity in stakeholder groups Include issues concerning climate change into basic technical university and college education courses Early warning systems	Building capacity in stakeholder groups Include issues concerning climate change into basic technical university and college education courses Early warning systems

Table 3.1. Adaptation measures for the tourism and outdoor recreation sector.

Adaptation measures	Climate change impacts	
	Higher winter temperatures	Higher summer temperatures
Technical measures	Artificial snow production and snow grooming Relocation of ski establishments Ski tunnels Cooltracks Substitution of snowmobiles for all-terrain vehicles Ski tracks sprinkled with salt	Measures that combat coastal erosion Measures that reduce algal blooms Measures that counteract turf grass problems, e.g., irrigation, using pesticides
Physical planning and infrastructure development	Increased diversification: mountain biking, horse riding, wildlife watching, etc.	Measures that handle increased competition for water resources, e.g., land-use planning Investments in beach recreation activities

		Investments in golf courses
Policy and regulatory measures	Weather insurance and weather derivatives National monetary compensation schemes	Measures that handle increased competition for water resources, e.g., water pricing policies Integrating water-related concerns into sectoral policies
Communication and education	Marketing Sweden as a year-round tourist destination	Marketing Sweden as a tourist destination

Table 4.1. Adaptation measures for the human health sector.

Adaptation measures	Climate change impacts			
	High temperatures	**Extreme weather events**	**Altered air quality**	**Spread of disease**
Technical measures	Air-conditioning, mechanical cooling facilities Awnings, sun screening Planting trees Cool roofs and cool pavements Green roofs	Sandbags Storm shelters See also sect. 2.2	Ventilation	More effective treatment of drinking water Control of disease vectors Algal bloom intervention
Physical planning and infrastructure development	Open spaces between buildings Green and blue infrastructure	Development and protection of wetlands Green and blue infrastructure	Urban greening	Changed land use practices and management of livestock Climate forecasting in

		Chart animal graves, industrial lands and known dumps		water infrastructure planning
Policy and regulatory measures	Adequate emergency response services Monitor the status of vulnerable groups Adjustment of working schedules Waive user fees and extend opening hours of cooling facilities	Restrictive land use zoning Modification of building codes Adequate emergency response services	Regulations and recommendations that take into account the problem of moisture	Management of agriculture with regards to food safety Stricter water-quality guidelines Stricter surveillance policies and regulations Vaccination
Communication and education	Heat-wave warning systems and heat-wave action plans Public education campaigns	Extreme weather warning systems and extreme weather action plans Public education campaigns	Smog alert warning systems Public education campaigns	Warning systems for algal blooms Information to consumers about basic hygiene and food handling Public health messages

				Information about the risks of poor water quality Training regarding infectious diseases

Table 4.2. Examples of heat-wave warning systems and heat-wave emergency plans.

France has introduced a national heat-wave plan in which meteorological forecasts are directly linked to healthcare and medical treatment resources. The plan includes four levels of information or alert developed by the Ministry of Health and Social Affairs (www.sante.gouv.fr/canicule/doc/plancanicule.pdf).

The **German** Weather Service has developed a heat health warning system through which information is distributed through the Internet and the press. There are also a number of regional heat warning systems in force. For example, the county of Hessen has established a system that gives information concerning urgent measures for the management of retirement homes and for all local health authorities and the public (EEA, 2005).

The **UK** (England and Wales) has adopted a heat-wave plan with four alert levels (Awareness, Alert, Heat wave, Emergency) that prescribe a multitude of actions to be taken during high temperatures (NHS, 2006).

The City of **Toronto** has implemented a Heat-Health Alert and Emergency Response System and an Extreme Cold Weather Alert System, both of which are designed to protect the City's most vulnerable populations through actions, such as media alerts, distributing water in bottles in the summer and hot food in the winter, and distributing transit tokens for those in need of transport to cooling centres (www.hc-sc.gc.ca).

In the City of **Philadelphia**, the Department of Public Health takes a number of steps every time a heat emergency is declared, including media broadcasts of information concerning how to reduce the likelihood of a heat-related illness, engaging the 'buddy system' in which a designated person in each street checks on the elderly and ill persons who live in that street, and staffing a 'heatline' to be used by people who are feeling ill effects from the heat (Kalkstein, 2000).