Climate adaptation in Sweden
Organisation and experiences

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Sammanfattning

Klimatanpassning har kommit att bli en central fråga för att hantera framtida klimatförändringar vid sidan av pågående åtgärder för att minska utsläppen av koldioxid. Den här rapporten ger en introduktion till pågående klimatanpassningsåtgärder i Sverige och beskriver det organisatoriska ramverk som omger klimatanpassningsarbetet. Rapporten baseras på publicerade dokument och ett mindre antal personliga kontakter.

Medeltemperaturen i Sverige förväntas öka med 3-5 grader till 2080 jämfört med medeltemperaturen för åren 1961-1990. Dessutom förväntas förändringar ske i nederbördsmönster samt en ökad havsnivå. Klimatförändringarna kommer därför att leda till nya former av sårbarheter för infrastruktur men också negativa hälsoeffekter till följd av längre perioder med riktigt varmt väder och en ökad risk för smittspridning.

Den svenska policyn för att hantera risker, sårbarheter och kriser har hitintills i Sverige tagit sin utgångspunkt i att ansvariga aktörer ska vara de som är ansvariga även under normala omständigheter. Detta innebär att det mesta av ansvaret, och därmed verktygen för att arbeta med klimatanpassning, återfinns på den lokala nivån. Kommunerna i Sverige är ansvariga för den fysiska planeringen och för mycket av den lokala infrastrukturen, dvs. områden som är centrala att skydda till följd av klimatförändringarnas negativa effekter. Kommunerna är dessutom ansvariga för åtgärder för att reducera sårbarhet vid extraordinära händelser. Den nationella regeringen och statliga myndigheter har endast litet operativt ansvar beträffande klimatanpassning, utan agerar mer som kunskapskällor och finansiärer samt ansvarar för lagstiftningen. Nätverk mellan olika myndighetsnivåer och mellan myndigheter och privata aktörer antas ha stor betydelse för att arbeta med klimatanpassning.

Klimatanpassningsarbetet i Sverige är i ett inledande skede. På den nationella nivån har några åtgärder gjorts för att ändra lagstiftningen så att klimatförändringar lättare kan inkluderas i de normala planeringsaktiviteterna. På olika samhällsnivåer har kartläggningar gjorts för att skatta de risker som klimatförändringarna antas medföra. Dessutom har nödvändig dokumentation för ett proaktivt

beslutsfattande tagits fram, t.ex. gällande landhöjning, vattenflöden och markförhållanden. Regelförändringar har gjorts gällande fysisk planering och byggnader får bara uppföras på platser lämpliga för det ändamålet och med hänsyn taget till olyckor, översvämningar och erosion. Boverket har fått ett särskilt ansvar att utveckla metoder och planeringsinstrument för detta.

Statliga myndigheter med särskilt ansvar har inom sina respektive områden påbörjat undersökningar över förväntade sårbarheter kopplade till klimatförändringar. Detta gäller särskilt Vägverket och Banverket. Jordbruksverket har också initierat ett projekt som syftar till att ta fram kunskap om hur framtida klimatförändringar kan komma att påverka de tekniska systemen i jordbrukssektorn såsom ledningar, vallar och konstbevattning.

Översiktsplanerna, som kommunerna ansvarar för att ta fram och regelbundet revidera och som ligger till grund för den fysiska planeringen i Sverige, är än så länge de mest betydelsefulla dokumenten för klimatanpassningsarbetet. Flertalet kommuner har också ändrat rekommendationerna i sina planeringsaktiviteter. Den hittills vanligaste åtgärden är en höjd miniminivå för byggnation. Ett annat område för klimatanpassningsarbete utgörs av skydd mot en ökad havsnivå eller översvämningar genom investeringar i vallar och pumpsystem. Överlag är anpassningsarbetet mest utvecklat i de kommuner som drabbats av erosion eller översvämningar och de som har en stark tradition av aktiv planering. Anpassningsarbetet är således huvudsakligen utvecklat som en reaktion mot extrema väderhändelser, men förändringar i lagstiftning och ansvar för ett proaktivt arbete förväntas i en kommande proposition.

Nyckelord: klimatförändring, anpassning, anpassningskapacitet, policyskapande

Summary

During recent years, adaptation to climate change has become a more explicit part of climate policy both internationally and in Sweden. This report gives an overview of adaptation activities in Sweden and describes the organisational framework that underpins such adaptation work. The report is based on published documents and a limited number of personal contacts.

In Sweden, the average temperature is expected to increase by 3-5 ^{o}C by 2080 compared with the mean level recorded during the period 1961-1990. Changes in precipitation patterns and higher sea levels are also expected. Climate change will thus lead to new vulnerabilities in infrastructure and negative health effects will appear as a result of longer periods with high temperature and an increased risk of spread of infection.

The general policy in Sweden for dealing with risks, vulnerabilities and crises is to allocate the various responsibilities to the same actors during crises as under normal conditions. Therefore much of the responsibility and tools for dealing with climate adaptation lie at the local level. Local authorities in Sweden are responsible for physical planning and most local infrastructure, i.e. areas that are important for guarding against negative impacts of climate change. Another area of responsibility for local authorities is measures to reduce vulnerability to extraordinary events. Central government and state agencies have few operational roles with regard to climate adaptation but act rather as a source of information and funding, and as providers of the regulatory framework. Networks between different levels of government and between government and private actors are expected to play an important role in dealing with climate adaptation.

The work on climate adaptation is still in its infancy in Sweden. Some efforts have been made at national level to change regulations so that climate change can more easily be included in normal planning activities. The risks of climate change have been mapped on different levels of society and material necessary for proactive decision-making, such as more detailed knowledge about land elevation, water flows and ground conditions, has been compiled. Regulations have been changed regarding physical planning and new buildings must be

located on land suitable for that purpose with regard to accidents, flooding and erosion. The National Board of Housing, Building and Planning has been specifically tasked with developing methods and planning instruments for this.

State agencies with special responsibilities have started investigating the expected vulnerability due to climate change in their respective areas. This is particularly evident for the Swedish Road Administration and the Swedish Rail Administration. The Swedish Board of Agriculture has also initiated a project aimed at providing knowledge of how future climate change will affect technical systems in agriculture, such as pipe drainage, embankments and irrigation installations.

The comprehensive plans that form the basis for physical planning in Sweden are the most important documents for climate adaptation work to date. The plans are revised on an area-specific basis by local authorities in Sweden and several local authorities have changed the recommendations to suit their planning activities, the most common measure being changes to the prescribed minimum levels for foundation-laying. Another area of adaptation work concerns protection from rising sea levels or flooding through investments in dykes and pumping systems. Adaptation work is more frequent in local authorities that have been affected by erosion and flooding and those with a tradition of active planning. The nature of adaptation work thus far is mainly reactive, driven by extreme weather events, but changing regulations and responsibilities concerning proactive work are expected in a forthcoming government bill.

Keywords: climate change, adaptation, adaptive capacity, policy-making

Innehållsförteckning

1 Introduction

During recent years, adaptation to climate change has become a more explicit part of climate policy both internationally and in Sweden. Although mitigation of greenhouse gas (GHG) emissions is still the main feature in global, EU[1] and Swedish climate policy, there is a growing insight that even with a successful GHG mitigation policy, climate change will continue. For example, the EU climate strategy aims to restrict average global temperature to no more than 2 °C above the pre-industrial level.[2] Furthermore, major emission reductions outside the EU will be required to reach the target and will therefore be outside the EU's own control. It therefore seems to be a reasonable hedging strategy to prepare for more significant changes in temperature than is the target for the mitigation policy. The green book on adaptation to climate change and its resulting processes are important steps in including climate adaptation to a greater extent in EU climate policy.[3]

Swedish climate policy has gradually been expanded since the end of the 1980s, when the first climate target was adopted. There followed a succession of policy decisions, although most with the focus on mitigation of emissions. There is no national strategy for climate adaptation but in 2005 a commission was appointed to put forward proposals for how society could be more robust as regards future climate change. The delegation reported in October 2007[4] and its proposals have been sent for consultation throughout Swedish society. Suggestions from the commission are expected to be included in the government climate bill planned for the beginning of 2009. Some of the results and suggestions from the delegation are described in the following chapters.

Measures to adapt to climate change can be anticipatory or reactive and, depending on the degree of spontaneity, they can be autonomous or planned.[5] Adaptation is made up of actions and decisions throughout society by individuals, businesses and civil society up to public bodies and governments at local, regional and national level and international agencies.[6] Action for adaptation involves measures that improve the adaptation capacity of society (capacity-building) and those that implement operational adaptation decisions (e.g. investments in risk-reducing technologies). The national report to the Swedish climate

[1] The EU Commission's climate and energy package currently being processed focuses totally on mitigation.
[2] European Council, 2007.
[3] European Commission, 2007.
[4] Commission on Climate and Vulnerability, 2007
[5] Smit and Wandel, 2006.
[6] Adger et al., 2005.

convention, NC4, stresses that there is great variety in how adaptation is dealt with among different actors in Sweden due to the lack of a national strategy.[7]

The focus of this report is on anticipatory operational adaptation decisions made with the intention of directly or indirectly reducing the vulnerability of various systems to climate change. Adaptive measures can be administrative/legal (such as land-use planning), engineering (e.g. construction of seawalls or changes to sanitation systems) or affect personal behaviour (e.g. heeding weather forecasts).[8]

It is often difficult to make a clear distinction between measures that reduce the vulnerability to current climate and those intended to manage a changing climate, and this distinction is seldom made by policy-makers. The occurrence of extreme weather events and the growing debate on climate change have together triggered the implementation of measures. However, experience shows that readiness to deal with current climate events improves the preparedness to act on new and more intense events as a result of climate change.[9]

When assessing society's vulnerability, the focus is often on critical societal functions.[10] These include infrastructure[11] and other resources necessary for the functioning of society. Climate adaptation work targets these societal functions but could also have broader aims, e.g. conserving economic resources in society and maintaining the well-being of the population.

This report provides an overview of adaptation activities in Sweden. It begins with a short introduction to the expected effects of future climate change in Sweden, in order to provide a sense of the type of problems Sweden will face in the future. It continues with an introduction to the existing organisational and regulatory structure providing the framework for adaptation measures in Sweden. Thereafter, examples of adaptation measures conducted at local, regional and national levels are provided. The report concludes with a discussion of Swedish experiences and the potential for other countries to use some of these experiences as support for their climate adaptation work.

[7] Swedish Government, 2005. p.88.
[8] Smit and Pilifosova, 2001.
[9] Mossberg Sonnek et al., 2007.
[10] See e.g. Swedish Emergency Management Agency, 2007.
[11] The are several definitions of critical infrastructure, ranging from including only traditional infrastructure such as communication and energy infrastructure to also including areas such as schools and healthcare systems.

Due to the short time available for the investigation, there was no possibility for systematic collection of comprehensive information from different actors throughout society through questionnaires, etc. Instead, the report is based on existing material published in print and/or found on the internet and information from a limited number of individuals with good knowledge of the issue. This approach creates a risk that those activities not widely documented or accessible to our approach being overlooked.

2 Vulnerability to Climate Change in Sweden[12]

Average temperatures in Sweden are expected to increase by 3-5 °C by 2080 compared with the average during the period 1961-1990. This is more than the predicted global average increase. Changes in precipitation patterns and higher sea levels are also expected. Climate change will lead to new vulnerabilities in technical infrastructure and negative health effects will appear as a result of longer periods with high temperature and increased risks of the spread of infection. Productivity in agriculture and forestry is expected to increase, although some negative effects will also increase.

2.1 Expected climate change in Sweden

According to current climate modelling, the temperature in Sweden is expected to increase more in Sweden than the global average. Model scenarios point out that Swedish average temperature will increase by 3-5 °C by 2080 compared with the average during the period 1961-1990. As a consequence, the number of warm days is expected to increase significantly.

Furthermore, precipitation patterns will change. Precipitation will increase in most parts of the country during autumn, winter and spring. In the summer, the climate will be warmer and drier, especially in southern Sweden. There will also be an increase in heavy rainfall events during autumn and winter, whereas there will be a decrease during summer. Higher water flows and more frequent flooding can be expected, although not everywhere in the country.

The global sea level is expected to rise by 0.2-0.6 metres in the coming 100 years. In Sweden, this change in sea level will interact with the on-going post-glacial rebound.[13] The combined effect is expected to be a sea level rise in southern Sweden by up to 0.8 metres, whereas the land elevation in the northern parts of the country will probably override the climate-induced sea level rise. However, significantly higher increases in sea levels cannot be totally excluded.

2.2 Agriculture and forestry

The conditions for agriculture are mainly expected to improve as a result of climate change. A longer growing period is expected to lead to higher crop yields and will provide opportunities to introduce new crops. Problems with pests such

[12] This chapter is based on the Commission on Climate and Vulnerability, 2007.
[13] In southern Sweden, land levels are in fact being lowered as a result of this process.

as insects, fungi and viruses will increase in the warmer climate and both irrigation and drainage systems might have to be adapted to changes in precipitation patterns. Although the general conditions for agriculture in Sweden will improve, the risk of crop damage due to extreme weather events will probably increase.

Climate change is expected to result in higher forest growth as a result of higher temperatures, a longer growing season and a higher CO_2 content in the atmosphere. However, these increasing rates of forest growth will lead to a greater risk of wind felling, something which is also expected to be the effect of wetter conditions in the winter time. The warmer climate will also make forests more prone to fire, fungus and insect attack.

2.3 Housing, industry and services

Western and south-western parts of Sweden are expected to face flooding more or much more often than today as a consequence of climate change. Increased flows in the north-western mountain areas might also spread to the east along rivers. However, the effects are uncertain due to the fact that most rivers are artificially regulated. In other areas, the risk of flooding will decrease or remain at current levels. An increase in sea level will have most negative impact on buildings in southern Sweden. An increased risk of landslides and erosion, especially in the south-western/western part of the country and along parts of the east coast, will also affect buildings negatively, whereas this risk will decrease in other parts of the country.

Wastewater systems are expected to be heavily burdened in a changed climate with expected increases in rainfall and a redistribution of the precipitation to periods of the year when evaporation rates are low. The risk of backflows and flooded basements will increase, as will that of overflowing sewage, with accompanying health risks. A higher risk of flooding will also increase the risk of chemical compounds spreading from polluted land.

2.4 Transport and energy

The negative effects of climate change for road transport include increased precipitation and higher flows, which will lead to flooding, washing away of roads, damage to bridges and an increased risk of landslides and erosion. Similar effects are expected for the railways. Stronger winds will increase the risk of storm felling, with potentially negative effects for power distribution. Higher average temperatures will give positive and negative effects on different types of maintenance costs.

Climate change is expected to result in better conditions for hydropower and wind power production. However, there is a risk that flows exceeding the levels for which the hydroelectric dams are designed will increase and therefore more investment might be required to reinforce these dams. The negative effects on electricity distribution of more frequent stormy weather will continue. Warmer weather will significantly reduce the need for heating, with significant cost savings, but the need for cooling will increase.

2.5 Health and water resources

Periods of high temperature are expected to become more frequent, with higher temperatures than today. This will lead to higher mortality, especially among vulnerable groups of people. On the other hand, fewer very cold days will give positive health effects. Air pollution levels can be expected to increase slightly as a result of climate change but other factors, such as measures for reducing emissions, will be of greater importance. A warmer climate with more precipitation will result in an increased risk of infections. The patterns of infection will probably change and new diseases may enter the country, but there are still major uncertainties regarding the actual effects.

The consequences of climate change on drinking water supply are expected to be significant, even though Sweden will still be in a good position regarding water supply. Water quality will probably be impaired, with higher humus content and more microorganisms. The risk of interruptions to supply and pollution will increase as a result of the higher risk of flooding and landslides.

2.6 Marine and fisheries

The effects of climate change will be severe, especially for the Baltic Sea, with temperature increases of several degrees Celsius and a great diminution of the ice cap. This, together with an increased inflow of nutrients, will probably lead to large-scale consequences for an already heavily polluted sea. With potentially increased winds from the west and more precipitation, the salt content will be reduced to half that of today. This will lead to drastic changes and the disappearance of most marine species, including cod.

In the western seas and in Swedish lakes, fish species adapted for warmer temperatures will be promoted at the expense of cold-water species. In total, fisheries in the western seas and some lakes might benefit from climate change.

2.7 Ecosystems and biodiversity

Land ecosystems will change significantly as a result of climate change and the loss of biodiversity is likely to increase. Particularly diverse areas will be especially sensitive to climate change, as they contain many demanding and specialised species that require a very specific environment. The Arctic region is very vulnerable. Measures carried out with the intention of adapting to climate change might also have a negative impact on biodiversity.

3 Organisation and Regulation

The general policy in Sweden for dealing with risks, vulnerabilities and crises is to allocate the various responsibilities to the same actors as under normal conditions. Therefore, much of the responsibility and tools for dealing with climate adaptation in Sweden lie at the local level. One of the areas of responsibility for local authorities is for measures reducing the vulnerability to extraordinary events. Furthermore, the local authorities are responsible for physical planning and most local infrastructure, areas that are important for guarding against negative impacts of climate change. Central government and state agencies have few operational roles with regard to climate adaptation but act rather as a source of information and funding and as providers of the regulatory framework. Networks between different levels of government and between governments and private actors are expected to play an increasing role in dealing with climate adaptation.

Swedish adaptation policy is in a transformative phase and a government bill that will give directions for future policy is expected in the beginning of 2009. This will be at least partly based on the report of the Commission on Climate and Vulnerability mentioned earlier. Even though changes are underway, this section clarifies the organisational and regulatory framework for climate change adaptation in Sweden to date and presents some of the suggestions proposed by the Commission on Climate and Vulnerability in its 2007 report.

Sweden has strong local government. This means that local authorities have a great deal of freedom to organise their activities and they have independent (although to some extent limited) powers of taxation. Their responsibilities are regulated through legislation formulated by central government. Swedish local authorities, which at present number 290, are responsible for their residents in terms of basic social functions (e.g. schools and childcare), physical planning and building, drainage and water supply, waste management and rescue operations. The responsibility for medical services is under the aegis of the county council. The regulations for local authorities and for county councils are laid down in the Local Government Act (1991:900).

Local authorities have a central role in implementing the national climate policy targets, not least due to their responsibility for e.g. physical planning and building as well as drainage and water supply. Another area of responsibility is for measures reducing the vulnerability to extraordinary events. The regulations for these areas are at least indirectly applicable to climate adaptation, but local authorities are not obliged to include climate adaptation issues. The two most important regulatory instruments in these areas are:

- Planning and Building Act (SFS 19987:10): This prescribes that each local authority must have a comprehensive plan[14] that can serve as guidance for decisions concerning the use of land and water and how the built environment should be developed and preserved. The Act demands that environmental and crisis aspects be considered in every decision concerning land and water planning.
- Act (SFS 2006:544) on local authorities' and county councils' measures before and during extraordinary events.[15] This Act aims to reduce vulnerability and increase the capability to deal with peace-time crises. It states that 'Risk and Vulnerability Analyses'[16] must be conducted on a regular basis. There are no single methods for performing these analyses, but the Swedish Emergency Management Agency has published several guidelines as an aid to local authorities.[17]

The work of local authorities and county councils concerning risk and vulnerability is overseen by the county administrative boards, which have overall responsibility for monitoring and supervision.[18]

Central government and state agencies have few operational roles with regard to climate adaptation but act as a source of information and funding and as providers of the regulatory framework. Since 2002, each agency must develop risk and vulnerability analyses similar those carried out by local authorities. Depending on the agency's area of responsibility, these analyses are more or less closely associated with climate change. The Swedish Emergency Management Agency (SEMA) and the Swedish Rescue Services Agency (SRSA) have had respective responsibility for general issues concerning crisis management and accidents. From 1 January 2009, these two agencies have been replaced by a new agency, the Swedish Civil Contingencies Agency (MSB). This reorganisation is intended to provide better opportunities for synergies and coordination in society's work with crisis of all kinds.[19]

While the regulatory and organisational framework is under development, there has been scope for the agencies themselves to define their roles and responsi-

[14] In Swedish: Översiktsplan.
[15] Lag (SFS 2006:544) om kommuners och landstings åtgärder inför och vid extraordinära händelser i fredstid och höjd beredskap.
[16] In Swedish "Risk och sårbarhetsanalys, RSA.
[17] There are two guidelines, one for local authorities and county councils, and one for government agencies. The latter has been translated into English by the Swedish Emergency Management Agency, 2008.
[18] http://www.lansstyrelserna.se/lst/en/ ; Commission on Climate and Vulnerability, 2007. pp. 619-620.
[19] Government Bill 2007/08:92 Stärkt krisberedskap – för säkerhets skull. In addition to the two agencies named, MSB also consists of the former National Board of Psychological Defence.

bilities. In 2004 an informal network was set up involving the Swedish Environmental Protection Agency (SEPA), the Swedish Meteorological and Hydrological Institute (SMHI), SEMA, the Swedish Geological Institute (SGI) and the National Board of Housing, Building and Planning. However, none of these agencies has overall responsibility for work on climate adaptation, as it is an issue that is considered to belong to each agency's overall mission.[20] In 2007 the network established an internet-based tool (Climate Adaptation Portal[21]), to assist other actors – agencies, local authorities, industry – in their work on climate adaptation.[22]

In addition to this, network coordination groups have been established between various actors – county administrative boards, local authorities, the Swedish Road Administration, the Swedish Rail Administration and the power plant industry – concerning the major rivers in Sweden. Thirty river groups are now in operation aiming at knowledge-building activities regarding high flooding and dam security.[23] The Swedish Association of Local Authorities and Regions (SALAR)[24] is also working with climate issues to some extent, but with climate adaptation to a lesser extent. Similar limitations apply as regards the SEPA-funded project 'Climate Coach', which is intended to support climate work in small local authorities.[25]

The Commission on Climate and Vulnerability emphasises that practical work on climate adaptation will be carried out at local level, by local authorities, businesses and individuals.[26] The role of the local authorities must therefore be strengthened and the risk and vulnerability analyses of each authority should include work on how to reduce society's vulnerability to climate change. The Commission suggests that county administrative boards should be given greater responsibility, not least due to their possibility to take an overall approach for coordinating the work on a regional level. According to the Commission, each county administrative board should establish a climate delegation in which local authorities, industry, government agencies, organisations and others are invited to participate.[27] Government agencies that are responsible for a specific area ought to be given clear responsibility for that area with regard to the effects of climate change. The agencies are also considered important with respect to providing knowledge and it is suggested that SMHI be given a special mandate to provide knowledge and disseminate information.[28] At national level, the

[20] Uggla, 2009a, p. 10.
[21] In Swedish Klimatanpassningsportalen, http://www.smhi.se/cmp/jsp/polopoly.jsp?d=9315&l=sv
[22] http://www.smhi.se/cmp/jsp/polopoly.jsp?d=9315&l=sv
[23] http://www.srv.se/templates/SRV_Page____2166.aspx
[24] http://www.skl.se/startpage_en.asp?C=6390
[25] http://www.klimatkommunerna.infomacms.com/?page=page44f2e2530248a
[26] Commission on Climate and Vulnerability, 2007. p. 622.
[27] Commission on Climate and Vulnerability. 2007. pp. 623-624, 628.
[28] Commission on Climate and Vulnerability. 2007. p. 625, 628.

Commission considers the EPA to be the agency most capable of taking responsibility for monitoring and coordinating the work on reducing vulnerability and adapting society to a changing climate.

To conclude, mitigation issues have dominated Swedish climate policy to date, and limiting the climate impact is one of the sixteen national environmental policy goals. That work mainly concerns limiting the impact through reducing greenhouse gas emissions. Lately, the issue of climate adaptation has risen to prominence and the area of adaptation is under development. Adaptations to climate change can be embedded in society's crisis management in general, but today it is up to each actor to decide the amount of work on climate adaptation that e.g. risk and vulnerability analyses need to include.[29] Networks and collaborations between different kinds of actors appear to be important for society's work on climate change in general and for climate adaptation in particular. The use of networks could be interpreted as a lack of political steering, but could also be interpreted as a new form of political steering,[30] a topic discussed in Chapter 5.

[29] Uggla, 2009b, see also Adger et al., 2005, p. 78.
[30] Montin, 2009.

4 Examples of Adaptation Activities in Sweden

The work on climate adaptation is still in its infancy in Sweden. Some efforts have been made at national level to change regulations so that climate change can more easily be included in normal planning activities. The risks of climate change have been mapped on different levels of society and material necessary for proactive decision-making, such as more detailed knowledge about land elevation, water flows and ground conditions, has been compiled. Changes in the prescribed lowest levels for building foundations are the most common measure within Swedish local authorities. The most active local authorities are those that have been affected by erosion and flooding and those with a tradition of active physical planning. Generally, most of the climate adaptation measures in Sweden are concerned with flooding, probably as a result of recent experiences of such events. Much less has been done to adapt to e.g. the potential negative health effects of climate change.

4.1 Introduction

Although most of the Swedish activities associated with climate change are directed towards mitigation of emissions, adaptation measures are now being discussed more broadly and have gradually started to be implemented at different levels of society. This is at least partly a response to several extreme weather events during the past decade. Extremely high water levels and flooding have occurred several times, threatening important infrastructure in the Swedish capital, Stockholm (2000), and flooding towns such as Värnamo (2004) and Arvika (2000). Hurricane events in southern Sweden in 2005 and 2007 caused significant damage to forests, which in some regions were totally devastated, and railway and road infrastructure.

Much of the focus regarding adaptation to date has been on the location and technical design of buildings and other infrastructure. This can partly be explained by the long economic lifetime of the infrastructure, which makes it especially important to take a proactive approach. Through the above-mentioned events, a growing understanding of the threat of climatic events to infrastructure has emerged.

4.2 Regulatory activities

At national level, some legal changes have been devised and implemented as a way to safeguard against extreme weather events. In the Planning and Building Act (1987:10), an addition to the requirements on the siting of new buildings was

implemented on 1 January 2008. According to the Act (Ch. 2, paragraph 3), buildings must be located on land which is suitable for that purpose. Important factors to be considered in this regard include: 1) the health of residents and others; (2) the soil, rock and water conditions; (3) the opportunities for providing traffic facilities, water supply facilities, sewerage facilities and other community services; and (4) the opportunities for preventing water, air and noise pollution. In addition to these requirements, the location must be suitable with regard to the risk of accidents, flooding and erosion. This provides a wider possibility to take climate change into consideration. The change in the legislation also includes an expansion of the causes for which the county administrative board is obliged to examine and, if necessary, annul a local authority's decisions regarding detailed development plans or area regulations. These causes now include the risk of accidents, flooding or erosion.

In addition, the Commission on Climate and Vulnerability has proposed that the period during which local authorities are liable for compensation be increased from 10 to 20 years. The argument behind this is to increase the financial responsibility of local authorities for the consequences of flawed planning with regard to the risks of flooding, landslides and erosion.[31] This proposal has met with a negative response from, amongst others, the Swedish Association of Local Authorities and Regions, and so far the proposal has not led to any central government legislation.

The National Board of Housing, Building and Planning has been specifically tasked with developing methods for, and showing examples of, how planning and building activities can be adapted to prevent, avoid and minimise negative effects of climate change. Particular attention will be directed to how different planning instruments can be used with regard to the risks of flooding, landslides and erosion.[32]

The possibility also exists to take account of a changing climate when specifying the requirements for permitting activities according to the Environmental Code. The Environmental Court in Sweden has required that design calculations take future climate change into account, at least in one case regarding a bridge.[33] In the application process for a permit for new ski slopes in a sensitive natural area, the argument was raised that climate change will reduce the possibilities to utilise these slopes in the future. According to the argument, this must be taken into account in the decision weighing the preservation of sensitive natural areas against the potential for providing new jobs in rural areas. In the final decision on the specific case, this factor did not play a specific role; however, as the permit

[31] Commission on Climate and Vulnerability, 2007. p. 663.
[32] Ministry of Environment, 2007.
[33] Rummukainen et al., 2005.

application was dismissed due to the high priority of nature conservation in the area, regardless of future climate.[34]

4.3 Direct operational activities

In 2007, the Swedish Road Administration started a risk inventory of Sweden's major roads. In parallel, the Administration has begun implementing preventive risk-reducing measures, which were carried out on sixteen objects during 2008. A significant part of risk reduction relates to nature and climate events, but not necessarily to climate *change*. The nature-related projects include e.g. reinforced protection against erosion, larger road culverts and different measures to handle inadequate clearance between bridges and high water levels. For 2009, SEK 95 million have been allocated for the implementation of risk reduction measures.[35]

The Swedish Rail Administration has taken a number of measures to reduce the vulnerability of the railway transport system to climate change.[36] However, it is unclear whether the intention behind these measures was to reduce the effects of future climate change or of current climate variations. The most extensive adaptation measure in progress today is the establishment of tree-free zones in railway corridors in high priority parts of the network. Approximately 4,000 kilometres of the national railway grid are to be protected from potential falling trees and branches. Other important measures are those taken against failures in the drainage system. Since the main cause identified for drain failures was lack of maintenance, the measures have focused on maintenance, monitoring and to some extent the use of new materials and equipment. However, no measures have been taken to adjust construction and design parameters. Some measures to improve maintenance and to stabilise tracks in order to prevent embankments from becoming dams have started in some areas.

The Swedish Board of Agriculture[37] has initiated a project to provide new knowledge of how future climate change will affect technical systems in agriculture, such as pipe drainage, embankments and irrigation installations. The target groups are landowners, farmers and rural businesses. The National Food Administration has developed a method for risk and vulnerability analysis of drinking water supply, aiming at strengthening the capability of local authorities for crisis management.[38]

[34] Government decision. M2006/5789/F/M. 2007-03-08.
[35] Personal communication. Håkan Nordlander, Swedish Road Administration, 2008-12-01.
[36] This section is based on Lindgren, 2006.
[37] http://www.sjv.se/nyhetsarkiv/nyheter/kunskapsprojektforhanteringavklimatforandringar.5.1c72e95711857a2245380004439.html
[38] Olausson (ed.), 2007.

On behalf of the Swedish Government, the county administrative board of Västra Götaland has signed an agreement with Vattenfall AB, Sweden's largest power company, regarding the regulation of Lake Vänern, Sweden's largest lake. According to the agreement, the regulation strategy has been changed in a way that is expected to reduce the highest levels by 40%. As a consequence, the average level of the lake is expected to be lowered by 15%.[39]

Few comprehensive adaptation plans or strategies at local authority level have been developed to date. To our knowledge there is no agreed plan in Sweden so far, but e.g. Kristianstad local authority is developing such a plan[40], which includes proposals on specific measures to reduce vulnerability. Malmö and Sundsvall local authorities are also starting to develop adaptation plans.[41] Other local authorities have made an inventory of their vulnerability to climate change and have identified potential measures to reduce this vulnerability.[42] A third approach has been taken by Ronneby local authority, where a consultant has made a quality evaluation of all the authority's steering documents from a climate and adaptation perspective to see how targets and directions should be altered.[43]

A measure that has been initiated in some counties and local authorities[44] is mapping of flooding risks. This measure will be an important foundation for vulnerability assessments, decisions regarding spatial planning, and investments in technical equipment etcetera. From January 2009 the Swedish Civil Contingencies Agency (the former Swedish Rescue Services Agency) has overall responsibility for providing county and local authorities with general maps on the risks of flooding, land collapse, landslide and erosion. A problem today is that current Swedish elevation mapping is too inaccurate for mapping the effects of flooding. Some local authorities have therefore used different methods to develop maps with higher resolution (down to 1 metre or even decimetres).[45] In parallel, Lantmäteriet[46] has started a 7-year project to develop a new elevation database, at a cost of SEK 200 million, with a lateral resolution of 2.5 metres and a vertical accuracy of 0.5 metres.[47] In general, local authorities are requesting

[39] County Administrative Board of Västra Götaland, 2008a and 2008b.
[40] Kristianstad Local Authority, 2008.
[41] Personal commmunication. Jessica Andersson, Swedish Association of Local Authorities and Regions, 2008-12-02.
[42] See e.g. City of Göteborg. 2006.
[43] Personal information. Jessica Andersson, Swedish Association of Local Authorities and Regions 2008-12-02.
[44] E.g. Kungsbacka, Stockholm,
[45] E.g. Kristianstad, Kungsbacka, Trelleborg, Helsingborg, Vellinge, Ystad.
[46] Lantmäteriet is responsible for providing basic geographical and land information to both the public and private sector on various levels, see http://www.lantmateriet.se/templates/LMV_Entrance.aspx?id=25
[47] Material from the workshop 'Centrala myndigheters roll i klimatanpassningsarbetet', 2 October 2008, Stockholm. and from http://www.lantmateriet.se/templates/LMV_NewsPage.aspx?id=14684

support for their planning from the central and regional state agencies, not the least regarding mapping, analysis, climate scenarios, etc.[48] In addition, the Stockholm authority has ordered a study of how to build in risk areas and how to manage new risks such as landslides.

Seven county administrative boards have given recommendations on how risks of flooding should be taken into account in physical planning.[49] The recommendation is that no buildings should be located below the 100-year flood level, with the exception of simple buildings such as garages and outhouses. Below the design level,[50] which is higher than the 100-year flood level, no buildings of great importance for society[51] should be located. The administrative boards make no specific analysis of how these levels will change as an effect of climate change, but note that the levels in most cases will be higher in the future; the current levels according to the recommendations above are thus the absolute minimum acceptable levels.

Consequently, several local authorities have incorporated these recommendations into their planning activities. In the region of Skåne, half the local authorities mention aspects regarding climate change in their comprehensive plans, but not always in a concrete way. However, one-third of the local authorities in the region mention rising sea levels as a potential problem.[52] It is worth noting that local authorities in Skåne are relatively active, as a result of the comparatively large changes expected in sea level in southern Sweden.

Changes in the prescribed lowest levels for foundation-laying are the most common measures within Swedish local authorities.[53] The most active local authorities are those that have been affected by erosion and flooding and those with a tradition of active planning.

For example, Halmstad local authority has included recommendations for new buildings that vary depending on their expected lifetime in its comprehensive plan.[54] According to the same plan, basements must be waterproofed and the wastewater system must be designed to handle high groundwater levels.

[48] County Administrative Boards of Skåne and Blekinge, 2008.
[49] County Administrative Boards of Stockholm, Uppsala, Södermanland, Östergötland, Värmland, Örebro and Västmanland, 2006.
[50] The probability of reaching this level is less than 1/10,000 for every individual year and the risk that it will be reached during a 100-year period is barely 1%.
[51] Such as hospitals, schools, important infrastructure such as national roads, roads with no real alternative junctions, railways, water, sewage and waste facilities, electricity and communication installations, industries with large environmental impact or other industrial areas. High-density residential areas are also included in this group.
[52] County Administrative Board of Skåne and Blekinge, 2008.
[53] Personal communication. Jessica Andersson, Swedish Association of Local Authorities and Regions, 2008-11-21.
[54] Halmstad Local Authority, 2007. Fördjupad översiktsplan för Söder i Halmstad.

According to Rummukainen et al.[55], planning material from 2003 for the same local authority took its starting point in the 100-year return flood and then added 0.7 metres to take account of future climate change.

In its in-depth comprehensive plan, Kungsbacka local authority has defined new lowest recommended foundation-laying levels, based on a new analysis of flooding risks.[56] In the plan, the effects of climate change have not been taken into account directly. Instead an extra 0.5 metres has been added as a buffer level. Similar approaches have been taken by others. Gothenburg in its water plan increased the lowest acceptable building level by 0.5 metres to reduce the risks of flooding,[57] while Malmö raised the level for new buildings from 2.0 metres to 2.5 metres above sea level in the comprehensive plan of 2000, but is now proposing to increase it to 3 metres above sea level.[58] In Örebro's revision of its comprehensive plans, it is apparent that adaptation issues have been specifically addressed.[59]

Lomma, one of the lowest-lying local authority areas in Sweden, in its guidelines for the development of a new comprehensive plan60 has included several aspects related to climate adaptation such as:

- In the comprehensive plan, flood management areas to which surface water can be directed when the normal systems are insufficient must be identified.
- New buildings must not be planned at ground levels lower than 2.5 metres above sea level.
- New buildings must not be planned so that storm water can be caught.
- Lomma local authority, in cooperation with other local authorities, must work to delay the flow of storm water to streams.
- The coast should be protected from erosion to the greatest degree possible.
- The plan should highlight future potential needs for protection of installations in response to rising water levels.

Vellinge is another local authority that has dealt with increasing water levels in its comprehensive plan. Building permits and detailed plans must take increased water levels into account. However, there is no move to remove buildings from risk zones, but instead damming is seen as a way of protecting new and existing buildings.[61] Arvika local authority has taken a similar approach.[62] Vellinge local

[55] Rummukainen et al., 2005.
[56] County Administrative Board of Halland. 2008.
[57] City of Göteborg, 2005.
[58] Rummukainen et al., 2005; Miljöförvaltningen Malmö, 2008.
[59] http://www.orebro.se/oversiktsplan
[60] Lomma Local Authority, 2008.
[61] Åkesdotter, 2008.
[62] Uggla and Lidskog 2006; Arvika Local Authority, 2007.

authority has analysed the potential to protect flood-prone areas by grass-covered dykes and sand ballasts. Cost estimates indicate relatively low outlay, for example less than 0.1% for dykes, in relation to the value of the properties protected.[63]

There are also examples of local authorities disregarding early warnings regarding the increased risks of flooding, and continuing to plan residential developments in flood-prone areas. According to an investigation in the county of Västra Götaland, only one-third of its local authorities are taking adequate account of the risks of building in waterside areas.[64] This conflict (ambivalence) between taking warnings into account and building in attractive areas, i.e. close to water, is discussed in several studies.[65]

In Mariestad municipality, for example, residential developments are being planned below the levels recommended by the Commission on Climate and Vulnerability. Langlais et al.[66] have identified several reasons why this local authority is refusing to change its plans in response to early warnings about climate change. They report that Mariestad local authority believes that technical solutions to the problem of flooding are preferable and that it is up to central government to provide such solutions. One reason for these arguments is that even without new buildings, many existing buildings in Mariestad are vulnerable to high water levels and other towns around the lake are vulnerable in a similar way. Furthermore, Mariestad local authority claims that the risk of flooding can be handled by measures such as appropriate foundation levels and water barriers. An important reason for this authority building in flood-prone areas is to increase the number of inhabitants by offering attractive housing and thereby improving the local economy. Finally, the fact that flooding has occurred in the past and that the town has recovered rather speedily from this is, according to Langlais et al, almost 'reassuringly lulling'.

Some local authorities have invested in dykes to protect themselves from higher sea and flood levels, sometimes in combination with pumps for coping with potential flooding events. For example, in the municipality of Kristianstad, which is located only 4 metres above the current level of the Baltic Sea, the local authority has invested SEK 200 million in dykes and pumping stations to prepare for higher water levels. These dykes are designed for future high water levels in the river Helgeå and in the Baltic Sea. The building of the dykes started in 2003 and is expected to be finished by 2012.[67] To allow for a rapid response to high water levels, Kristianstad local authority has also invested in its own forecasting system, which provides 48-hour forecasts on sea levels in the Baltic. In conjunc-

[63] Presentation by K. Nilermark and H. Folkesson 2008-08-28. Malmö.
[64] Sellius, 2007.
[65] See e.g. Uggla and Lidskog 2006; Storbjörk 2006; Langlais et al., 2008.
[66] Langlais et al., 2008.
[67] Storbjörk, 2006.

tion with the new dykes, the local authority has chosen to let water flow freely over the wetlands outside the city centre, rather than trying to control and direct the water with the help of dykes.[68]

In contrast, Falun local authority has chosen to work with temporary, mobile barriers to protect against potential flooding events.[69] In parallel, Falun is working on flood plans by designing areas that are dry at normal water levels but flooded during high water periods.

The Stockholm public transport company has invested in pumps to protect vulnerable parts of the underground train system from inundation. Moreover, Stockholm public transport has moved technical equipment from the low-lying, subway station of 'Gamla stan' to a level approximately one metre higher. Due to its location, the Gamla stan station is essential for the functioning of practically the entire underground train system of Stockholm. High water levels also threatened the station in the year 2000.

There is an ongoing planning process in Stockholm to increase the possibilities to tap off the regulated Lake Mälaren to the Baltic Sea. These plans are being integrated with the planned transformation of one of the most important transport nodes in Stockholm (Slussen), which makes this a rather complicated project. Similar and perhaps more severe problems with flooding have been identified for Sweden's largest lake, Vänern, but possible solutions to these problems are still under investigation.[70] One of the proposals is to build a 30-43 km[71] tunnel from Lake Vänern to the west coast of Sweden.

Municipal water and sewage systems have very long lifetime (more than 100 years), which makes it a very long-term and potentially expensive task to reduce their vulnerability to climate change. However, some local authorities, amongst others Stockholm, have started to demand higher levels for the connection of new sewage systems to the net to reduce the risk of backflow of sewage water into buildings. Other local authorities such as Malmö have tried to take account of recent intensive rainfall levels when dimensioning storm water systems.[72]

Malmö local authority is also actively involved in testing new methods for adaptation and is working on several adaptation measures within an EU-funded project. For example, systems for open storm water management will be constructed. Furthermore, green facades grown on a system of wires at a short

[68] Storbjörk, 2006.
[69] Storbjörk, 2006.
[70] Although as already mentioned, some temporary measures have been implemented.
[71] The length depends of the actual choice of location.
[72] Svensson, 2007.

distance from building facades will be tested, as will new, light-weight green roofs.[73]

From the work of local authorities, it can be concluded that the focus lies on adaptation activities concerning high flows and building standards. Installation of dykes is being treated as a strategy for protecting existing houses in some local authorities. As the comprehensive plans are revised, efforts are being made to integrate climate adaptation issues to a larger degree.

Even though adaptation also concerns companies of various kinds, this report only identified a few examples of adaptation activities in private companies (which to some extent could be explained by the method selected for this study). The most common approach appears to be investigation of needs and not of adaptation work, as is the case e.g. with energy supply.[74] One exception is the winter sports companies, which are trying to adapt to a changing climate through efficiency improvements in the artificial snow supply and ground preparation to reduce the need for snow fall.[75] One company claims that it will no longer build new slopes without artificial snow production and has a strategy to geographically diversify its facilities to reduce its exposure to varying weather conditions.

[73] Malmö Local Authority, 2008.
[74] Gode et al., 2007.
[75] Rummukainen et al., 2005.

5 Main Conclusions and Discussion of Transferability

Climate adaptation work has gradually started to take place at different levels in Swedish society. Most work to date involves responses to extreme weather events during the past decade and the adaptation work is mainly incorporated into the existing organisational structure for crisis management in general. This concluding chapter summarises Swedish experiences and discusses the Swedish organisation of climate adaptation. It also raises the issue of transferability and discusses what could be learnt from the Swedish experiences.

5.1 Conclusions from the Swedish experiences

Climate adaptation work is characterised by networks and collaborations between different kinds of actors. One explanation for this is that working in networks or partnerships is an adequate way of dealing with uncertainties, i.e. uncertainties can be reduced through incorporating different forms of actors. A side-effect of this is that the responsibility is diffused and the political leadership is not solely responsible for eventual failures.[76] Nevertheless, even though cooperation and actor involvement are considered a necessity, central government could take a strong position in establishing the framework from which specific actions emanate, e.g. requiring that risk and vulnerability analysis should include predicted climate change and extreme weather events. The need for a responsible actor is evident from the investigation of local authorities' work on climate adaptation. This does not necessarily mean responsibility for the outcome, but responsibility for driving the adaptation process forward. The experiences from local actors also demonstrate the need for expert support, particularly in the case of small local authorities. It will be interesting to see how the Climate Adaptation Portal and the system of Climate Coaches provided by central government can be developed to provide such support.

Swedish adaptation work to date is mainly orientated towards dealing with extreme weather events, which is not a problem since these historical extreme events provide empirical data relevant for preparing for future events.[77] The main experiences in Sweden thus involve extreme high water levels, flooding and hurricanes. Nevertheless, we would like to emphasise the need to include future climate change scenarios in adaptation work in preparation for new types

[76] Montin, 2009.
[77] Naess et al., 2005.

of events, e.g. new forms of disease, longer periods of warm weather, and changing conditions in the Baltic Sea.

From the starting point of the OECD division of adaptation measures into institutional and specific or local,[78] the Swedish experiences concerning institutional measures principally involve a change in the Planning and Building Act. Buildings must now be located on land suitable for that purpose. In addition, the Commission on Climate and Vulnerability has proposed to extend the timeframe for which local authorities are financially liable for the consequences of flawed planning (from 10 to 20 years). The specific and local measures mostly deal with higher water flows, while adaptation actions comprise an increased minimum level for building foundations (e.g. Halmstad, Lomma and Vellinge), dykes around areas vulnerable to flooding or higher sea levels (e.g. Arvika and Vellinge), and investment in new pumping systems (Kristianstad).

The organisation of adaptation work to date has been integrated into existing structure for physical planning. The strength of using existing processes, as argued by Urwin and Jordan, is that the structure is already available and, depending on the experiences, the processes can be changed.[79] Nevertheless, this approach takes for granted that there already exists an institutional framework for physical planning and/or crisis management. Countries that lack this structure are much more vulnerable to all kinds of crises and, as such, to future climate change.[80] In Sweden, physical planning and crisis management are two major obligations of relevance for climate adaptation work, i.e. the mandatory comprehensive plan and the risk and vulnerability analysis could play significant roles. It has become evident that local authorities that are used to making and updating e.g. the comprehensive plan are more inclined to incorporate climate adaptation issues.

5.2 Transferability of Swedish experiences

The Swedish work on climate adaptation is under development and the number of specific climate adaptation projects is rather few. Nevertheless, in the literature on climate adaptation strategies, there is a distinct emphasis on the local community and the need for cooperation. Swedish politics could thus be used as an example of how this can function in practice. The local level – the local authority – is self-determining to a certain degree and Sweden has a long tradition of cooperation between various societal actors (labour unions, politics and industry). According to Smit and Wandel, climate adaptation is the least

[78] OECD, 2006.
[79] Urwin and Jordan, 2008.
[80] UNDP, 2007. pp. 182-184.

developed research area in the field of climate change research.[81] Research on Swedish climate adaptation work could thus serve as an example of climate adaptation practices. However, transferring the experience from one local arena to another is difficult and the difficulties are similar to those concerning how to define successful adaptation.

How can success in relation to climate adaptation be defined? Adger et al. argue that this is often done in terms of efficiency, i.e. that an action has been efficient in meeting a certain objective. In estimating efficiency, it is crucial to pay attention to factors such as robustness to equity, uncertainty and flexibility, i.e. an ability to change in response to altered circumstances.[82] The most prominent reasons for this are: (1) The exact effects of climate change are very uncertain; (2) an action could be considered efficient for one specific objective, but it could entail negative side-effects on other spatial and temporal scales; and (3) an action could be effective for one agent, but could produce negative externalities potentially increasing impacts on others or reducing their capacity to adapt. The definition of success therefore clearly depends on the spatial and temporal scale, and should not simply be assessed in terms of the stated objectives of individual adaptors.[83]

Transferring experiences from one arena to another, or one country to another, could be important in motivating or inspiring adaptive work. However the uncertainties expressed above concerning estimation of efficiency must be taken into account. Most actions have long-term effects (not least in the case of physical planning) and a flexible system that can be changed throughout changing circumstances is less vulnerable. However, the most fundamental issue from a global approach is the existence of any form of crisis management system and an infrastructure for society in general. In that respect, wealthy nations have a crucial responsibility in assisting the most vulnerable countries to prepare for climate change, but also for other kinds of vulnerabilities.[84]

[81] Smit and Wandel, 2006.
[82] Adger et al., 2005. p. 81.
[83] Adger et al., 2005. p. 80.
[84] See e.g. discussion in Chapter 4 of UNDP, 2007.

List of abbreviations

MSB: Swedish Civil Contingencies Agency

SALAR: Swedish Association of Local Authorities and Regions

SEK: Swedish kronor

SEMA: Swedish Emergency Management Agency

SFS: Svensk författningssamling (Swedish Collection of Acts)

SGI: Swedish Geological Institute

SMHI: Swedish Meteorological and Hydrological Institute

SRSA: Swedish Rescue Services Agency

SEPA: Swedish Environmental Protection Agency

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