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Climate change in Norway: Analysis of economic and social impacts and adaptations

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Sammendrag:

Denne rapporten går gjennom resultatene fra flere studier av samfunnets sårbarhet overfor klimaendringer, som ble gjennomført i Norge I tidsperioden 2000 til 2004. Disse studiene hadde som mål å utvikle metodisk rammeverk for analyse av sårbarhet og klimaeffekter; å identifisere de sårbare økonomiske sektorer og geografiske regioner i Norge og de viktigste faktorene som fører til denne sårbarheten; å identifisere sårbarhet overfor tiltak for å redusere utslipp av klimagasser; og å analysere institusjonelle strukturer som legger til rette for eller forhindrer tilpasning til klimaendringer. Vi konkluderer at sårbarhet er veldig differensiert mellom økonomiske sektorer og geografiske regioner. Mange klimaeffekter blir først tydelige når belastningen overskrider en viss terskel. Selvom Norge som nasjon ofte har blitt antatt å kunne vinne på klimatisk oppvarming viser analyse av den samfunnsmessige konteksten til klimaendringer blant annet at det er strukturelle hindringer for klimatilpasning som kan forsterke potensielle negative effekter i sårbare sektorer og regioner. For å øke vår forståelse av sårbarhet i Norge bør videre forskning benytte fler-metodiske, fler-skala og tverrfaglige innfallsvinkler. Dette er spesielt viktig fordi de viktigste klimaeffektene ikke belyses ved å analysere begrenset til isolerte system, sektor eller skala.

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Abstract:

In this report, we review the findings from a number of studies carried out between 2000 and 2004 in order to shed light on the likely socioeconomic impacts of climate change in Norway. These studies have been aimed at: first, developing a methodological framework for impacts and vulnerability analysis; second, identifying the most vulnerable sectors and regions of Norway and identifying the main factors that contribute to this vulnerability; third, identifying vulnerability to greenhouse gas mitigation policies; and fourth, analyzing the institutional structures that promote or constrain adaptation. We conclude that vulnerability to climate change is highly differentiated between regions and sectors. Many climate impacts are only likely to be visible once thresholds are surpassed. While Norway has sometimes been regarded as a potential winner from increased warming, analysis of the social and economic circumstances of climate change impacts shows that there are important barriers to adaptation that may exacerbate negative impacts in certain sectors and regions. Moving forward with these findings implies increased focus on multi-method, multi-scale and interdisciplinary research. In particular, the most important climate impacts may not be captured in studies focusing on a single system, sector or scale.

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1 Introduction

The 1990s was the warmest decade and the 1900s the warmest century during the last 1000 years. In a hundred years, the average surface temperatures have increased by 0.6 ± 0.2 °C (IPCC 2001a). This warming is expected to escalate in the future, as scenarios show a warming of globally averaged surface air temperature by 1.4 to 5.8 °C by 2100 relative to 1990. The warming increases moving northward. Downscaled models for Norway project an increase in annual mean temperatures of between 1 and 2.5 °C for 2030-49 as compared to 1980-99, with the greatest warming occurring inland and in the north (Benestad 2002; Hanssen-Bauer et al. 2003). This warming is likely to be accompanied by an increase in precipitation of about 10% by 2050.

The effects of human-induced climate change are already visible in natural ecosystems (Parmesan and Yohe 2003; Root, Price et al. 2003). The impacts from further warming are likely to be even more pronounced and severe, and some species, ecosystems and social groups are likely to be threatened. In contrast to many other regions, Norway is unlikely to experience large disasters or a large number of deaths as a result of climate change. Given the relative frigid annual average temperature in Norway, some changes may even be advantageous, with agricultural productivity likely to increase, for example. Regardless of whether impacts related to climate change are seen as challenges or opportunities, they will presumably be met with adaptation, or adjustments that minimize negative effects and take advantage of positive effects. As a nation, Norway scores well in all characteristics that determine adaptive capacity, including economic wealth, technology, education, information, infrastructure, access to resources, and institutional capabilities. Thus from the national level, single stressor perspective, Norway appears resilient (O'Brien et al. 2004a). Most climate change impacts studies in Norway – and in Europe in general – have been carried out on different sectors and ecosystems using climate scenarios generated by global circulation models. However, O'Brien et al. (submitted b) point out that whereas these studies demonstrate the nature and extent of the climate problem, they provide insufficient understanding of the real implications of these changes for society. Studies taking a more holistic approach, such as a recent study that looks at social and economic changes affecting vulnerability in the light of how society responds to climatic and other stressors, suggest that climate change impacts in Norway may not be trivial, and that there are challenges to climate change adaptation (O'Brien et al. submitted b). Adaptation has so far received minimal attention both within research and policy, however, and often appears as an afterthought represented in technical solutions once impacts have been identified and measured.

In this report, we review the findings from a number of studies carried out between 2000 and 2004 in an attempt to shed light on the likely socioeconomic impacts of climate change in Norway. These studies have been aimed at the following: i) developing a methodological framework for impacts and vulnerability analysis; ii) identifying the most economically vulnerable sectors and regions of Norway, and identifying the main factors that contribute to this vulnerability; iii) determining the socio-economic vulnerability of different sectors and regions to climate change mitigation policies; and iv) analyzing the institutional structures that promote or constrain adaptation. The report begins with a presentation of recent conceptual and methodological developments in climate impact research. Focus is placed on vulnerability and related concepts such as exposure, sensitivity and adaptability. Following the conceptual discussion, a number of CICERO-led research projects regarding impact and vulnerability are reviewed, focusing on objectives, main results and publications.

Five critical issues emerge from examining recent research regarding socioeconomic aspects of climate change. First, climate change is likely to have large effects on sensitive and marginal ecological and social systems. The sustainability of species and livelihoods in the Arctic region is particularly at risk with increasing temperatures because many of the ecosystems operate at their southernmost boarder. In addition, Norway has a climate-sensitive economy, as much industrial production and employment is based on climate dependent

sectors such as agriculture, fishery and aquaculture, forestry and hydropower. Whereas agriculture is perceived to benefit, other sectors such as transport and infrastructure are likely to face adverse effects from climate change. A second critical issue is our limited understanding of uncertainties inherent in climate change impacts. There are likely to be thresholds in responses in natural and social systems to climate impacts. Third, multiple stressors may interact with climate change to amplify or reduce vulnerability. Research shows that climate change is not taking place in isolation from other ongoing environmental and social processes. People are facing multiple stressors; in some cases, regions, social groups or sectors are doubly exposed. Fourth, vulnerability is scale dependent, and the vulnerability of an individual or household can be very different from the overall vulnerability of a social group, region or economic sector. Fifth, and related, while Norway has a high technical and financial capacity at the aggregate level, the ability of communities to adapt is highly differentiated within Norway, depending on economic wealth, social structures, and previous experience with climate variability. As systems are faced with adversity or opportunities, social and natural systems will seek to adapt to the changing circumstances. Hence, vulnerability is shaped not only by exposure, but also by underlying social and economic conditions that shape adaptive capacity. This capacity is not equally distributed in society. Despite increasing research attention paid to the role of adaptation, the process of adaptation is still little understood: who adapts, to what and why? Thus the general notion that the Norwegian society is resilient and well-equipped with strategies for coping and adapting to climate change underestimates the different sources and levels of vulnerability of particular regions or social groups. Sixth, the importance of adaptation has to a large extent been neglected within policy. Until now, climate policy has been equated with greenhouse gas mitigation policies and has not included measures aimed at reducing harmful effects or taking advantage of opportunities produced by climate change.

2 Vulnerability and related concepts

Vulnerability has emerged as a crucial concept both in environment, development, and global change discourses as well as in practical decision-making. (See Sen 1981; Liverman 1990; Watts and Bohle 1993; Blaikie, Cannon et al. 1994; Dow 1992; Downing 1991; Adger 1996; Cutter 1996; Vogel 1998.) Vulnerability is applied as a framework for understanding how global change processes are manifested at the local level. The contribution from various research fields and disciplines to the conceptualization of vulnerability has been tremendous. As reviewed by McLaughlin and Dietz (2002), there has been widespread cross-fertilization and convergence of theoretical perspectives on vulnerability in recent years. Nevertheless, numerous theoretical and methodological orientations can be identified in current vulnerability research, including hazards literature, food insecurity and famine literature, and more recently within climate change studies. These various fields have all come to recognize that the physical or technical nature of a hazard or natural event, be it a storm or drought, cannot alone explain why some groups are more at risk than others (Wisner 1993; Blaikie, Cannon et al. 1994; Cutter 1996).

With increasing concerns about the potential adverse impacts of climate change, a growing number of studies have examined vulnerability by taking global levels of climate change as a starting point (see McCarthy, Canziani et al. 2001). These studies focus on vulnerability and the related concepts of exposure, sensitivity and adaptability (see textbox). These are characteristics of systems that jointly determine the extent to which a system is susceptible to sustaining damage from climate change (McCarthy et al. 2001). Exposure relates to the climate stress, including climate change, variability and extremes, experienced by a system. Chambers (1989) contrasts the external aspect of vulnerability, or the shock or stress to which an exposure unit is subject, with an internal aspect of vulnerability, the latter referring to a lack of means to cope and a situation of defenselessness. Exposure units in impacts assessments can include geographical regions, countries, sectors, ecosystems and social

groups. Some definitions of social vulnerability exclude exposure, a biophysical component (Blaikie, Cannon et al. 1994). Kelly and Adger (2000) on the other hand argue that vulnerability and exposure are inseparable because the exposure and resulting impacts set the context for the study. The question “vulnerable to what?” is essential in studying vulnerability.

Factors influencing climate vulnerability

Exposure is the degree of climate stress upon a particular unit of analysis. Climate stress can refer to long-term changes in climate conditions or to changes in climate variability and the magnitude and frequency of extreme events.

Sensitivity is the degree to which a system will respond, either positively or negatively, to a change in climate. Climate sensitivity can be considered a precondition for vulnerability: the more sensitive an exposure unit is to climate change, the greater the potential impacts, and hence the greater the vulnerability.

Adaptability is the capacity of a system to adjust in response to actual or expected climate stimuli, their effects, or impacts. The latest IPCC report (McCarthy et al., 2001, p. 8) identifies adaptive capacity as “a function of wealth, technology, education, information, skills, infrastructure, access to resources, and stability and management capabilities.”

Source: Smit, Burton et al. 2000; McCarthy, Canziani et al. 2001.

Sensitivity is the “degree to which a system will respond to a given change in climate, including beneficial and harmful effects” (Smit, Burton et al. 2000). However, a sensitive system is not necessarily vulnerable, as systems tend to respond to mitigate the adversity. Societies initiate actions to withstand, cope, recover, and adapt to stresses put upon them. Whereas coping strategies can be seen as a short-term response to secure livelihood within the prevailing systems in periods of stress (Davies 1993), adaptation includes longer term “adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts” (Smit, Burton et al. 2000, p. 881). The capacity to change the institutional arrangements and strategies for securing livelihoods is a “function of wealth, technology, education, information, skills, infrastructure, access to resources, and stability and management capabilities” (McCarthy, Canziani et al. 2001). Research shows that the most vulnerable are often those most exposed to stress and who have limited coping capacity and who are thus least resilient (Bohle, Downing et al. 1994). Improving resilience is important in efforts to enhance systems adaptive capacity and facilitate adaptation (Adger 2000b; Folke, Carpenter et al. 2002).

A myriad of characteristics, phenomena or processes – operating at different scales – influence the levels of vulnerability. Many studies following the work of Sen (1981) relate the levels of vulnerability to the availability and distribution of entitlements (Watts and Bohle 1993; Bohle, Downing et al. 1994; Cutter 1996; Hewitt 1997; Kelly and Adger 2000). According to this perspective, vulnerability is created by political, demographic and economic structures of resource ownership and control (Bohle 1993). These structures are what Cutter 1996) defines as root causes of vulnerability and coping capacity. Thus any attempt to reduce levels of vulnerability have to tackle the underlying causes of unequal distribution of resources, such as social and economic processes and institutional structures in the prevalent political economy (Adger and Kelly 2001). Within this framework, Kelly and Adger (1999) distinguish between individual and collective vulnerability. Individual vulnerability is determined by access to resources, the diversity of income sources, and social status within a

community. Collective vulnerability, meanwhile, is determined by infrastructure, income, and institutional and market structures. According to Adger and Kelly (2001), increased inequality leads to increased collective vulnerability, as a lack of access to resources constrains coping and in turn affects distribution of poverty.

3 Methods

No single focus can provide a complete picture of climate change impacts; consequently, several methodologies have been developed to assess the socioeconomic impacts of and vulnerability to climate change. These methods include biophysical modeling, economic modeling, integrated systems modeling, vulnerability assessments, and analogue and empirical or statistical analysis. Some of the methods are quantitative, relying on aggregate data and modeling. The majority of studies, in particular the early ones, take climate change scenarios as a starting point for determining potential impacts. Climate scenarios driven from GCMs (general circulation models simulating the global climate) have been applied in models projecting direct and indirect effects of climate change on various systems. Prior to the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (Watson, Zinyowera et al. 1996), a lot of research was directed at assessing the biological impacts of climate change in various sectors. As reflected in the Third Assessment Report (McCarthy, Canziani et al. 2001) the tool box has since expanded to also include the human dimension of climate change and cross-sectoral issues concerning vulnerability, adaptation and decision making. There have also been efforts directed at valuing impacts in monetary or economic terms within and across sectors and activities. These scenario-driven impact studies provide aggregate estimates of residual impacts after projected adaptation has taken place. Vulnerability, or such net impact, is the end point of such analyses. Figure 1 shows the sequence of analysis applied in the IPCC working group 2.

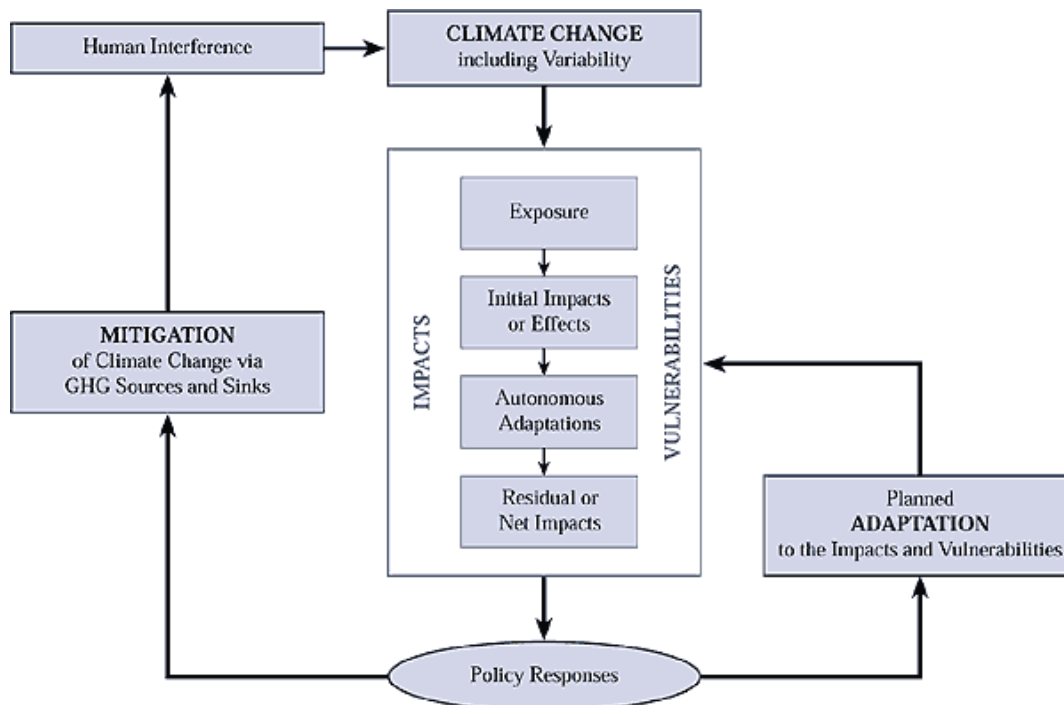


Figure 1. Sequence of analysis applied in the IPCC WG II – Exposure, impact, adaptation and vulnerability (Source: Smit, Burton et al. 1999).

A fast growing field of vulnerability assessment has attempted to bring vulnerability to the foreground of the analysis of climate change impacts (Downing 1991; Bohle, Downing et al. 1994; Ribot 1996; Adger 1999; Handmer, Dovers et al. 1999; Moss, Brenkert et al. 2001). Considering vulnerability as the *focal point* rather than *end point* of analysis entails profound shifts in emphasis. Societal conditions and processes rather than projected changes in climatic and environmental parameters are at the core of assessing who is likely to be adversely affected by a natural hazard. This approach focuses on identifying the underlying causes of vulnerability, and emphasizes the role of economic, social and cultural context. Studies rely on locally-specific information regarding exposure, sensitivity and adaptive capacity, and are bottom-up rather than top-down in nature.

4 Vulnerability and impact studies in Norway: A brief overview

Over the past few years, several projects have been undertaken in Norway for the purpose of enhancing our understanding of the socioeconomic impacts of climate change. Much of the work has been towards developing conceptual and quantitative models for understanding Norway's economic and social vulnerability. Several case studies have been carried out in parallel. This extensive research material on socioeconomic aspects of climate impacts, vulnerability and adaptability is the basis for this report. In this section, we present four major research projects in the field of climate impact and vulnerability research undertaken at the Center for International Climate and Environmental Research – Oslo (CICERO) since 2000.

The project *Socio-economic impacts of climate change in Norway: A pilot study* (2000-2004) represents the first step toward assessing the impacts of climate change in Norway and understanding the issue of vulnerability to climate change in the context of an affluent country. This project aimed to develop a preliminary understanding of the socio-economic impacts of climate change for Norway. As part of this study, O'Brien et al. (2004a) carried out a multiscale assessment of climate change impacts and vulnerability in Norway. Findings show that vulnerability depends on the scale of analysis. Both exposure and the distribution of climate sensitive sectors vary greatly across scale. The underlying social and economic conditions that influence adaptive capacity similarly vary. These initial findings challenge the common notion that climate change will necessarily be beneficial for Norway and that the country can readily adapt to climate change. Aunan and Romstad (2004) examine the potential effects of accelerated sea-level rise (ASLR) in Norway. While the topographical and geomorphological features, including a generally steep coastline and resistant coasts, suggest a low physical vulnerability to ASLR, they find that areas highly dependent on economic activities in the coastal zone and western and northern coastlines (where an extensive and well-developed infrastructure of roads, bridges and ferries link cities, towns and villages) are likely to be negatively affected by sea-level rise.

Following these early investigations, a project was initiated to develop the methodological foundations for an analysis of the regional impacts of climate change in Norway was started. The project *Climate change impacts and vulnerability in Norway: A regional assessment* (2001-2002) focused on new approaches to research on the vulnerability of different regions and economic sectors to changes in climate and climate variability. As part of this study, O'Brien et al. (2004b) explore two competing interpretations of vulnerability in the climate change literature and consider the implications for both research and policy. The practical interpretations of the two interpretations are illustrated through the examples of Norway and Mozambique. Eriksen and Kelly (In Press) compare the indicators and measures that five past national-level vulnerability studies have used and examine how and why their approaches have differed. They address the issue of how to develop credible indicators of vulnerability to climate change that can be used to guide adaptation policies.

Focusing on local vulnerability to both climate change and mitigation policy, the project *Climate change vulnerability in Norway: Socio-economic perspectives on policies and impacts (2001-2005)* aimed to gain a deeper understanding of the socio-economic impacts of the climate change issue in Norway. Thus, the project aimed identified “winners and losers” in terms of climate policies and climate impacts. As part of this study, Aandahl (2004) examined governmental statistics and insurance records related to extreme weather events. Lisø et al. (2003) investigated the effects of extreme weather on the building sector. Kasa (2003) examined the political positions and strategies that Norwegian industrially based municipalities have in the political processes determining regulations regarding greenhouse gas emissions. The vulnerability of communities to climate change mitigation policies was then mapped at the municipal level, based on an index composed of three sets of indicators: employment in industry or petroleum-related activities; level of industrial CO₂ emissions; and adaptive capacity. O’Brien et al. (2003) mapped vulnerability to climate change among Norwegian municipalities, selecting agriculture, winter tourism and forestry for analysis. As part of this project, an analytical framework for assessing of socioeconomic impacts of climate change to Hordaland county was also developed, based on a national accounting system.

A comprehensive research effort, *Climate change in Norway: Analysis of economic and social impacts and adaptation (2001-2004)* (IMP4) aimed to further develop conceptual and quantitative models for understanding Norway’s economic and social vulnerability to climate change, as well as develop a framework for analyzing the institutional responses that facilitate or constrain adaptation. A number of different study approaches were employed. For example, Aaheim and Schjolden (2004) developed an approach to utilize climate change impacts studies in national assessments. Further economic modeling was carried out in order to estimate the climate change impacts on agricultural productivity in Norway (Torvanger et al. 2003). Case studies were carried out on vulnerability in the transportation sector (Askildsen 2004), the agricultural sector (Gaasland 2004) and the tourism sector (Teigland 2003). The economic effects of extreme weather were investigated using the 1992 hurricane as a case study (Teigland 2002b). Groven (2004, In Prep) conducted a case study of the effects of the 1992 hurricane on emergency management and municipal planning in two municipalities in Western Norway. Aall and Groven (2003) explored the opportunities for strengthening climate adaptation in four key institutional systems: insurance, emergency management, environmental management, and municipal planning. Lindseth (2003, submitted) presents an empirically grounded perspective on work with climate change adaptation at the local level, on the basis of experiences in North America and Europe. Aall and Norland (2004) investigated the development of vulnerability indicators and argue for local level identification of biophysical, socio-economic and institutional vulnerability to complement scenario-based mapping of macro-level indicators. Næss et al. (In Press) investigated institutional barriers and constraints to adaptation in Norway, by examining municipal responses to the 1995 floods in eastern Norway.

The findings from this multiple-method approach show that the Norwegian economy is indeed sensitive to climate change, with both negative and positive effects; however, indirect economic effects and thresholds may be more important than aggregate direct effects. Furthermore, Norway’s ability to meet the challenges posed by climate change depends on its adaptive capacity, to which several barriers exist. Findings challenge the assumption that Norway – through its high economic, technological and institutional capacity at the national level – will automatically be able to adapt even if climatic changes should be dramatic.

Table 1 gives an overview of the studies reviewed here, including their objectives, main findings and publications.

Table 1: Vulnerability and impact studies in Norway

Project	Main objective	Main findings	Selected publications
<p>Socioeconomic impacts of climate change in Norway, 2000-2004</p> <p>Funding: Research Council of Norway and CICERO</p> <p>Partners: CICERO</p>	<ul style="list-style-type: none"> • Identify which sectors will be most affected by climate change • Analyze how the impacts of climate change will vary across the different sub-regions of Norway • Identify which regions are most vulnerable to climate change from a socio-economic perspective 	<ul style="list-style-type: none"> • Exposure, sensitivity and adaptive capacity vary considerably across scale, thus vulnerability is highly scale dependent • As scale differences are brought into consideration, vulnerability emerges within some regions, localities, and social groups. To cope with actual and potential changes in climate and climate variability, it will be necessary to acknowledge climate vulnerabilities at the regional and local levels, and to address them accordingly. • In comparison with many other countries, it appears that Norway – as a whole – will not be seriously affected by accelerated sea-level rise (ASLR). Nevertheless, some specific areas of Norway are highly dependent upon economic activities related to the coastal zone, which implies that the socio-economic impacts of ASLR in these areas may be significant. • Along the western and northern coastlines, the extensive and well-developed infrastructure of roads, bridges and ferries linking cities, towns and villages is likely to be negatively affected by sea-level rise. 	<p>Alfsen, Knut H., (2001) <i>Klimaet er i endring!</i>. Policy Note 2001:02. CICERO, Oslo, Norway. 12pp.</p> <p>Aunan, K. and B. Romstad. (In Press). Strong coasts, vulnerable communities: Potential implications of accelerated sea-level rise for Norway. <i>Journal of Coastal Research</i>.</p> <p>O'Brien, K., L. Sygna and J. E. Haugen. (2004a). Vulnerable or resilient? Multi-scale assessments of the impacts of climate change in Norway. <i>Climatic Change</i>, 64 (1-2): pp. 193-225</p>
<p>Climate change impacts and vulnerability in Norway: A regional assessment YEAR?</p> <p>Funding: Research Council of Norway</p> <p>Partners: CICERO and the Norwegian Meteorological Institute</p>	<ul style="list-style-type: none"> • Develop the methodological framework for impacts and vulnerability analysis 	<ul style="list-style-type: none"> • If the underlying causes and contexts of vulnerability are not taken into account, the magnitude, scope and urgency of climate change may be estimated for a country like Norway. • The policy relevance of national level indicators can be enhanced by capturing the processes that shape vulnerability rather than trying to aggregate the state itself. • Assumptions and conceptualization underlying 	<p>Eriksen, S. and M. Kelly (In Press). Developing credible vulnerability indicators for policy assessment. <i>Mitigation and Adaptation Strategies</i>.</p> <p>O'Brien, K., S. Eriksen, A. Schjolden and L. P. Nygaard (submitted a) What's in a word? Conflicting interpretations of vulnerability in climate change research. Journal article.</p> <p>O'Brien, K., S. Eriksen, A. Schjolden and L. P. Nygaard, (2004b) <i>What's in a word? Conflicting interpretations of vulnerability in climate change research</i>. Working Paper 2004:04. CICERO, Oslo, Norway 16pp</p>

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Project	Main objective	Main findings	Selected publications
<p>Climate change vulnerability in Norway: Socio-economic perspectives on policies and impacts, 2001-2005</p> <p>Funding: Research Council of Norway</p> <p>Partners: CICERO and Norwegian Institute for Urban and Regional Research (NIBR)</p>	<ul style="list-style-type: none"> • Gain a deeper understanding of the socio-economic impacts of the climate change issue in Norway • Identifying the sectors and regions that are most vulnerable to potential changes in temperature, precipitation, and the frequency and magnitude of extreme events • Distinguish the socio-economic vulnerability of different sectors and regions to climate change mitigation policies • Enhance understanding of the implications of the differential impacts of climate policies for social and political conflicts and for developing policies aimed at reducing this vulnerability 	<p style="text-align: center; font-size: small;">indicator selection needs to be made transparent.</p> <ul style="list-style-type: none"> • Both the exposure to closedown of industry in own or neighbouring municipality and industrial traditions influence the political leadership's position regarding greenhouse gas regulations, independent of political party affiliation. • The annual costs of all climate-related disbursement records amount to more than NOK 556 million. • Climate- related damages on buildings have been estimated to cost NOK 3 billion each year. • In addition to uneven exposure, some areas in Norway are more sensitive to climate change because climate-sensitive activities play a larger role in local economies. Furthermore, some communities have a higher adaptive capacity than others. 	<p>Kasa, S. (2003) Vekstmaskiner og horisontale nettverk: Klimapolitiske posisjoner og strategier overfor utslippsintensiv industri i fem norske industrikommuner. <i>Tidsskrift for samfunnsforskning</i>, 44 (3): pp. 367-390.</p> <p>Kasa, S. (2003) <i>Historiens kraftlinjer: Klimapolitiske posisjoner og strategier overfor utslippsintensiv industri i fem norske industrikommuner. Policy Note 2003-01</i>. CICERO, Oslo, Norway</p> <p>Lisø, K. R., G. Aandahl, S. Eriksen and K. Alfsen (2003) Preparing for impacts of climate change in Norway's built environment. <i>Building Research & Information</i> 31(3-4): 200-209.</p> <p>O'Brien, K., G. Aandahl, G. Orderud and B. Sæther (2003) Sårbarhetskartlegging - et utgangspunkt for klimadialog. <i>Plan: Tidsskrift for Samfunnsplanlegging, byplan og regional utvikling</i>, (5): pp. 12-17</p> <p>O'Brien, K. L. (2003) Regions, climate change and water: Issues of scale, environmental justice and governance Pages 181-206 in W. Lafferty and M. Narodslawski, (ed), <i>Regional Sustainable Development in Europe: The Challenge of Multi-Level Co-operative Governance</i>. Oslo: PROSUS</p> <p>Aandahl, G. (2004) <i>Kostnadene ved ekstreme værhendelser i Norge</i>. Unpublished report.</p>

Project	Main objective	Main findings	Selected publications
<p>Climate change in Norway: Analysis of economic and social impacts and adaptation, 2001-2004</p> <p>Funding: Research Council of Norway and CICERO)</p> <p>Partners: CICERO, Western Norway Research Institute (WNRI), the Foundation for Research in Economics and Business Administration (SNF), and The Program for Research and Documentation for a Sustainable society (ProSus)</p>	<ul style="list-style-type: none"> • Identify the most economically vulnerable sectors and regions of Norway, and identify the main factors that contribute to this vulnerability • Develop a theoretical framework for modelling the economic vulnerability of different sectors and local communities to extreme weather events and gradual change • Test the model through case studies • Analyze the institutional structures that promote or constrain adaptations • Integrate and synthesize the findings to draw conclusions and identify important areas for future research • Communicate results with policy members, stakeholders and the scientific community 	<ul style="list-style-type: none"> • The Norwegian economy, including sectors such as agriculture, transport and tourism, is sensitive to climate change, with both negative and positive effects • Indirect effects and thresholds may be more important than aggregate direct effects • Norway's ability to meet the challenges posed by climate change is dependent on adaptive capacity, to which there are currently several barriers • The transportation sector is relatively flexible in coping with weather interruptions, but most costs are borne by the individual transportation companies. • There are structural disincentives to proactive adaptation to climate change among municipalities. • Higher temperatures and longer growing seasons are likely to generally result in higher agricultural crop yields, and expanded areas suitable for crop cultivation. • Under climate change the current degree of self-sufficiency can be achieved with less budget support and higher economic welfare. When considered in the context of landscape conservation, rural settlement and biodiversity as main policy targets, however, the welfare gains are substantially lower, and possibly even negative. 	<p>Askildsen, T. (In Press). Extremværsituasjoner og Transporteffekter – Næringslivets Transporttilpasninger til Klimaendringer. CICERO Rapport.</p> <p>Groven, K. (In Prep) Natural disaster and adaptation: Hurricane experiences and preconditions for local climate change adaptation. In preparation.</p> <p>Groven, K. (2004) Naturskade og tilpassing. Institusjonell respons på orkan i to norske kommunar. VF-rapport. Sogndal: Vestlandsforskning</p> <p>Gaasland, I. (2004). Can Warmer Climate Save the Northern Agriculture? SNF-report 16, pp. 20, Institute for Research in Economics and Business Administration (SNF)</p> <p>Lindseth, G. (submitted) Local Level Adaptation to Climate Change: Discursive Strategies in the Norwegian Context. Journal article.</p> <p>Lindseth, G. (2003) Addressing Climate Adaptation and Mitigation at the Local and Regional Level: Lessons for Norway. ProSus Report no. 3/03</p> <p>Norland I.T., Næss, L.O., Lafferty, W., and Aall, C. (In Prep) Integrated vulnerability assessment for policy-making and adaptation: the need for a dualistic approach. Journal article.</p> <p>Næss, L.O. (In Prep a) Institutions and adaptation to climate change and variability: Synthesis of issues and a tentative framework for analysis. In preparation as CICERO Working Paper</p> <p>Næss, L.O. (In Prep b) Institutions and adaptation to climate change and variability: Synthesis of issues and a tentative framework for analysis. Journal article.</p> <p>Næss, L.O., Bang, G., Eriksen, S. and J. Veatne (In Press) Institutional adaptation to climate change: Flood responses at the municipal level in Norway. Global Environmental Change.</p> <p>O'Brien, K. S. Eriksen, L. Sygna and L. O. Næss, (Submitted b). Questioning complacency: Climate change impacts, vulnerability, and adaptation in Europe. Journal article.</p>

			<p>Teigland J. (2002a). Hvordan Vær og Klima Påvirker Reiselivs- og Rekreasjonsatferd. VF-rapport 11, 2002</p> <p>Teigland J. (2002b). Sosioøkonomiske Effekter av Ekstrem Vær i Norge – en Studie av Effekter i Tid og Rom av Nyttårsorkanen 1992. VF-rapport 7, 2002</p> <p>Teigland, J. (2003). Klimaendringer og Norsk Reiseliv. Er Sommerturismen på Vestlandet Klimafølsom? VF- rapport 6, 2003. Vestlandsforskning</p> <p>Torvanger, A. M. Twena, M. and B. Romstad (In Press). Climate Change Impacts on Agricultural Productivity in Norway. CICERO Report, Oslo.</p> <p>Aaheim, A. (2003). Sosioøkonomiske virkninger av klimaendringer: Metoder for å anslå virkninger på aggregert nivå. CICERO Working Paper no 5, Oslo</p> <p>Aaheim, A. and Schjolden, A. (2004) An approach to utilise climate change impacts studies in national assessments. <i>Global Environmental Change</i> 14 (2): 147-160.</p> <p>Aall, C. and K. Groven (2003): ”Institusjonell respons på klimaendringer: Gjennomgang av hvordan fire institusjonelle systemer kan bidra i arbeidet med å tilpasse samfunnet til klimaendringer” VF Report 3/03</p> <p>Aall, C. and Nordland I.T. (2004): Indikatorer for vurdering av lokal klimasårbarhet. ProSus-rapport nr.2/04</p> <p>Aall, C., Høyer, K.G. (In Press a) Re-structuring the tourist industry: policymaking. In Gösslong, S., Hall, C.M., Richardson, J. eds. (In Press): <i>Tourism and Global Environmental Change. Ecological, social, economic and political interrelationships.</i></p> <p>Aall, C., Høyer, K.G. (In Press b) Tourism and climate change adaptation - the Norwegian case. In Hall, C.M., Higham, J. eds (In Press): <i>Tourism, Recreation and Climate Change.</i> London: Channelview Press.</p>
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5 Climate change in Norway

The weather in Norway is known to vary considerably from one location to another, as well as between seasons. The southern part of Norway, in particular the coastal areas, shows a much higher annual temperature than areas further north. The wettest areas are located on the west coast, where the annual precipitation reaches 3575 mm.¹ The inner parts of East Norway² and the Finnmark Plateau in the north are considerably drier, with average annual precipitation as low as 278 mm. The occurrence of extreme weather events is also regionally differentiated. Norway's mountainous terrain in a frontal zone presents particular challenges to climate modeling. The mountainous terrain combined with the geographic location of Norway in the cyclonic west-wind results in the west coast being exposed to both unpredictable and strong winds. Windstorms and hurricanes tend to hit the coastal communities far more often than inland Norway. Storms generate by far the highest number of insurance claims annually in Norway. The inland areas, on the other hand, are more prone to floods hazards, which tend to have the highest costs per claim. The incidence of avalanches is highly dependent on local climate conditions and topography. Northern and western areas in particular frequently experience avalanches and landslides.

An increase in temperatures over the last century, similar to that which has been observed in the global average, has also taken place in Norway. There has been a significant increase in temperatures for almost all parts of Norway, ranging from 0.4 to 1.2 °C. Although fewer changes have been observed in total annual precipitation averages, there have been some seasonal changes over the past 25 years, with increased precipitation and increased frequency of intense precipitation events in western Norway. There has also been an increase in high speed wind events on the western coast of Norway. These developments are consistent with global level observations (Frei and Schär 2001; Frich, Alexander et al. 2002) that many regions have been witnessing more frequent extreme events the last 50 years. Similarly, Benestad (2003) observes that the high temperatures have been occurring more frequently in recent years in the Nordic region than one should expect under a stable climate (Benestad 2003). Although single events cannot be directly attributed to climate change, Norwegian temperatures conspicuously reached highest levels in the history of instrumental measurements on several occasions during 2003 (Benestad and Førland 2004).

The exact magnitude and rate of climate change that is likely to result from global warming is uncertain. General circulation models (GCMs) are complex, gridded, three-dimensional computer-based models of the climate system and form the basis for constructing climate change scenarios. Global scenarios show a general warming in Europe with the largest increase in northern areas, including Scandinavia (Hume and Carter, 2000). These scenarios indicate that mean annual temperatures in different parts of Norway are likely to increase by 0.1–0.5 °C/decade (Benestad 2002). The increase is largest during winter and smallest during spring and summer. This warming is likely to be accompanied by increased precipitation. Average annual precipitation in Norway is expected to increase by 35–55 mm over the next 50 years, with the largest increases occurring in the autumn (Benestad 2000). These scenarios, derived from results presented in the Third Assessment Report from the IPCC (Houghton, Ding et al. 2001) have been aggregated from GCMs³ with a grid size of about 300 x 300 km². These coarse-resolution models lack topographic detail for the Scandinavian Peninsula.

¹ Brekke in Sogn and Fjordane County.

² Oppland County.

³ The uncertainty regarding the positive temperature and precipitation trends can be attributed to variations in estimates of future greenhouse gas emissions, natural climate variability, and differences in the response of the climate system in individual GCMs to increased greenhouse gas concentrations in the atmosphere.

Coarse-resolution climate scenarios have shown to not fully capture regional differences in exposure to climate change for a country such as Norway. Norway has extensive mountain areas and a long coastline. In response, a multi-institutional initiative called Regional Climate Development under Global Warming (RegClim)⁴ (Iversen, Førland et al. 1997) has since 1997 been studying how climate may change in the future in Northern Europe and adjacent sea areas. As a first step, RegClim has produced one scenario that has been downscaled from the HIRHAM regional climate model and the ECHAM4/OPYC3 global scenario from the Max Planck Institute (which assumes a 1% p.a. increase in the CO₂ concentrations from 1990, estimating a near doubling in 2050). (Iversen, Førland et al. 1997; Haugen, Bjørge et al. 1999; Bjørge, Haugen et al. 2000). In Table 2 we show the results from a dynamic downscaling (downscaling involving the nesting of a finer-scale Regional Climate Model within the coarse-scale GCM, as opposed to empirical downscaling, which involves applying identified quantitative relationships between the observed large-scale and regional climate, to large-scale GCM output)⁵. These scenarios show that climate change is likely to differ across Norway, both in terms of magnitude and seasonality.

Table 2. Absolute change in temperature (c/decade) and relative change in precipitation and wind-speed (%) between 1980-99 and 2030-49. The results are from dynamical downscaling with the HIRHAM regional climate model of the ECHAM4/OPYC3 global scenario from the Max-Planck Institute, Germany, assuming a 1% increase in CO₂ concentration per year after 1990 (O'Brien et al. 2004a).

<i>RegClim Results</i>		<i>Temperature change (°C/decade)</i>	<i>Precipitation change (percent)</i>	<i>Windspeed change (percent)</i>
All	Whole year	0.24	9.33	1.89
	Spring	0.22	0.01	0.86
	Summer	0.17	9.79	0.02
	Autumn	0.28	16.70	4.25
	Winter	0.31	8.69	1.91
Northern Norway	Whole year	0.31	7.36	2.17
	Spring	0.28	5.08	1.38
	Summer	0.23	2.09	-1.06
	Autumn	0.33	17.16	3.57
	Winter	0.40	3.87	3.64
Southwestern Norway	Whole year	0.20	13.32	2.11
	Spring	0.19	1.19	1.11
	Summer	0.13	18.75	1.83
	Autumn	0.22	23.60	5.44
	Winter	0.24	8.21	0.20
Southeastern Norway	Whole year	0.21	4.16	1.13
	Spring	0.19	-4.39	-0.34
	Summer	0.13	1.71	-0.02
	Autumn	0.26	5.92	4.28
	Winter	0.26	13.91	0.45

⁴ WWW. Regclim.

⁵ See www.cru.uea.ac.uk/cru/info for further information

While regional scenarios offer insights into the likely range and nature of future weather scenarios, they should not be considered as forecasts in an absolute sense. In addition to uncertainties related to scenarios for global climate change, the effects of global warming on regional-level climate is not fully understood. For example, climate models differ in their indications of changes in the North Atlantic Ocean current (Gulf Stream) and in the extent of sea-ice cover in the Arctic. Such changes directly influence the climatic conditions in Norway (Lisø et al. 2003). As such, the scenario results presented below represent just one out of a range of possible climatic outcomes for Norway.

Annual average temperature is estimated to increase by 0.24 °C/decade. The warming is stronger in the northern areas (0.3 °C/decade) compared to southwestern areas of Norway (0.2 °C/decade) and the increase is estimated to be larger inland than at the coast due to the stabilizing influence of the ocean. Most warming will take place during winter and the smallest increase will be during summer. Figure 2 displays the distribution of temperature increases for the winter months December–February over the period from 1980–1999 to 2030–2049. The map shows that the polar regions are likely to be exposed to much larger increase during winter than areas further south, as the temperature is projected to increase by more than 2.5 °C /decade in the northernmost parts. This strong warming may have large implications both for the ecosystem and for human activities in the region (ACIA 2004; O'Brien et al. 2004c).

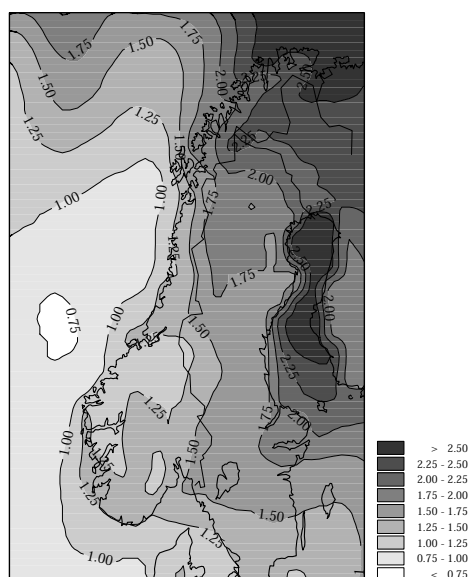


Figure 2. Change in winter temperature (Dec-Feb) over the period from 1980-99 to 2030-49. (Units: C). The results are from dynamical downscaling with the HIRHAM regional climate model of the ECHAM4/OPYC3 global scenario from the Max-Planck Institute, Germany, assuming a 1% increase in CO₂ concentrations per year after 1990 (O'Brien et al. 2004a).

Scenarios indicate that precipitation is likely to increase in all areas by an average of about 10%. The largest increase will be felt in southwestern regions, and along the western coast further north. Generally the largest increase will take place during late summer to early winter. In fact, southwestern Norway is expected to receive almost 25% more rain during autumn. Analyses show that increased precipitation will take the form of more events with heavy precipitation and not necessarily more rainy days. Figure 3 shows the regional distribution of the increase in number of days during autumn with more than 20 mm/day. Within the next 50 years the west coast is expected to have an additional 6 days or more with heavy precipitation (more than 20 mm/day) from September throughout November, and an additional two days per year with daily precipitation exceeding 50 m. Spring changes are

expected to be much less. In fact, there is a negative tendency in terms of a slight decrease in precipitation on the leeward side of the mountains in southeastern Norway.

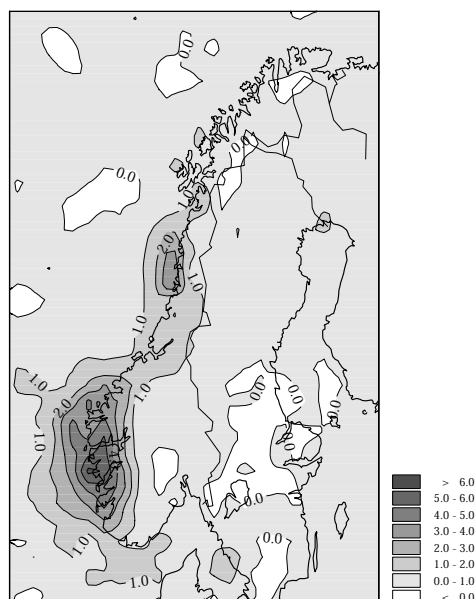


Figure 3. Change in autumn precipitation (SEP-NOV) over the period from 1980-99 to 2030-49. (Units: Number of days with $P > 20$ mm/day). The results are from dynamical downscaling with the HIRHAM regional climate model of the ECHAM4/OPYC3 global scenario from the Max-Planck Institute, Germany, assuming a 1% increase in CO_2 concentrations per year after 1990 (O'Brien et al. 2004a).

Changes in wind-speed are also presented in table 2. The changes are moderate with the largest increase in annual mean wind speed found in northern and southwestern coastal areas of Norway. This is also reflected in Figure 4, which shows a map of the simulated increase in mean wind-speed in percent over the next 50 years. The seasonal change in wind speed is potentially of greater importance, indicating a tendency towards stronger storms during autumns in all areas. For Northern Norway strong storms may also appear more frequently during winter.

Even at the very local level, exposure to climate change is likely to vary considerably. This difference can be attributed to influences of topography on local climates as well distance from the coast (O'Brien et al. 2004a). The method of empirical downscaling can be used to capture these local climate characteristics. In its second phase, the RegClim project has focused attention on empirical downscaling techniques. Temperature fields are downscaled for a global model in order to develop an empirical relationship between large-scale fields and the local climate (O'Brien et al. 2004a). This relationship is then applied on a large-scale field simulated with global climate models for the present and a future period. This method assumes that the statistical relationships are also valid under future climate conditions. Two empirically downscaled climate change scenarios for the southwestern region of Norway are presented in Table 3. The table shows that the scenario for the locations can be notably different even though they are only 60 km apart. The growing season in Voss is estimated to be extended by 27 days, whereas Sauda may experience a 19-day longer growing season in 2050. At the same time, Voss is likely become wetter, as yearly precipitation increases by 17% as compared to 11% in Sauda. More results are available at: <http://noserc.met.no/effect/>.

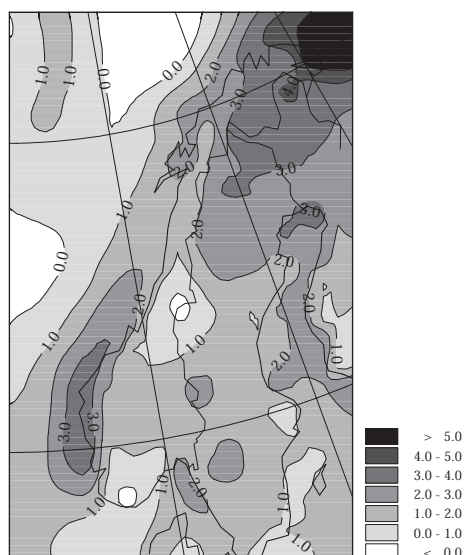


Figure 4. Change in annual mean wind-speed over the period from 1980-99 to 2030-49. (Units: %). The results are from dynamical downscaling with the HIRHAM regional climate model of the ECHAM4/OPYC3 global scenario from the Max-Planck Institute, Germany, assuming a 1% increase in CO₂ concentrations per year after 1990 (O'Brien et al. 2004a).

Table 3. Empirically downscaled climate scenarios for southwestern Norway. The results are from dynamical downscaling with the HIRHAM regional climate model of the ECHAM4/OPYC3 global scenario from the Max-Planck Institute, Germany, assuming a 1% increase in CO₂ concentrations per year after 1990 (O'Brien et al. 2004a).

Station	Sauda			Voss		
	Control (1981- 2000)	Scenario (2021- 2050)	Change	Control (1981- 2000)	Scenario (2021- 2050)	Change
Length of winter (T _{day} <0°C)	80	58	-22	108	82	-26
1st winter day (T _{day} <0°C)	8/12	19/12	+11	21/11	3/12	+12
1st spring day (T _{day} >0°C)	26/2	15/2	-11	9/3	23/2	-14
Length of growing season (T _{day} >5°C)	201	220	+19	184	211	+27
Yearly precipitation in mm	2207	2462	255 (11%)	1260	1473	213 (17%)

As the downscaling of global models improves, we will gain a better understanding of how climate change will be manifested at the local level. The downscaled model results are increasingly being applied in studies of climate change impacts. The simulations have been the basis for a number of impact studies in Norway.

6 Climate impacts and vulnerability in Norway: critical issues

6.1 Sensitive ecosystems, sectors and regions

The effects of climate change are not only the result of exposure to changes in climatic variables, but also the responses of natural and social systems exposed to these changes. These systems may respond either positively or negatively to these changes. In Norway, both natural and social systems can be characterized as highly sensitive to changing climate. In particular, the Arctic is among the most fragile regions in the world (McCarthy et al. 2001; ACIA 2004). The Arctic region has a unique environment that is host to rich biodiversity. At the same time, this region is home to some of the most sensitive ecosystems in the world. These areas are expected to experience a warming twice that for temperate and low latitudes, a change likely to be critical for species already living on the southernmost border of their habitats. The increased temperatures are also likely to influence the sea ice, ocean currents, vertical mixing and salinity, which in turn are critical to the region's biology and ecology (O'Brien et al. 2004c). According to the IPCC Third Assessment Report, "(c)hanges in sea ice will alter the seasonal distributions, geographic ranges, patterns of migration, nutritional status, reproductive success and ultimately the abundance and balance of species" (Anisimov and Fitzharris 2001, p. 804). Climate change will be critical to many species and ecosystems as adaptation options are limited. Thus, the Arctic is extremely vulnerable to projected climate change, and major physical, ecological, sociological and economic impacts are expected (Anisimov and Fitzharris 2001).

As humans depend on ecosystem services, society is affected through the first- and second-order impacts of climate change. Climatically sensitive sectors such as agriculture, forests, fishery and aquaculture, and hydro-electric power, are together with oil deposits, the basis of much of the industrial production and employment in Norway. Of particular importance is the role that these climate sensitive activities have at the regional level as sources for employment, livelihoods, and thus regional settlements.

The differential dependency on climate sensitive sectors implies that the impacts of climate change (both positive and negative) are likely to be felt more severely in some regions than in others. For example, fisheries and aquaculture are important sectors along the coast, from Rogaland in the south to Finnmark County in the far north. Forestry is mainly conducted in the interior south-eastern counties. Agriculture is practiced throughout the country; however, it is particularly important for inland municipalities in mid Norway. While the direct contribution to national GDP is small, agriculture directly or indirectly represents more than half of the employment in one of four Norwegian municipalities. In many rural areas, few employment opportunities other than agriculture exist. Most crop productions are highly sensitive to temperature, which, in addition to the amount and timing of precipitation is critical during the crop cycle. In the past, incomes from cereal and potato production, for example, have shown to be particularly variable as a result of inter-annual climate variations (Nersten 2001). In terms of future trends, higher temperatures and longer growing seasons (Skaugen, Tveito et al. 2002) are likely to generally result in higher agricultural crop yields, expanded areas suitable for crop cultivation, and introduction of new crops (Haglerød 1990; Gaasland 2003; Torvanger, Twena et al. 2003; Gaasland 2004). The fertilization effect of higher CO₂ concentrations in the atmosphere is also likely to contribute positively.

The general trends depicted above are likely to be manifested very differentially from one locality to the other. O'Brien et al. (2003) investigated exposure by mapping an index

comprising variables considered important to Norwegian agriculture. The variables included autumn precipitation, spring precipitation, length of the growing season, frost/thaw days in spring and autumn and winter snow depth. The index was first calculated for the current climate, and then adjusted to account for changes under 2xCO₂ conditions. The results were assigned to municipalities using an interpolation function. The resulting map (Figure 5) illustrates the differential exposure of agriculture to the impacts of climate change, based on the results of one climate model. Agricultural production in Western Norway and along the coast in Northern Norway is more prone to worsening climate conditions due to increased precipitation during spring and autumn, reduced snow cover, and the relatively moderate extension of the growing season compared to other areas in Norway. The inland municipalities in Eastern Norway, on the other hand, will be less exposed to unfavorable climate conditions in the future.

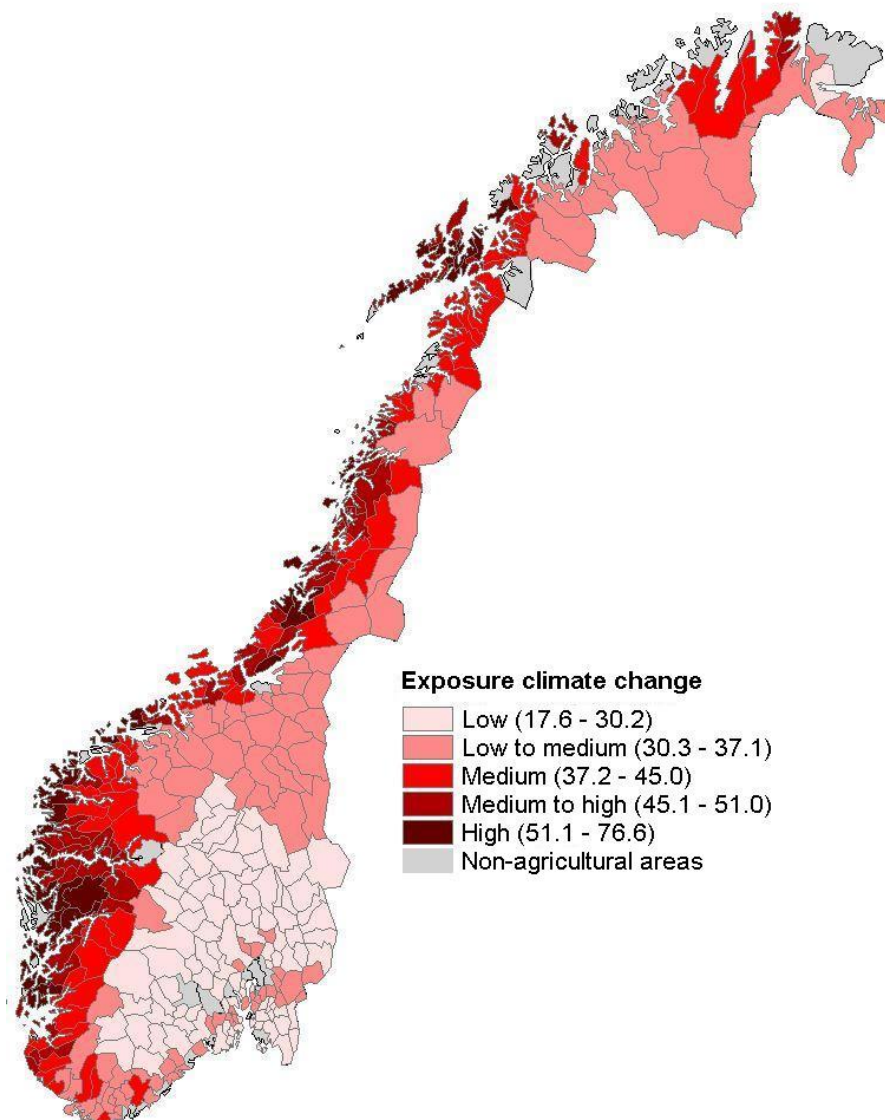


Figure 5. Composite index of agricultural exposure to climate change in Norway. The index is compiled from RegClim projections for spring and autumn rainfall, spring and autumn frost/thaw days, the length of the growing season, and average winter snow depth. The indices were calculated as absolute changes between the periods of 1980-2000 and 2030-2050. All indicators were equally weighted in the composite index.

This is in contrast to the findings of most national level impact assessments, which base their conclusions on scenarios generated by coarse-resolution model and imply that Norwegian agriculture will be a winner under climate change (Haglerød 1990; Parry 2000; Fischer, Shah et al. 2001; McCarthy, Canziani et al. 2001). A comprehensive study from 1990 for example, using global scenarios, estimates that the production of grain will increase by 35% and the production of fruit and berries will increase by 20% and 30% respectively (Haglerød 1990). Livestock production is potentially more sensitive to second order impacts from climate change, including forage quality and availability, than to the change in climate itself.

These results are supported by more recent studies. Using a regional climate change scenario, Gaasland (2004) estimate a 14% increase in wheat yields in the best lowlands of south-eastern Norway. Increases are found also for forage grasses and potatoes. Applying the same scenarios in a statistical model predict a 30% increase in potato yields in Northern Norway, with the largest benefits in Nordland country where the crop values were estimated to increase by almost 6 million NOK. Potentially undermining these positive changes is the potential increased risk of incidents of pests and diseases, soil erosion and nutrient deficiencies resulting from climate change (Hessen and Wright 1993). Torvanger and colleagues (2003) for example found that there was negative yield response to increased precipitation in many parts of Norway, particularly in the west. Erosion in agricultural areas with exposed soils is to a large extent determined by snow cover during winter months. Warm episodes during the winter increase the erosion manifold, with large effects on agricultural productivity (Ref NLH). However, all in all these studies suggest that the net impacts for this sector are likely to be positive. Using a numerical model, Gaasland (2004) finds that under climate change the current degree of self-sufficiency can be achieved with less budget support (-15%) and higher economic welfare. When considered in the context of the broader economic and political context, findings are less positive, however. As in most European countries, the agricultural sector in Norway is strongly regulated by the state. Total support to farmers in 2002 amounted to 71% of the total value of production. In recent years, the policy target has been landscape preservation, biodiversity and rural settling rather than production efficiency. Taking these factors into account, the Gaasland study suggests that the welfare gains are substantially lower, and possibly even negative.

While the agricultural sector may be a net winner under climate change, at least if the national average rather than geographic differentiation is considered, other sectors such as the construction industry, infrastructure, transport and tourism may potentially be net losers. The Norwegian population is highly diversely settled, and the building mass, the infrastructure and transport activity is exposed to more or less exhausting climate conditions throughout the year from the windy and wet coast to the dry and cold inland. Past climate related damages on buildings have been estimated to be NOK 3 billion each year (Ingvaldsen 1994). According to Lisø and colleagues (2003), these costs have been rising as the Norwegian buildings have become less robust over the years, partly due to demand for cost efficiency in the construction industry as well as changing preferences in house choice and location towards high-risk constructions. At the same time, the future prospect of increased precipitation and wind, as well as other meteorological triggered events, such as hurricanes, floods, avalanches, and landslides, is likely to heighten the cost further (Lisø, Aandahl et al. 2003). Norway has an extensive coastline which populates more than 40% of the total population. Projections show an increase in precipitation of as much as 30% in some coastal areas. A relatively closely knit system of electricity installations, lines of communication, roads, tunnels, bridges and ferries is vital for these communities. According to Lisø and colleagues (2003), increased heavy rains and in particular lashing rain is expected to increase dampness and material damage to buildings and infrastructure installations. Although sea-level rise is not considered a serious threat for Norway, Aunan and Romstad (2001) conclude that a rise in sea level is likely to have a negative impact on infrastructure in some areas, particularly along the western and northern coastlines. Another potentially more pressing concern along the coast is the potential increase in frequency and magnitude of storms. On New Year's Day, 1992, the western part

of Norway was hit by the strongest hurricane recorded in Norway, resulting in damages estimated at NOK 2 billion (Hessen and Wright 1993). More than 50,000 buildings and 2 million cubic meters of forest were damaged, as well as infrastructure, cultural monuments, fish-farming installations etc. (Teigland 2002b).

Altered flood patterns are yet another likely effect of changing climate. In particular, floods that strike populated areas cause great damage. The most serious among several severe floods taking place over the past few decades is the 1995 flood in southeastern Norway. This flood had a 200-year return period and resulted in damages in the range of NOK 1.8 billion. Several studies indicate that climate change is likely to alter the patterns of floods. The exact character of this change is not accurately known, but studies indicate that some of the changes may be detrimental to Norwegian society. Sælthun and colleagues (1998) find that if there is an increase in the frequency of underlying hydrological and meteorological triggering situations – such as late snow melt, high and extensive summer precipitation – these may coincide to produce larger floods more often. This will in turn affect hydro power installations and patterns of floods in the country. According to Skaugen (2003), the annual runoff is likely to increase in almost all parts of Norway. For the wettest areas on the west coast this means an additional runoff between 100 and 1100 mm/year, and most of this increase will take place during winter. Finnmark and inner parts of southern Norway are likely to have the largest increase in runoff during spring (Skaugen 2003). The likelihood of experiencing increased frequency of extreme flood events in an area depends to a large extent on the relative importance of the spring and autumn floods. Scenarios suggest that in areas where spring floods dominate in the present climate, flooding will generally decrease. Areas with autumn floods, on the other hand, may experience more extreme floods (Sælthun, Aittoniemi et al. 1998). In general, spring floods are more common in south-eastern Norway, whereas autumn floods tend to hit western regions more often.

A shift from spring flooding to autumn flooding increases the chances that the flood will hit a filled reservoir. Autumn floods are generally less predictable than the spring floods. In addition, reservoirs usually fill up from August onwards in order to meet the higher electricity demand during winter season. Aaheim (2003) shows that in order to generate benefit from increased runoff, there is likely to be substantial costs associated with rebuilding dams. Ice-drift in rivers during the winter is already a big problem along major rivers in Norway, creating barriers and leading to local floods. In the case of increasing temperature fluctuations, there are concerns that this will become a bigger problem in the future (NVE, 2003). The projected increase in local intense precipitation events may also lead to an increased frequency of flash floods in side rivers, which can cause considerable damage to buildings.

The transportation sector is highly sensitive to climatic events. For example, closed mountain passes, train cancellations and delays due to heavy snowfall, detours because of icy roads, and delays caused by the need to use wheel chains due to icy conditions already represent a challenge to the marketing of Norwegian exports. Askildsen (2004) finds that more frequent extreme events are likely to hamper the regularities within the transport sector even further. However, up to now, the sector has shown remarkable adaptability and flexibility when faced with transport irregularities. In most parts of the country, alternative routes and modes of transport are available if irregularities occur. Nevertheless, the large additional costs are largely covered by the transport companies rather than the producers of goods or export products. Although the state spends a significant amount of resources to maintain transport infrastructure, particularly extreme events have led to impacts beyond past experiences and coping ranges. Communities in northern Norway, for instance, have been vulnerable to transport irregularities in the past. This is exemplified by the heavy snowfall in the winter of 1997. Troms County received 717.2 mm precipitation and the maximum snow depth was 240 cm. According to Askildsen (2004), the transport sector faced additional costs of NOK 23.9 million. Transport both at land and sea as well as electricity supply in these areas are highly prone to risk from climate-related risks such as snow avalanches, storm and

heavy snowfall. In addition, the trend towards increased centralization and concentration of commodity trade has been particularly strong in Northern Norway (Tørmo et al., 2002). A study analyzing the risk and vulnerability of supply of main commodities in the northern-most part of Norway found that the main challenge is the isolation of communities over time (Tørmo et al., 2002). Such disruptions are most often caused by climate-related events. This sensitivity was articulated during the critical event of winter 2000 when more than 100 communities in Northern Norway were isolated due to bad weather conditions and snow avalanches (Verdens Gang, 01.02.00, Uværet: 27 veier stengt).

Tourism is yet another climate-sensitive sector that, despite being less important than the transport sector at the national level, has a strong regional dimension. With its place-specific characteristics, the tourist sector can be highly sensitive to the very local manifestations of climate change and related fluctuations in demand and preference of alternative destinations. Many of Norway's tourist attractions are based on outdoor activities, such as viewing fjords and glaciers. Although intuitively the weather plays an important role in determining the quality of such tourist activities, findings indicate that visitor numbers to some attractions may not be as sensitive to climatic conditions as expected. In a recent study Teigland (2003), addresses how weather and climate directly affects the choices of tourists. Two case-studies were carried out in the fjord areas in Sogn and Fjordane County on the west coast of Norway. Meteorological data (temperature, precipitation, and cloud cover) and indicator data for tourist numbers were analyzed to identify the relationship between climate and tourism in important areas for summer tourism in this region. One tourist attraction related to glaciers was selected for examination and several indicators of visits to the attractions were used to measure tourist visits. To assess the general applicability of the results, a comparative study in fjord districts of New Zealand was carried out. Although a main conclusion from the study is that the numbers of summer tourists visiting these kinds of attraction are not, in general, very sensitive to weather, the study indicates that the number of tourists is nevertheless somewhat sensitive to temperature, whereas the amount of precipitation seemed to play a minor role.

While the direct effects of increased temperatures on tourism seem moderate, the indirect effects may be more important. These are not yet well understood, however. Climate change is likely to affect the tourism industry not only through changing climatic conditions, but also through secondary effects such as changes in natural conditions, including reduced biodiversity and altered landscapes (Teigland 2003; Aall and Høyer In Press b). Since Norwegian tourism is strongly linked to experience of nature, changes in natural habitats are likely to affect the patterns of tourism considerably. Mountainous areas, with their open landscapes and characteristic fauna and flora, for example, attract a large number of visitors each year. These areas are shrinking year by year due to natural forestation (Austad, Røysum et al. 2001). Large areas are currently being reforested as a result of the dramatic reduction in summer grazing of large domestic animals. During the last 40 years, the number of cattle on summer grazing has been reduced by 70 percent (Aall and Høyer In Press b). The projected increase in temperatures and length of growing season is likely to reinforce and speed up this development.

Skiing is an activity that is deeply rooted in the cultural identity of Norwegians. In addition to the traditional popularity of cross-country skiing, the popularity of alpine skiing has grown, with the number of alpine constructions tripling between 1980 and 1995 (Stølen 1995). This trend has taken place in parallel with a general warming in many areas. For example, the number of days with acceptable snow conditions for cross-country skiing has been more than halved in Nordmarka, a very popular skiing area of 300 km² of wooded countryside situated just outside Oslo and serving the most densely populated area in the country. During the 1970s, the inhabitants of Oslo and surrounding areas experienced an average of 150 days of good conditions for cross-country skiing. Twenty years later, this number was reduced to 75 days (Bjørnbæk 2000). There are few alternative cross-country skiing areas within a reasonable day-trip distance; however, the impact of this development on the population has not yet been studied.

The number of Norwegians engaging in some kind of skiing (including alpine and cross-country skiing) does not, however, appear to have been dramatically reduced by the decrease in number of days of good skiing conditions during the 1980s and 1990s (Teigland 2002a). One reason for this is the large increase in the numbers of artificial snowmaking facilities. The large investments have been motivated by the potential for extending the season for downhill facilities as a way of increasing incomes. The costs of these installations are, however, very high. Almost 5% of all facilities are currently operating at the margin.⁶ This number is likely to increase as the cost of maintaining beneficial snow conditions and extended seasons increases with warmer winters. Such technical adaptations are not feasible as a way of extending or maintaining the cross-country skiing season because this activity, apart from competitions, is far less commercially oriented and is based on skiing longer distances and experiencing forest wilderness.

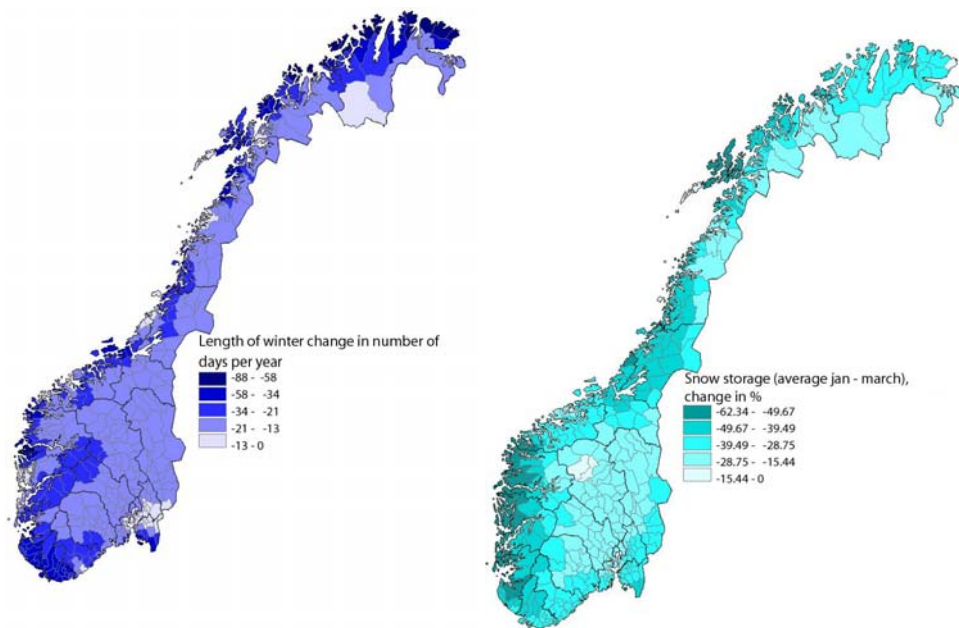


Figure 6. Maps showing the change in the length of winter as days/year and the change in snow storage as percent at the municipal level.

While many areas may face deteriorating skiing conditions, some locations may benefit from climate change. Warmer winters are likely to worsen the snow conditions in many areas. According to Skaugen (2003), the high mountain areas in the south and the northernmost areas of the country are projected to have an increase in snow storage (per the 1st of April), whereas the rest of the country is likely to have a reduction (see figure 6). The largest reduction is likely to take place in central areas in western Norway and mountainous areas in Nordland. Furthermore, the length of winter is reduced by as much as 58-88 days in some areas on the south-western coast and along the coast in the northern most country, Finnmark (see figure 6). In an attempt to visualize the differential climate exposure, O'Brien et al. (2003) constructed a climate sensitivity index for the tourism industry. Indicators were aggregated to a municipal level and put together in composite indices, as shown in Figure 7. Indicators include the length of winter and absolute and relative snow depth. According to figure 7, the coastal areas from the very southwest to mid Norway and the northern-most

⁶ A survey from 1998 showed that 25 out of a total of 800 alpine facilities were run with economic loss, and an additional 11 were in practice bankrupt (Norske Fjell AS 2000).

areas are likely to experience adverse climate conditions in future, from a winter tourism point of view,.

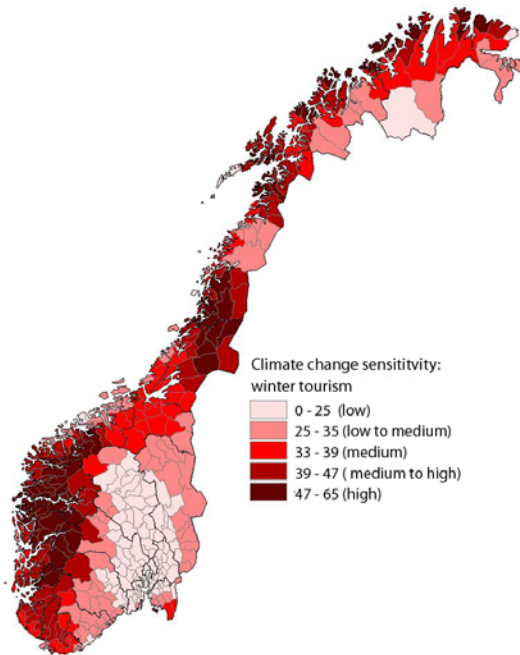


Figure 7. Map showing sensitivity for winter-tourism at the municipal level.

The skiing industry is particularly vulnerable in the years following a snow deficit, as people tend to adjust their travel behavior based on past snow conditions (Koenig and Abegg 1997). Resorts in southern Norway, such as Hemsedal, Trysil and Geilo, and resorts in the northern most areas of Norway, such as in Troms, are likely to benefit, whereas resorts in the west, such as Voss, and low lying resorts in southern Norway and Nordland are likely to be negatively affected. There are a number of indirect effects of changes in snow conditions that may affect winter tourism, potentially also in the areas projected to experience beneficial changes in snow conditions. For example, it is possible that as the urban population experiences less snow, their desire to visit relatively snow rich areas will also be reduced simply because they find it hard to relate to such conditions. These indirect effects have not yet been studied, however.

6.2 Uncertainty and thresholds

Global climate change implies increasing uncertainty regarding future climatic conditions at both the regional and local levels, in particular with regard to extreme climatic events (Mitchell and Hulme). In addition to the sensitivity of natural and social systems discussed above, there may also potentially be critical thresholds and unexpected effects that may heighten the seriousness of the climate change problem in Norway. The IPCC concludes that there are large uncertainties regarding the magnitude and character of the impacts (McCarthy, Canziani et al. 2001). There is inherent uncertainty in the analysis of both future climate conditions and the responses to such changes by natural and social systems. Climate scenarios provide a range of possible futures due to different assumptions regarding future emissions of greenhouse gases and the variability of the atmosphere, as well as the response of the atmosphere to a gradual change of the climatic forcing. In addition, the range of scenario

outcomes reflects an incomplete understanding of the physical relationships between different elements of the climate system at both the global and regional scales. As climate scenarios have been further developed over the past decade, the range of scenario outcomes has in fact increased for global temperature, as reflected in the difference between the second to the third IPCC assessment report estimates for 2100 (from 1-3.5°C in the second to 1.4–5.8°C in the most recent assessment report).

Extreme events are even more difficult to project due to the complex climatological relationships that form them and the local variations. According to Glantz (2001), the largest impacts from climate change are likely to be felt through extreme weather events. Due to nonlinear relationships in the climate system, an increase in variability can result in a substantial increase in the frequency of extreme impacts. Adding to this uncertainty is the possible altering of the ocean currents, such as the Gulf Stream, in response to climate change impacts. The climate conditions in Norway are highly dependent on the heat transported by the thermohaline circulation in the North Atlantic. A premise for this heat transport is the North Atlantic Drift, a deep-water formation that “pulls” the Gulf Stream northwards. During the past several decades, a significant reduction in deep-water formation has been observed (Houghton, Ding et al. 2001). It is thus possible that a weakening of the North Atlantic Drift may result in new periods of climatic instability in Norway and other areas, and possibly a negative feedback in terms of temperature changes (Davies, Cartwright et al. 2001). Recognizing the uncertainty of the climate system and our limited understanding of processes determining climate in Norway, the third phase of the RegClim project is focusing on developing a range of downscaled scenarios aimed at capturing the whole range of natural variability at the regional level. Comparing ensembles of scenarios will improve the detection of uncertainties and thus improve the accuracy of climate projections.

As we move further down the causal chain of first and second order impacts, uncertainty increases. Even though the relationship between climate, biological and social systems have been studied for more than two decades, understanding of the biophysical and social impacts of climate change is still limited. For instance, there is insufficient knowledge regarding how climate change is going to alter ecosystems and biodiversity in the Arctic region (ACIA 2004). The human dimensions of climate change are even less understood. Locally specific characteristics tend to shape vulnerability, thus making every individual, sector, or locality different from the others. At the same time, inter-sectoral and inter-regional interactions and dependencies add complexities to the analysis. An examination of the interactions between regions and sectors indicates that the impacts of climate change may be surprising, potentially taking on a different form than that expected from analysis of individual sectors (Aaheim and Schjolden 2004). Aaheim and Schjolden (2004) highlight the uncertainties of sectoral sensitivities, showing that sectoral studies seldom take into account the linkages between the sector of focus and other sectors of the economy, thus missing likely positive and negative indirect climate impacts on the sector. This is illustrated by the fact that the change in output from one sector may change the need for input from another sector. The study concludes that the indirect effects in fact exceed the direct effects of climate change in Norway.

6.3 Multiple stressors

Climate change is only one of many challenges facing society. Research shows that to understand the dynamics of vulnerability and adaptability, it is necessary to go beyond studies of climate change alone and *include multiple stressors in the analysis* (see O'Brien and Leichenko 2000; Leichenko and O'Brien 2002; and O'Brien et al. 2004c). Most traditional impact studies give little attention to present and future economic, political, social and cultural factors, which together with environmental change determine the adversity produced by climate change socio-economic conditions. Climate impacts may in some cases have synergistic effects with other stressors, whereby the combined effect is more harmful than the sum of the separate effects of the stresses (Harte, Torn et al. 1992). For example, the Arctic region is likely to be highly affected by climate change; yet climate change is only one of many stressors facing these areas, as radioactive pollution, offshore oil and gas exploration,

heavy metals and organic contaminants are becoming increasing concerns (O'Brien et al. 2004c). Studying the role of multiple stressors in the Barents Sea ecoregion, O'Brien et al. (2004c) find that the climate change impacts intersect and interact with other stressors, influencing the overall vulnerability of the ecosystem to human-induced pressures. The multiple stressors of transport and climate change together represent risks that are greater than additive impacts on health and habitat.

This pattern, whereby intersection of climate change with one or more other stressors compounds the effects of each stressor alone, is likely to be a critical characteristic of vulnerability in Norway. One of the greatest concerns in Norway is maintaining the current level of development in a post-oil economy. Another challenge is the aging of the Norwegian population. In the course of the next 30 years, retirement and disability payments will double relative to Norway's GDP growth, assuming that benefits remain at today's level (Ministry of Foreign Affairs 2002). Many of the above trends will result in fiscal constraints in the years to come. According to the OECD (2004), Norway may have to implement measures aimed at reforming social policies and economic transfers in order to maintain the growth of the economy. Such measures will affect individuals and sectors across Norway, potentially leading to increasing social and economic inequalities. The consequences are likely to be particularly high in sectors heavily dependent on governmental support, such as agriculture. This sector is also vulnerable to future international trade agreements. As is the case in most European countries, the agricultural sector in Norway is strongly regulated by the state. Total support to farmers in 2002 amounted to 71% of the total value of production (OECD 2004). The number of farm enterprises has declined by one third since the 1960, mainly due to structural changes (Statistics Norway 2000). This trend is likely to continue under current national fiscal policies, potential EU membership, and future WTO regulations. Climate change impacts and adjustments necessitated by changing climatological conditions may aggravate adverse effects of the above economic developments on the agricultural sector.

Preliminary findings indicate that the building sector may be among the sectors that are become increasingly vulnerable to climatic variability and change. For example, according to Lisø et al. (2003), the building sector is seeing a loss of, and declining consideration of, traditional building techniques. During the severe 1992 hurricane in western Norway, for example, most of the damage was suffered by new buildings while almost all older buildings survived with minor damage. Despite the existence of construction methods adapted to local climatic conditions and the development of new technologies that could further improve on the traditional techniques, housing structures are becoming less robust in the face of extreme events. The exact reasons for this development are not yet well known; however, Lisø et al. (2003) identified the following trends: Housing is increasingly constructed as pre-fabricated units with standardized methods; companies experience increasing pressures on economic profit and decreasing production costs; and people's preferences in terms of location of the houses in the landscape are changing, favoring locations with good views, which are also often more exposed to wind. Existing rules and regulations regarding building standards are also not being followed, one of the major reasons for the structural damage seen in 1992.

6.4 Multiple scales

Vulnerability is scale-dependent, in that the vulnerability of one individual or one unit may be different from the overall vulnerability of that social group or sector. According to (Mohan and Mohan 2002) this issue has been dealt with only in a pragmatic way in the vulnerability literature. Studying climate vulnerability in the Barents Sea ecoregion, O'Brien et al. (2004c) find that climate-induced changes in populations of cod, capelin or herring are likely to have widespread implications for the overall vulnerability of this area, as these species are keystone species that link different levels of the food chain. Such synergy effects are difficult to take into account in studies that have a single-scale approach. Similarly, aggregate or economic sector sensitivity to climate change may mask variations in vulnerability between social groups and geographic areas to such changes. At the same time, generalizations regarding the

pattern and distribution of vulnerability based on localized information may also be misleading because measures applied in one area may not be relevant in other areas or at other scales. Generalization across scales may thus hide the differential vulnerabilities and thus winners and losers under climate change (O'Brien and Leichenko 2001). For instance, in a multi-scale assessment of impacts and vulnerability in Norway, O'Brien et al. (2004a) find that as scale differences are brought into consideration, vulnerability emerges within some regions, localities and social groups. A major weakness in the current understanding of vulnerability in Norway is the lack of local context-specific vulnerability studies and analysis aimed at revealing the conditions, and combination of stressors, under which vulnerability is created (or conversely, resilience and new opportunities are fostered).

The issue of scale has also strong implications for adaptation research and policy. Measures to increase resilience and adaptive capacity are likely to be undertaken at the local and community level by various actors. As stressed by Adger (2001, p. 11), "the nature of adaptive capacity is such that it has culture and place specific characteristics which can only be identified through culture and place specific research (...) policy interventions for planned adaptation at national and other levels (...) may not be sensitive to these nuances and hence adaptive capacity will be differentially affected by such policies." However, any local decisions will be taken within and also in response to social, political and economic structures at higher geographical scales that may mandate, encourage and inform actions (Wilbanks and Kates 1999). Linkages between micro and macro scales are of vital importance when analyzing constraints and opportunities for adaptation. Maladaptation is likely to occur if the development of national adaptation measures does not take into account the local conditions and the processes at the local level that shape vulnerability. According to Berkes and Jolly (2001), coping and adaptation strategies must be seen as continuous along the temporal scale from the very local to higher scales. For a system to be absorptive or resilient, there needs to be well-developed institutional linkages for feedback and communication between the various spatial scales. Within the building sector, Lisø et al. (2003) find that "for measures to be effective ... these must come in tandem with larger societal and institutional adjustments." The above discussion reinforces the importance of scale in climate change research.

6.5 Differential adaptive capacity and barriers to adaptation

Although Norway's economy is sensitive to climate change, levels of vulnerability also depend on capacity to adapt. At an aggregate level, Norway is perceived to be well prepared to adapt to both gradual and abrupt changes in climate, as it scores well on a number of factors associated with adaptive capacity, such as "wealth, technology, education, information, skills, infrastructure, access to resources, and management capabilities" (McCarthy, Canziani et al. 2001). The annual economic growth has averaged 3% over the past decade, and equality in income distribution is relatively high. Norway also has well-developed social policies that include a universal social security and health service. Comprehensive social programs ensure that poverty is virtually non-existent. According to the UNDP Human Development Index for 2004,⁷ Norway ranks first in the world (ahead of Sweden and Australia) in terms of human development. In addition, the principle of reallocating risks and costs from natural perils has been in operation for more than four decades both through the Norwegian National Fund for Natural Damage Assistance and funds operated by the state.

On the other hand, international research shows that high adaptive capacity does not necessarily result in successful adaptation (McCarthy et al. 2001; Burton et al. 2002; Yohe and Tol 2002). Most existing climate impact studies in Norway assume that options for adaptation are known and will automatically and effectively be adopted. However, the actual capacity to make adaptations is highly socially differentiated, and other priorities such as

⁷ http://hdr.undp.org/reports/global/2004/pdf/hdr04_HDI.pdf Accessed November 26, 2004

shorter term economic incomes may be favored over longer term adaptation. While Norway has a high technical and financial capacity at the aggregate level, findings indicate large variations in the ability of communities to adapt within Norway, depending on economic wealth, social structures, and previous experience with climate variability. Identifying the distribution of adaptive capacity and barriers to adaptation may be a premise for successful adaptation at the local level. Despite the virtual non-existence of absolute poverty, “there are still a number of groups which are more or less marginalized in relation to welfare developments otherwise in the community” (White Paper no. 50 (1998-1999) 1999). Nationally 2.1% of the population is defined as chronically poor⁸ (Andersen, Epland et al. 2003). These figures display large regional differences. Relative poverty is generally higher in urban areas; however, there are a number of rural areas with large shares of poor people.

To investigate geographic variations between municipalities, O'Brien et al. (2003) constructed an index for adaptive capacity within the agricultural sector based on indicators of sensitivity (number of employed in the agricultural sector), economic factors (income per capita, governmental transfers, and projections of future employment) and demographic context (age distribution among workers, emigration/immigration, share of young and old as a percentage of the total population). While the municipal-level climate exposure presented earlier displays a clear west-east gradient (see figure 5), the capacity to adapt shows a more fragmented picture (figure 8). The resulting map shows a disproportionate clustering of municipalities in mid-Norway with lower adaptive capacity (O'Brien et al. 2003). Even if climate change offers opportunities for production, these municipalities are likely to be less able to meet the challenges by adapting to changing conditions. If government transfers are excluded, vulnerability in many northern municipalities also increases.

Recent research identifies a number of key institutional factors that constrain or facilitate adaptation, including conflicts of interest, communication processes, budget pressures in municipalities, past experience, local knowledge, and institutional learning (Adger 2000a; Næss, Bang et al. In Press). According to Næss et al. (In Press), institutions affect both the social distribution of vulnerability and the management of climate-sensitive aspects of society, and in turn the capacity to adapt successfully. Strategies and measures for adaptation at various scales will necessarily result in the prioritization of some areas, sectors or groups, sometimes at the expense of others. Studying the intuitional responses to floods in Norway, Næss et al. (In Press) find that as strong local political and economic interests coincide with state-level willingness to pay and provide support, measures are likely to be carried out quickly and often at the expense of weaker environmental interests.

Past climatic events have shown to be important triggers to institutional changes (Miller, Rhodes et al. 1997). In the case of the 1995 flood in mid-Norway, rules and regulations at the national level were changed, including new tools and guidelines and clarification of responsibilities of different actors (Næss, Bang et al. In Press). This learning did not take place to the same extent at the local level mainly due to the “high degree of personalized rather than institutionalized learning, high reliance on key individuals, and the difference in culture and perceptions between the local and the national level of governance” (Næss, Bang et al., In Press, p. 21). Studying the effects of the 1992 hurricane in western Norway on emergency management and municipal planning in two municipalities in Western Norway, Groven (2004, In Prep) found few signs of long-term institutional change, apart from some changes in the organization of emergency management. Næss et al. (In Press) found a slightly greater range of institutional changes in the aftermath of the 1995 floods, including new standards and guidelines for building in and use of flood prone areas and entailed increased responsibilities for municipal governments. At the same time, however, Næss et al. (In Press) find that the institutional framework for flood management weakens the incentives for a proactive flood management at the local level. Faced with generous government compensation funds, many municipalities may have limited motivation to engage in proactive

⁸ Assuming an income less than over a period of 3 years.

climate adaptation, especially in a situation with increasing pressures on budgets (Aall and Groven 2003).

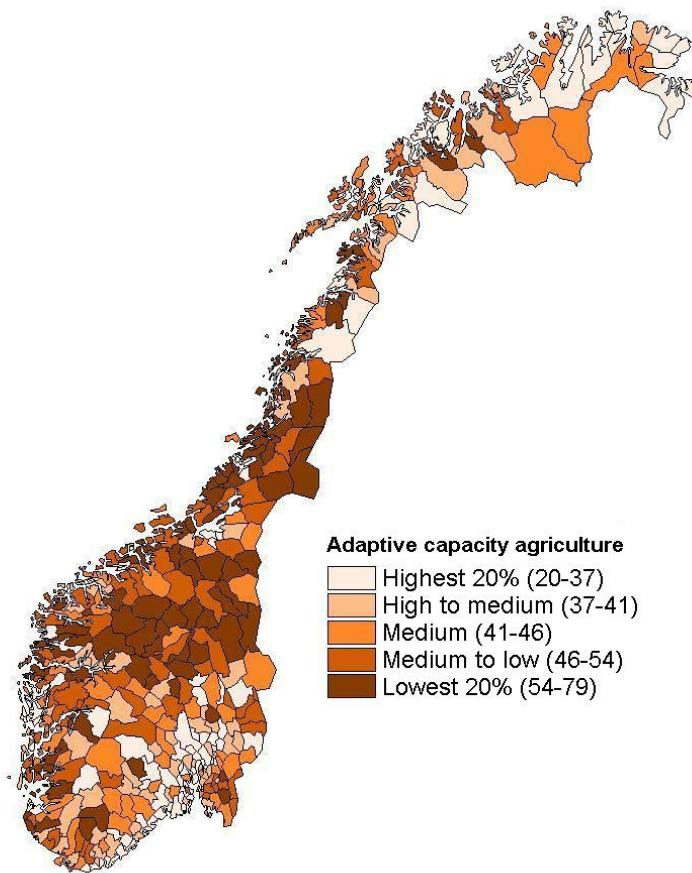


Figure 8. Index of adaptive capacity within the agricultural sector in Norway. The index consists of municipal-level data representing socio-economic sensitivity (the percent of the population involved in agriculture), economic factors (per capita income, state transfers per capita, employment prognoses), and demographic factors (age structure of the work force, migration rates, and percent of dependents—young and old—in the population), with each factor given 1/3 weight.

Olsson and Folke (2001) argue that local knowledge is crucial for local-level adaptation. As observed regarding vulnerability of the building sector, local knowledge itself may also be declining. Studies looking at the costs of climate related damages on buildings show that people currently have less knowledge about local natural conditions, including weather and weather related events than in the past (see Lisø et al. 2003). This decline in knowledge in turn affects how well houses are adapted to local conditions. Of even greater importance than the existence of local knowledge, however, is the ability to successfully transfer knowledge to the relevant institutions and to achieve collective learning. In a case study of responses to the floods of 1995 in Norway, Næss et al. (In Press) found a prevalence of a technical bias in formal responses. Even though local knowledge played an important role in actual responses at the local level, this knowledge was not well integrated in formal procedures. (Aall and Norland 2004) argue for the need for local-level identification of biophysical, socio-economic

and institutional vulnerability to complement scenario-based mapping of macro-level indicators.

These barriers to adaptation identified above demonstrate the need to look beyond the mapping of vulnerability and impacts and analyze the processes of adaptation. An institutional perspective shows that adaptation is not likely to happen automatically, even in cases where extensive knowledge exists on what future climate impacts might entail. The studies reviewed above support the need for more comprehensive discussions at the local level with regard to both sensitivity and adaptation across sectors, and that adaptation to climate change requires action both at the local and at the national level.

6.6 Adaptation as climate policy

Climate change and its associated impacts can be mitigated by reducing emissions of greenhouse gases. The European Union, through the European Environmental Agency, has focused on initiatives to inventory greenhouse gas emissions and develop policies to reduce emissions in accordance with the UN Framework Convention on Climate Change (UNFCCC). Despite these efforts, climate change impacts are inevitable because emissions that have already taken place will affect the future climate for decades. In addition, the emission reduction targets⁹ set in the Kyoto Protocol are far from sufficient to achieve a stabilization of greenhouse gases in the atmosphere at a low level. Present emissions reductions can only slow down the projected warming and rise in sea level. The IPCC Third Assessment Report therefore stresses that adaptation is needed, at all scales, as an addition to mitigation efforts (McCarthy et al., 2001).

However, climate policy has so far been more or less synonymous with efforts to reduce greenhouse gas emissions. Little attention has been directed toward adaptation. There are several explanations for this unequal focus throughout the years. First, uncertainty attached to the climate change problem may have fostered some kind of passivity with respect to initiating impact and adaptation research and even more so adaptation policies. Some argue that we need to know the precise nature of future climate change in order to act. Until we know more about the magnitude of the likely temperature change, there is a tendency to postpone any efforts to estimate impacts or identify adaptation measures. Others argue that evidence of climate change is already starting to accumulate (Parmesan and Yohe 2003; Root, Price et al. 2003). The complexity of the climate system is such that we will never be able to predict future climate change with absolute certainty, however. It has been suggested that one way forward is to take vulnerability to current climate variability as a starting point for analyzing vulnerability to future changes. Because the uncertainty (or range of possible futures) seems to increase with knowledge about the future climate, Adger et al. (2001) argue that this uncertainty should in fact be the basis for measures to increase adaptive capacity and resilience in society. This means broadening societies' coping range, thus creating "ways to exit adversity".

Second, admitting that the world has a climate problem and that the consequences will be felt no matter how much emissions mitigation takes place engenders a sort of helplessness. Third, adaptation can be viewed as a way of buying out of obligations to curb current and future emissions. And finally, there has been a general assumption that adaptation will take place automatically and often at low costs (Parry, Arnell et al. 1998; Kates 2000; Klein, Schipper et al. 2003; O'Brien et al. submitted b).

Adaptation is adjustments in practices, processes, or structures to take into account changing climate conditions, to moderate potential damages, or to benefit from opportunities associated with climate change (McCarthy, Canziani et al. 2001). Adaptation strategies have

⁹ Requires the signature of at least 55 parties to the UNFCCC, including Annex 1 countries accounting for at least 55% of the 1990 emissions of all Annex 1 countries together. This was achieved during 2004 and The Protocol will become legally binding on its 128 Parties on 16 February 2005

traditionally been highly impact-driven as managerial and technocratic interventions have been the endpoint of the sequence of cause and effect from exposure-impacts-adaptation. Within the agricultural sector, measures may include adjusting crop calendars, introduction of new crops, and changing farming technologies. Whereas this top-down approach often calls for predefined specific technical solutions aimed at either reducing sensitivity to specific changes in climate parameters, a bottom-up approach directs attention to the underlying social and economic conditions that influence adaptive capacity and vulnerability (O'Brien et al. 2004b). Instead of moving directly from research on climate change impacts to strategies and policies for adaptation and thus bypassing the adaptation process itself, it is currently increasingly emphasized that understanding the process of adaptation in terms of *who* adapts *how* and *why* is essential for enhancing systems adaptive capacity and facilitates adaptation (O'Brien et al. submitted b). As pointed out by Adger and Kelly (1999, p. 256), "just as vulnerability provides an entry point for study of the implications of climate change, so study of the ability of a population to respond- to cope recover and adapt – must take centre stage in any policy-relevant analysis of vulnerability to climate change." Adaptation research of this kind has become increasingly place specific, and views adaptation in a more holistic than climate-parameter specific way, with climate variables representing only one set of factors affecting the adaptive capacity or resilience of systems. Climate change is only one among many challenges facing society, and adaptation has to take various stressors into account. Many regions, sectors and social groups are double exposed to, for example, the processes of climate change and globalization, and will have thus have to adapt to both simultaneously (O'Brien and Leichenko 2000). This has strong implications for which strategies could be used to enhance the overall adaptive capacity.

The extent of the climate problem calls for adaptation, and it has been recognized that any adaptation regime will have to include justice and equity considerations. According to Schneider (2003), adaptation is not neutral, as many adaptive responses might accentuate vulnerability and inequality in some regions, while the absence of adaptation in others may have the same effect. Climate change and its impacts will thus widen the gap between those who have and those who don't. As argued by Wisner (1993, p. 18), dominant groups in society who have "ownership to resources, monopoly of lethal force, and the ability to control information and to define agendas" will dictate society and development. This trend may also undermine local coping and adaptation strategies by those far removed or few connections with the dominant groups. It should be noted that included in the external dimension of vulnerability are the various actors that are involved in mitigating the effects of various hazards, including state agencies, interest groups, bi- and multilateral donor agencies. Wisner (1993) observes that the state has generally not been regarded to be a partisan actor in the sense of favoring any particular group with resources that reduce vulnerability. On the contrary, it may be argued that states and other agencies in fact influence the levels and distribution of vulnerability and marginality through priorities of hazard mitigation, concerning "what," "who," and "where" (Wisner 1993; Blaikie, Cannon et al. 1994; Cutter 1996). How to prioritize between events, systems, social groups and location or scale is going to be a major challenge both nationally and internationally. For example, Schneider (2003) argues that all species should be included when defining adaptation, not just the human species. Furthermore, society's values determine the factors (or facets of society that we do not wish adversely affected) that end up being included in our understanding of adaptation. What constitutes dangerous climate change is thus a rather subjective issue.

Nevertheless, the issues of mitigation and adaptation are likely to be strongly liked in any future negotiations of the UNFCCC, as mitigation targets for developing countries should be tied to financial assistance for adaptation (Pronk 2004). Three international funds have been established within the UNFCCC to fund adaptation in developing countries including the Special Climate Change Fund, the Kyoto Protocol Adaptation Fund, and the Least Developed Countries fund. How accessible these funds are, is, on the other hand, questionable. First of all, there is very little money available in these funds and the Adaptation Fund is not yet in effect. Secondly, the interplay between these funds, and the way the funds will be operated is

still undecided. It is likely that poorer countries will be left with the least bargaining power. According to Mace (2004), developing countries face several challenges in the upcoming negotiations. Adaptation concerns are spread throughout the UNFCCC text. Negotiations therefore occur in parallel, making them difficult for small developing-country delegates to follow. In addition, developing countries are a highly heterogeneous group. Within the UNFCCC negotiations, the fossil-fuel producing countries have the loudest voice. The remaining countries have seen little progress in pushing adaptation higher on the agenda. Scientific uncertainty also delays the decisions on UNFCCC funding for adaptation projects. Finally, many developing countries lack the institutional capacity to express national adaptation needs in the negotiation process. There are thus major challenges regarding not only in establishing adaptation funds but also in developing mechanisms for burden sharing among the developed countries. Even if these issues were settled, there are tremendous equity issues that remain regarding, for example, how adaptation funding should be prioritized. Should the adaptation funds be allocated to those suffering the highest costs of climate change impacts or those most exposed to stress and the least capacity to adapt? The GEF is responsible for guiding this process.

While some attention has been focused on adaptation in a developing country context, little attention has been directed toward the issue of adaptation within the developed world (see O'Brien et al. 2004b). The developed world is assumed to have high adaptive capacity, based on macro level indicators such as wealth, technology, information, skills, infrastructure, institutions, equity, empowerment, and the ability to spread risk (McCarthy, Canziani et al. 2001). As discussed above, however, there are few studies demonstrating that these factors will de facto lead to successful adaptation in developed countries. Indeed, the entire process of adaptation is poorly understood at present. What is clear, though, is that “adaptive capacity in human systems varies considerably among regions, countries and socioeconomic groups” (Smith 2001, p. 918).

7 Conclusions and direction for future research

Global climate change is likely to have strong manifestations in terms of local climatic changes in some areas in Norway. Moreover, some of these areas contain highly sensitive ecosystems and economic sectors. Thus the impacts are likely to be particularly high in particular areas and among certain groups in Norway. Increased warming and a longer growing season may have a positive impact on agricultural yields, and increasingly so moving from the southern to the northern parts of the country (Gaasland 2003; Torvanger, Twena et al. 2003; Gaasland 2004). Whereas agriculture may potentially benefit from warming, sectors such as tourism and transport are likely to face adverse effects from climate change (Teigland 2002a; Askildsen 2004). These highly climatically sensitive sectors are important to regional production and employment. Both climate exposure and the distribution of climate sensitive sectors vary greatly across scale. Case studies show that climate change will be felt differentially among sectors and regions. In addition, many of the impacts of climate change at the local level are likely to be felt through climate variability and extreme events rather than through gradual changes to average conditions.

There are multifaceted interactions within and between different ecosystems and sectors. An examination of the interactions between systems – be they ecosystems, sectors or regions – indicates that the impacts of climate change may be surprising, potentially taking on a different form than expected, based on the findings from individual units (O'Brien et al. 2004a; O'Brien, Tompkins et al. 2004; Aaheim and Schjolden 2004). In asking whether Norway is resilient or vulnerable to climate change, O'Brien et al. conclude that the answer depends highly on the scale of analysis. In a global context, Norway may serve as an example of a resilient country, or even a winner under climate change. However, at the regional and local level, neither adversity nor opportunities from climate change will be evenly distributed. At the national level, the impacts of small changes that affect many people may be more

significant than large impacts for a few. Findings also show, however, that impacts from climate change have to be analyzed in a wider context, including not only natural conditions but also economic, social and cultural circumstances. A critical issue that emerges in recent studies is that many impacts are likely to be felt only at certain thresholds in society. Gradual changes may not appear to be significant, and some variability and extreme events may be easily tolerated. Once a threshold is surpassed, the impacts of climate change become evident, and sometimes irreversible. These thresholds are determined not by climate sensitivity or exposure alone, but by wider socio-economic trends.

Whether or not society is able to meet the challenges posed by the positive or negative impacts of climate change is very much dependent on the capacity to adapt. Norwegian society as a whole is often perceived as being able to handle the challenges that climate change may present in the future. While Norway has a high technical and financial capacity at the aggregate level, findings indicate large variations in the ability of communities to adapt within Norway, depending on economic wealth, social structures, and previous experience with climate variability. It is at the local and regional levels that impacts from climate change will be felt, and it is at this level that practical adaptation measures will have to be put into place. Results suggest that communication processes, budget pressures in municipalities, local knowledge and institutional learning are key factors that either constrain or facilitate adaptive behavior. There are important barriers to adaptation, and in some cases even maladaptation to current climate variability is taking place. There is clearly a need for local level identification of biophysical, socio-economic and institutional vulnerability to complement scenario-based mapping of macro-level indicators. Some of the structural factors that constrain local adaptation may have to be addressed at the national level, however. Adaptation as a social and institutional process has to be understood if Norway is to successfully adapt to a changing climate.

Moving forward with these findings implies increased focus on multi-method, multi-scale and interdisciplinary research. First, the most important effects may not be captured in studies that focus on a single system, sector, or scale (O'Brien et al. 2004a; O'Brien et al. 2004c). There is a need for integrative studies that look at cross-sectoral and cross-regional issues. Climate change and extreme events are likely to have the largest impacts on the weakest points of societies and ecological systems – among communities living in marginal areas and operating under marginal conditions and where vulnerability to other stressors are exacerbated by a change in one or more important climate variables. There is, however, a gap between local case studies and national level studies. One of the biggest challenges within climate change research is how to scale up from case studies to generalizations. There are considerable challenges in moving from case studies to larger scales and generalizations. A further challenge is the fact that patterns of adaptation are not very well understood. Currently policy is moving ahead of research on adaptation – for instance, with the newly established framework for implementing funding for adaptation within the UNFCCC. Understanding the process of adaptation and the underlying processes determining adaptive capacity is a precondition for understanding climate vulnerability and thus the extent of the climate problem.

8 References

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