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Climate change in Northern Norway

Toward an understanding of socio-economic vulnerability of natural resource- dependent sectors and communities

Jennifer J. West and Grete K. Hovelsrud

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CICERO
Center for International Climate
and Environmental Research
P.O. Box 1129 Blindern
N-0318 Oslo, Norway
Phone: +47 22 85 87 50
Fax: +47 22 85 87 51
E-mail: admin@cicero.uio.no
Web: www.cicero.uio.no

CICERO Senter for klimaforskning
P.B. 1129 Blindern, 0318 Oslo
Telefon: 22 85 87 50
Faks: 22 85 87 51
E-post: admin@cicero.uio.no
Nett: www.cicero.uio.no

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Forfatter(e): Jennifer J. West og Grete K. Hovelsrud
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Sammendrag:
Rapporten er CICEROs bidrag til Tema 4 av NorACIA prosjektet som er den norske delen av oppfølgingen av Arktisk Råds ACIA prosjekt (http://acia.npolar.no/)

Rapporten viser at det er behov for bedre integrering av kunnskap på tvers av disipliner for å finne frem til sårbarhetsfaktorer knyttet til klimaendringer. Studier der både sosiale, kulturelle, økonomiske og miljømessige faktorer blir undersøkt kan gi bedre innsikt og forståelse for både klimasårbarhet og mulige tilpasningsstrategier for folk og samfunn. Vi undersøker to indikatorer for å analysere sosioøkonomisk sårbarhet til klimaendringer i klimasårbare sektorer i Nord-Norge: andel sysselsetting og bruttoverdi. Ved å bruke disse to indikatorene viser vi at sårbarhet for klimaendringer for ulike sektorer varierer med nivået for analysen, enheten som er tatt i bruk, og indikatorene som velges. Gitt disse begrensingene, foreslår vi å forbedre sårbarhetsstudier ved å inkludere informasjon fra lokale utøvere, om deres syn på egen følsomhet og tilpasningskapasitet i forhold til klimaendringer. En kombinasjon av ovenfra-og-ned med nedenfra-og-opp tilnærming er nødvendig for å analysere sårbarhet av klimasensitive sektorer.

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Abstract:
The work in this report is a contribution from CICERO to Theme 4 of the NorACIA project, a Norwegian follow-up to the Arctic Council's Arctic Climate Impact Assessment: http://acia.npolar.no/

It has been recognized that there is an urgent need for better and integrated knowledge of the social, economic and environmental conditions that underpin vulnerability to climate change at the local level. Such knowledge is necessary in order to develop credible vulnerability and adaptation assessment methodologies that can in turn inform local, regional and national planning processes and adaptation strategies. We examine two indicators of socio-economic vulnerability to climate change in climate-sensitive sectors in Northern Norway: share of employment and gross value added. Using these two indicator examples, we show that vulnerability to climate change in different economic sectors varies depending on the scale at which analysis is undertaken, the unit of analysis and the indicators employed. Given the identified limitations of applying a top-down approach to assessing socio-economic vulnerability, we suggest elements of a strengthened methodology for vulnerability studies that incorporates stakeholders' own information on their exposure-sensitivities and adaptive capacity to climate change. We conclude that a combination of top-down and bottom-up approaches for assessing the vulnerability of climate-senstitive sectors is waranted.

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1 Introduction

The Arctic Climate Impact Assessment (ACIA) determined that climate change in the world's Arctic areas is proceeding at a rate that is nearly double the rate of change at a global scale (ACIA, 2005). As a principle contributor to the ACIA report and a key stakeholder in debates surrounding the impacts and consequences of climate change in its northern areas, Norway is committed to pursuing the report's findings and recommendations. Specifically, Norway supports the need highlighted in the ACIA report for a comprehensive and on-going research and assessment program in the Arctic in order to assess and devise appropriate responses to the environmental, social and economic consequences for Arctic peoples and environments.

Previous and ongoing research at CICERO and other Norwegian institutions confirms the need articulated in the ACIA report for better and integrated knowledge of the social, economic and environmental conditions that underpin vulnerability to climate change in northern areas. The work undertaken in this report forms part of the Norwegian follow-up to ACIA (NorACIA) and is CICERO's contribution for 2006 to thematic working group 4 of NorACIA on human and societal impacts. This report complements the report by Groven *et al.* 2006: *Regional klimasårbarheitsanalyse for Nord-Norge: Norsk oppfølging av Arctic Climate Impact Assessment (NorACIA)*, undertaken by Vestlandsforsking under thematic group 4 in 2006.

The goal of the preliminary work presented here is to show how socio-economic vulnerability to climate change varies depending on *the scale at which analysis is undertaken*, *the unit of analysis* (individual, administrative unit, or sector) and *the indicators employed*. This report argues that both top-down, and bottom-up, approaches are needed to assess vulnerability to climate change at the municipal level in Norway. The methods and indicators for vulnerability assessment outlined in Groven *et al.* 2006 and in this report provide complimentary starting points for selecting municipalities for further in-depth study.

A key goal for the second phase of the Norwegian follow-up to ACIA (NorACIA) is to document the nature and range of vulnerability and adaptation needs in northern Norway (NorACIA Handlingsplan, 2005). Theme 4 in NorACIA addresses climate change in the context of people and society and has determined that the following economic sectors are particularly sensitive, or vulnerable, to climate change and therefore merit detailed investigation:

- Fisheries
- Tourism
- Energy production
- Agriculture and reindeer herding
- Infrastructure

Each of these sectors depends either directly or indirectly on natural resources, and all may therefore be sensitive to changes in climate that also affect the specific resources in question. Communities and regions that depend heavily on these sectors for income and employment are in turn more exposed to the effects of climate change than regions, communities and sectors that rely less on natural resources. For example, climate change will increase sea surface temperatures and reduce the extent and thickness of sea ice in Arctic regions (ACIA, 2005). These changes are expected to affect the movement, growth, habitat and reproduction of key commercial fish species (Drinkwater, 2006; IMR, 2006). The effects of these changes will be experienced first-hand and directly by communities located along the west and northern coasts of Norway where fisheries and fish-related industries are concentrated.

"*Vulnerability"* in the context of impacts research, is not only a function of exposure and sensitivity to climate change, but depends equally on the capacity of communities, regions and nations to respond and adapt to climate-related changes – also referred to as their adaptive capacity (IPCC, 2001). Like exposure, adaptive capacity is unevenly distributed across space and time. Communities or sectors that possess the necessary resources (wealth, technology, education, skills, employment options, access to resources) to proactively respond to climate change are likely to be less vulnerable than communities and sectors that lack access to the resources and capacities necessary for effective adaptation (McCarthy, Canziani et al. (eds), 2001). The functional relationship between exposure-sensitivity and adaptive capacity will vary by context and over time, but it is expected that vulnerability is positively related to exposure-sensitivity and negatively related to adaptive capacity.

Climate change does not occur in isolation from other change factors. In addition to climate change, the Arctic is currently experiencing rapid changes in societal, cultural, economic and political conditions (ACIA, 2005; AHDR, 2004; Fenge, 2001; Ford and Smit, 2004). Regional and global environmental processes – including those that are induced or accelerated by global climate change – have local manifestations, and require local responses. However, the particular local conditions which shape exposure-sensitivities and adaptive capacity to climate change also reflect regional, national and global, social and economic change processes or conditions (McCarthy and Martello, 2005). While these changes will be experienced at all levels of society, they pose particular challenges for local communities, who must respond to the changes directly. However to date, the particular environmental, socio-economic and political conditions to which communities in northern Norway are sensitive (and in which ways) have yet to be comprehensively documented (Smit & Hovelsrud, 2006). Moreover, neither the strategies employed to deal with changing conditions in communities, nor their effectiveness, have been assessed.

At the same time, little is known about local level decision-making processes and how they interact with higher-level governing structures that support local actions (Corell, 2003). Finally, a wealth of local and indigenous knowledge and information with respect to climate change in the Arctic has been documented in a number of recent studies, but it has yet to be integrated with scientific knowledge (Hovelsrud and Winsnes, 2006). However, partnerships between local resource users and scientists in the creation of knowledge are not commonly applied in research on coupled social-ecological systems despite the fact that such partnerships are increasingly recognised as being crucial to success (Ludwig, 2001; Berkes, 2002; ICARPII, 2005, in Tyler *et al*., 2007).

Scale emerges as a vital parameter in impacts and adaptation research with respect to climate change. Both the ACIA and the latest IPCC reports emphasise that vulnerability to climate change varies by region, sector, and social group (McCarthy, Canziani et al. eds., 2001; ACIA, 2005). In order to design effective adaptation strategies therefore, it is necessary to understand how vulnerability to climate change varies at different scales – from the level of local communities to national economies. As a number of authors point out, the vulnerability of any coupled social-ecological system – and the ability to respond to changes within it – are a function of local conditions (Tyler *et al.*, 2007). At a local level, adaptive capacity is reflected in the ability of a community to manage current and past stresses, its ability to anticipate and plan for future changes, and its resilience to perturbations. In conducting a vulnerability assessment, there is therefore a clear need to identify the factors that influence local vulnerability and adaptation to climate change. Identifying the factors that influence local vulnerability and adaptation in turn requires knowledge of the priorities and perspectives of local people experiencing this change (Tyler *et al.*, 2007; Hovelsrud and Winsnes, 2006).

Scale is also important when considering the dynamic legal, political, institutional and market environments within which different natural resource-based communities operate, environments that, as several of the ACIA scientific report's chapters highlight, may have greater aggregate impacts than climate change when it comes to determining the future availability, distribution and quality of natural resources (as might be the case with fisheries and forests, to name two examples). Institutional environments at a variety of scales –from the level of local municipal authorities to international treaties and financial institutions – shape the ways in which people manage natural resources (e.g. Ostrom , 1992) and will influence the vulnerability profiles and adaptation options of people who depend on these resources in the future.

Despite the consensus that impacts of and vulnerability to climate change are highly scale-dependent, few studies to date have examined how local and sectoral vulnerability methodologies can be integrated with top-down assessments to inform local, regional and national decision-making processes and policies. A number of authors and studies therefore propose the development of a methodology that synthesises "bottom-up" and "top-down" approaches to climate change vulnerability assessments in coupled social-ecological systems, and that incorporates local vulnerability indicators and local knowledge (O'Brien et al., 2003; O'Brien et al., 2004; Aall & Nordland, 2005; Tyler et al. 2007). This new body of research has arisen from the recognition that a range of adaptive responses will be needed at various scales to overcome the challenges posed by climate change in northern regions, including Norway (e.g. McCarthy and Martello (eds.), 2005).

Local case studies are a necessary means of ground-truthing the results of a top-down vulnerability analysis or vulnerability ranking exercise (O'Brien et al., 2004; Wilbanks and Kates, 1999). Key aims of conducting local case studies are to identify local environmental, economic, social, cultural and institutional factors that influence local vulnerability and adaptive capacity (either qualitative, quantitative, or both); in other words to uncover local factors that complement, contest, or modify vulnerability and adaptation indicators suggested in top-down assessments. Important outcomes of a local vulnerability study are the documentation of factors that influence socio-economic vulnerability at a local level, analyses of the ways in which local factors vary from those suggested at different scales of analysis, and a discussion of the trade-offs for different groups (individuals, communities, policy-makers) at various scales. Local vulnerability studies have particular relevance for local adaptation policies and practices, which are place - and context - specific.

In this report we examine two indicators of socio-economic vulnerability or sensitivity to climate change in climate- sensitive sectors: share of employment and gross value added. The indicators were chosen based on the ease of availability of both types of data, and are not intended to be comprehensive. We focus on the climate-sensitive sectors identified above, excluding reindeer herding. A comprehensive assessment of the vulnerability of reindeer herding and herders to climate change will be covered under a partnership with the Sami University College, with input from the EALAT reindeer herders vulnerability network study on reindeer. Using these two indicator examples, we show that socio-economic vulnerability to climate change varies depending on *the scale at which analysis is undertaken*, *the unit of analysis* (individual, administrative unit, or sector) and *the indicators employed*.

In conclusion we suggest elements of a strengthened methodology for vulnerability studies based on the principles outlined in Turner et al., 2003; Keskitalo, 2004; Ford and Smit, 2004; Smit & Hovelsrud, 2006). This approach is founded on the notion that a crucial aspect of vulnerability assessment is to incorporate stakeholders' own information on exposure-sensitivities and adaptive capacity. The open and active engagement of community representatives and other stakeholders at the local level is a necessary element of this approach, and should be considered a vital component of a comprehensive vulnerability analysis considering that:

- Vulnerability is scale-dependent. For any given indicator, vulnerability will vary at different scales of analysis. Although a county or region may not appear to be vulnerable to climate change, a municipality or specific settlement within it may be.

- Aggregated and statistical data does not pinpoint the vulnerability issues and processes that are most relevant to local communities.

- Climate change interacts with additional place and context- specific change factors that may considerably influence vulnerability and adaptation locally.

The work in this report builds on previous and ongoing research at CICERO and other Norwegian institutions that highlights the urgent need for better and integrated knowledge of the social, economic and environmental conditions that underpin vulnerability to climate change at the local level in order to develop credible vulnerability and adaptation assessment methodologies that can underpin and inform effective local planning processes and adaptation strategies.

2 Impacts of climate change on climate-sensitive sectors in northern Norway

2.1 Fisheries

The fishery sector is important, both in terms of employment and income, as well as in cultural terms, for a number of municipalities in northern Norway. It is also a sector that is highly sensitive to the impacts of climate change. The ACIA report concludes that a moderate warming of mean ocean temperatures is likely to "improve conditions for some of the most important commercial fish stocks…due to enhanced levels of primary and secondary production resulting from reduced sea-ice cover" (Vilhjálmsson et al. 2005:692). Changes in ocean temperatures are also expected to increase the extent of habitat for certain fish species, including cod and herring (ibid). Climate change is also likely to result in changes in species composition, and a number of studies have shown that the growth rate, time to maturity, and reproductive, and recruitment rates of different fish species are at least partly dependent on temperature (ACIA 2005; Drinkwater, 2006; IMR, 2006). However, marine biologists point out that warming of the Arctic sea waters may not necessarily lead to an increase in the northern extent of commercially important northern fish stocks, since biophysical and human management interactions and feedbacks in Arctic marine ecosystems are complex, and still relatively difficult to project over long time periods. Warmer Atlantic Ocean waters flowing into the Barents Sea also transport nutrients and food to northern fish stocks. If the direction and strength of ocean currents in the Arctic change significantly, the recruitment, habitat and species composition of key commercial fish species would likely change significantly. The complexity of factors and interactions between biophysical, social, economic, political, legal and institutional contexts and changes in shaping vulnerability to climate change in the fisheries sector in northern Norway is discussed in more detail in section six.

2.2 Agriculture

Changes in climate in northern regions will affect potentials for agricultural production. While some authors point out that an increase in average temperatures, by extending the length of the growing season and the latitude at which some crops might be grown, will lead to net benefits for agriculture in northern regions, others point out that increased temperatures will lead to heightened disease pressures and pest outbreaks (ACIA, 2005). Understanding variations in the agricultural practices of northern residents today – including the importance of the sector in terms of employment and income, the types of crops grown, number and extent of agricultural areas in use, and number of holdings keeping livestock – provides a basis for assessing how future changes in climate might affect different regions, and for understanding and identifying the vulnerability and adaptation needs of northern municipalities.

2.3 Infrastructure

Climate change will affect the functionality of the existing built environment and the design of future buildings in Norway (Lisø et al., 2003). The impacts of climate change on the built environment depend on a host of factors, including the scale and magnitude of actual and predicted changes, the climate variables referred to, and the type and physical location of buildings involved (Holm, F.H. 2003). Different climate parameters are important for different constructions – for example, duration of rainy periods very important for some constructions, while intensity of rainfall events is more important for others. The temporal aspect of climate changes is also an important consideration. While the average duration of rainy periods that a building may be exposed to over its lifetime is important for some structures, exposure to short periods of intense rainfall events may be more important for other types of structure.

The potential impacts of climate change on infrastructure in arctic regions are discussed in chapter 16 of the ACIA report (2005), where the authors define infrastructure as *"facilities with permanent foundations or the essential elements of a community*", including schools, hospitals, various types of buildings and structures, facilities such as roads, railways, airports, harbors, power stations, and power, water and sewage lines. Changes in the permafrost, and in the frequency, intensity and magnitude of storms, slides, avalanches and floods, as well as changes in precipitation and sea and air temperature – expected to occur across the Arctic – could have serious repercussions for infrastructure in northern Norway, in particular infrastructure that is located along the coastline.

Climate change will likely affect the construction and transportation sectors, including the share of employment, in both positive and negative ways. Changes in climate, and in particular, in the frequency and intensity of extreme weather events such as storms, floods and land slides, are likely to threaten infrastructure, including roads, bridges, tunnels and homes, along the coast, as well as inland, in Norway's northern regions. Accelerated sea level rise will also pose challenges to the extensive system of coastal infrastructure upon which many northern coastal communities depend (Aunan and Romstad, *in press*). More frequent and extreme weather events that require temporary closure, or that cause damages or delays to major transportation routes could have large negative economic impacts for the transportation sector. On the other hand, insofar as knowledge progresses and as new buildings standards, building materials and technologies emerge, there will likely be new demand and perhaps even greater opportunities for employment in the construction sector. Increased attention to training and skills development for workers in the construction and transportation sectors will probably be needed however in order to equip workers to handle new materials and apply new technologies and construction methods.

2.4 Energy production

Hydropower dominates Norwegian electricity production. Climate change could affect the electricity sector in several ways. Climate change will bring changes to precipitation patterns. The Regional Climate Development under Global Warming (RegClim) regionally downscaled data shows an increase of 0.4 mm of rainfall/day (or 13.6%) for Nord-Troms and Finnmark, and 0.5 mm/day (or 11.6%) for Sør-Troms and Nordland, for the period 2071-2100, relative to the period 1961-1990 (RegKlim, 2005). Although these are annual averages, greater extremes in the timing and amount of rainfall are also anticipated. These changes will affect the timing and amount of peak runoff and the discharge rates of water into hydroelectric dams, affecting electricity supply, and possibly requiring greater attention to flood management, or relocation of existing dams due to lack of rainfall.

More precipitation will influence the reservoirs and the distribution over time could influence the dimensions of dams and the distribution network. More wind could result in higher effectiveness and economical potential. This could in turn mean fewer wind mills and area conflicts. Ice combined with wind could represent a risk for the electricity cables. While the net effects for employment in the electricity supply sector are unclear, given the economic importance of the sector nationally, there will likely be a greater need for training and skills development for monitoring, constructing and maintenance of existing hydroelectric dams in order to ensure adequate supply under a changing climate.

2.5 Tourism

Climate change is already bringing changes to northern environments via warmer temperatures and changes in amount and patterns of precipitation (including snow). Where the effects of these ongoing changes are felt, there is likely to be a reduction in the attractiveness of certain areas for tourism, and a corresponding reduction in the share of people employed in this industry. For examples, a decrease in the quality and quantity of snow in and near large urban centres may decrease peoples' interest in skiing over time, or shift interest and use to areas like Oppland and Voss. A decrease in winter tourism opportunities could also affect summer tourism, because tour operators depend on opportunities in both seasons (O'Brien et al., 2003).

The impacts of changes in weather and climate on tourist industry will depend on the activity in question (for example whether the tourist comes to enjoy the view, to enjoy cultural heritage, or to take part in a physical activity outdoors). In general, the tourist industry has little flexibility for responding dynamically to the impacts of climate change. This is because unlike individual tourists, who can choose among a range of travel destinations and adjust their behaviour based on weather forecasts or other variables, tourism services and the physical infrastructure associated with tourist destinations tend to be fixed in space and time.

Employment in the hotels and restaurants sector and in tourism, cultural, and travel agency services (see section 5) depends in large part on the success of and the wealth generated by the tourism industry. In northern Norway tourism depends largely on the attractiveness of the natural resource base – whether for skiing, hiking, or viewing – to Norwegian and international vacationers. Municipalities that receive a large proportion of their income from seasonal tourism may be negatively impacted by climate change, for example changes in the amount and timing of snowfall.

3 Employment in climate-sensitive sectors

A general hypothesis is that counties, municipalities and human settlements in which a high proportion of the resident workforce is employed in climate sensitive sectors are more vulnerable to climate change compared to those having a lower share of employment in these sectors (O'Brien et al., 2003; Aall and Nordland, 2005). The proportion of the workforce employed in climate-sensitive sectors therefore provides an indication of the relative vulnerability/sensitivity of different counties and municipalities to the effects of climate change.

A question then emerges with respect to what should be considered a "high", and a "low" share of employment within the various sectors. In the case of fisheries, Lindkvist (2000) defines 'dependent' localities as those for which the share of persons participating in fishing and fish processing activities exceed five percent of the working population. The tables and figures below show that the transportation and construction sectors are the only climate-sensitive sectors for which the share of employment exceeds five per cent of the resident work force in any of the northern counties. However, share of employment at the municipal level varies more widely within each of the sectors than what these county averages suggest. In addition, the variation among municipalities is greater for some sectors compared to other sectors. For example, the share of employment in the fisheries sector at the municipal level varies from 0 to 30 per cent, whereas for the construction sector the range of variation is smaller (0 to 14 per cent).

Table 1. Number and per cent of municipalities for which the share of employment in climate-sensitive sectors exceeds 5 per cent *(† = share of employment at county level > 5 per cent)*

Sector	Nordland	Troms	Finnmark
Agriculture	11 of 45 (24%)	8 of 25 (32%)	4 of 19 (21%)
Fisheries	21 of 45 (47%)	9 of 25 (36%)	11 of 19 (58%)
Hotels - restaurants	2 of 45 (4%)	0	0
Construction	35 of 45 (78%) †	24 of 25 (96%) †	14 of 19 (74%) †
Transportation	30 of 45 (67%) †	17 of 25 (68%) †	12 of 19 (63%) †
Electricity supply	0	0	0
All Sectors	†	†	†

3.1 Regional Overview

Table 2 provides an overview of the number and share of residents employed in sectors sensitive to climate change for the three northern counties[1]. In terms of total number of people employed and share of employed persons in the regions, the most important sectors are the construction and transportation sectors, followed by the hotel and restaurant sector[2], fisheries sector, and agricultural sector. The electricity supply sector employs the least amount of people and accounts for the smallest share of employment in the region.

Table 2. Number of residents employed in climate sensitive sectors in northern Norway in 2004. *Source: Statistics Norway*

Sector	Nordland County	Troms County	Finnmark County	Regional total	Share of regional total (% resident workforce)
Agriculture	3,543	1,652	879	6,074	2.7
Fisheries	3,710	2,051	1,510	7,271	3.2
Electricity supply	1,256	584	336	2,176	1.0
Hotels - restaurants	3,683	2,826	1,337	7,846	3.5
Transportation[3]	7,074	4,338	2,067	13,479	6.0
Construction	7,613	5,176	2,536	15,325	6.8
Total employment	111,976	76,670	35,535	224,172	100

[1] Sectors in the table are according to the two-digit NACE industrial classifications employed by Statistics Norway

[2] Used here as a proxy for the “tourism” sector

[3] The transportation figures include employment in land, sea and air transportation, and employment in services incidental to the transport sector

3.2 County overview

The figures below show the importance of the different sectors in terms of their share of total employment in the individual counties.

3.2.1 Nordland

In Nordland, the transportation and construction industries each employ between 6 and 7 per cent of the county workforce. Fisheries, hotels and restaurants, and agriculture each account for about 3.2 percent of the labor force. Electricity supply accounts for 1 percent of employment.

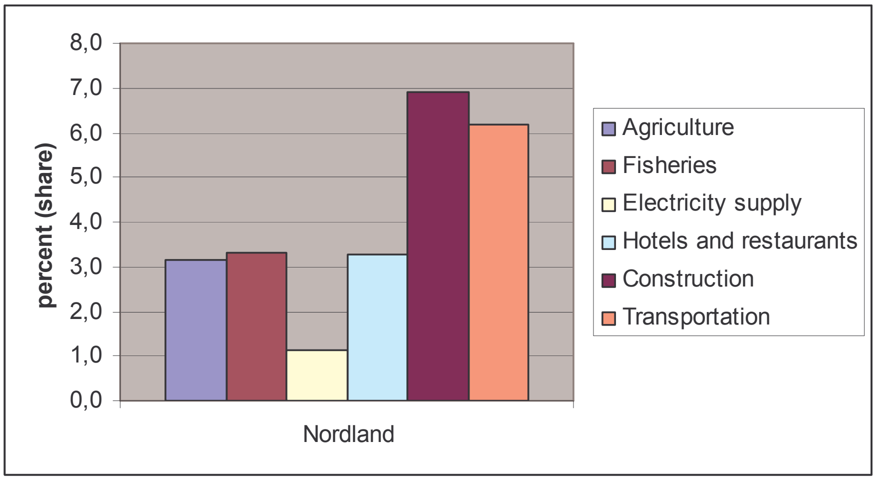

Figure 1. Share of employed residents in climate sensitive sectors in Nordland, by industrial classification, 2004. Source: Statistics Norway

3.2.2 Troms

Although the transportation and construction industries dominate in terms of share of employment among the selected industries in Troms, unlike in Nordland, the hotels and restaurants sector employs greater share of the workforce than fisheries. Fisheries and agriculture account for 2.7 and 2.2 percent of total employment respectively, while electricity supply accounts for less than 0.8 per cent of employment in the county.

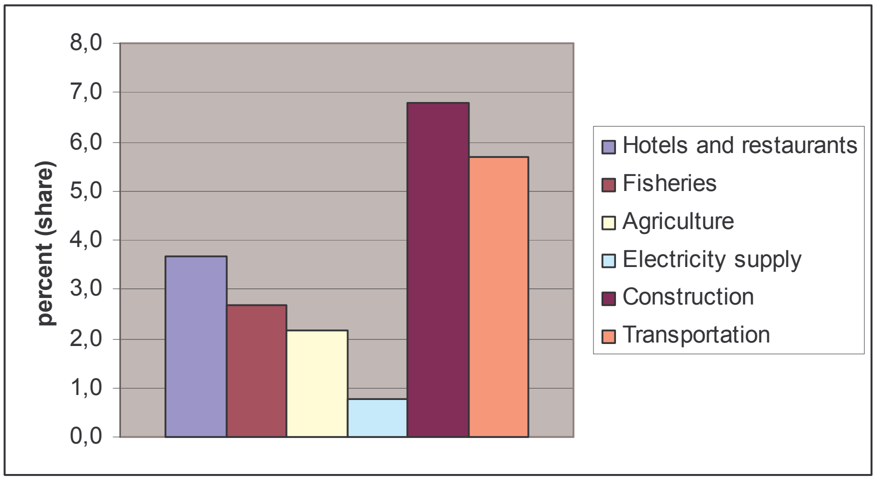

Figure 2. Share of employed residents in climate sensitive sectors in Troms, by industrial classification, 2004. Source: Statistics Norway

3.2.3 Finnmark

In Finnmark, the fisheries sector employs a greater share of the workforce compared to Troms and Nordland. Agriculture accounts for 2.5 per cent of employment, while electricity supply accounts less than 1 percent of employed residents in the county.

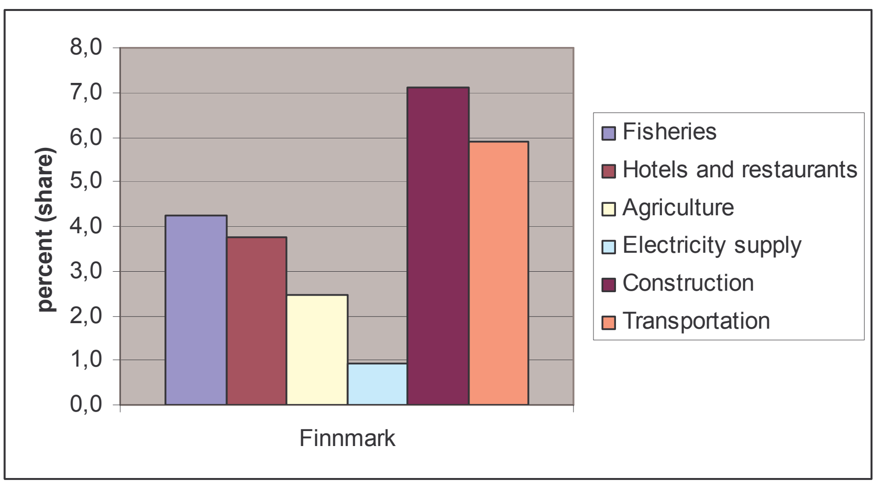

Figure 3. Share of employed residents in climate sensitive sectors in Finnmark, by industrial classification, 2004. Source: Statistics Norway

3.3 Municipal Overview: variation in employment within climate-sensitive sectors at the municipal level

Variation in share of employment in different industries at the municipality level illustrates the importance of scale in vulnerability assessments. For example, table 1 above showed that the fisheries sector employed between 2.7 and 4.3 percent of the workforce in the northernmost counties in 2004. This relatively low share of total employment at the county level could lead to a conclusion that the fishery sector is a minor employer for communities in northern Norway. However, large variations emerge when one compares available employment information at the municipal level. The tables and figures below show that dependence on climate sensitive industries for employment varies more widely between municipalities, than between counties, highlighting the need to examine vulnerability at a variety of scales.

3.3.1 Fisheries

Lindkvist (2000) defines municipalities that are 'dependent' on fisheries as those for which the share of persons participating in fishing and fish processing activities exceed 5 percent of the working population. Although the employment figures from Statistics Norway do not include fish processing, they could be used to classify the municipalities in a similar manner. According to Lindkvist's criteria, 38 out of 88 municipalities in Nordland, Troms and Finnmark could be defined as 'dependent' on fisheries. Twenty of these are located in Nordland, while 8 and 10 are located in Troms and Finnmark respectively[4]. Figure 4 shows that although fisheries accounted for only 2.2 percent of the total employment in Nordland in 2004, it accounted for between 21-30 per cent of employment in the municipalities of Moskenes, Flakstad, Verøy, Træna and Røst.

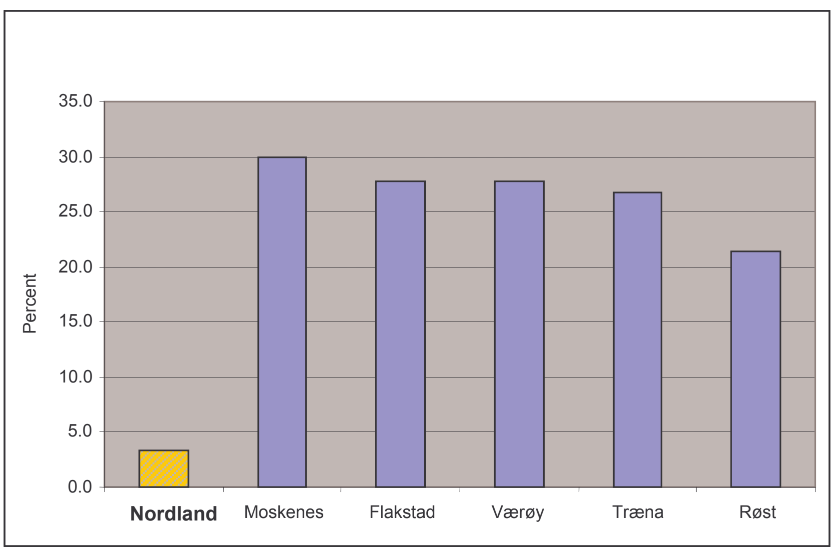

Figure 4. Share of the resident workforce employed in the fisheries sector in selected municipalities in Nordland, 2004, compared to the county average. Source: Statistics Norway

[4] Note that Lindkvist also uses data on catches and landings to classify the degree of dependence on fisheries among municipalities.

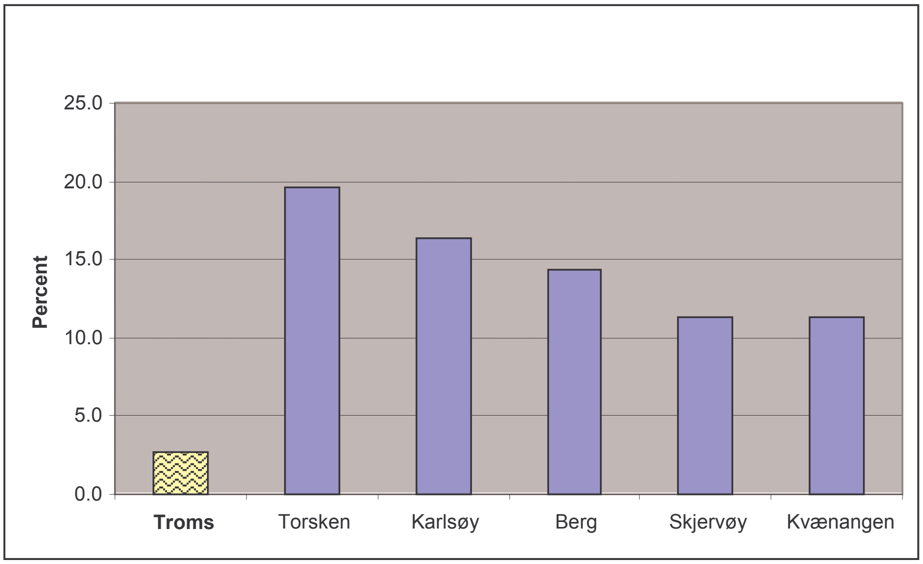

Figure 5. Share of the resident workforce employed in the fisheries sector in selected municipalities in Troms County, 2004. Source: Statistics Norway

Similarly, although the fisheries sector employs just 3.7 percent of the workforce in Troms County as a whole, it accounts for between 11-20 percent of employment in Torsken, Karlsøy, Berg, Skjervøy and Kvænangen municipalities.

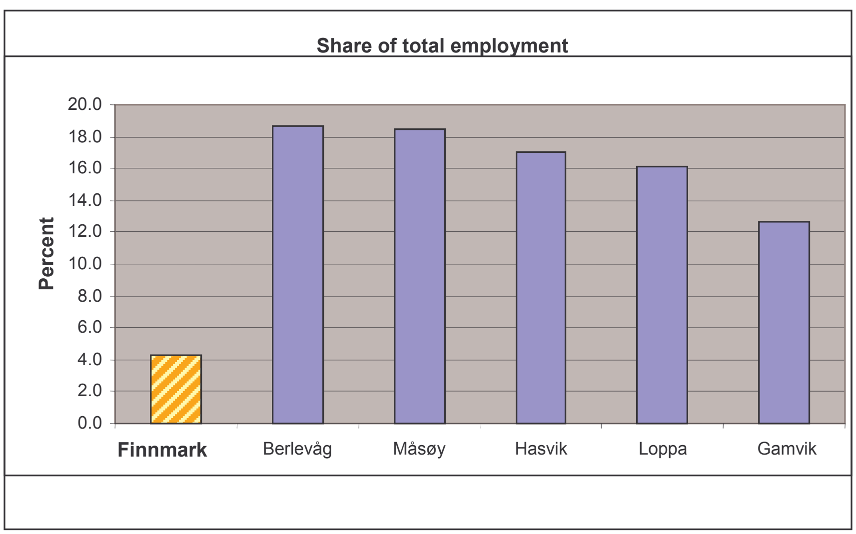

Figure 6. Share of the resident workforce employed in the fisheries sector in selected municipalities in Finnmark County, 2004. Source: Statistics Norway

In Finnmark, the fisheries sector accounts for 4.2 percent of the total employment. However, the figure varies substantially at the municipal level, where it accounts for between 12 and 19 percent of total employment among residents in the municipalities Berlevåg, Karlsøy, Hasvik, Loppa and Gamvik.

3.3.2 Agriculture

Table 3 shows that, like employment in the fisheries, the share of employment in agriculture in northern Norway varies widely at the municipality level. Although the county level figures show a low share of employment in agriculture, 13 -- or 15 per cent -- of municipalities across the three counties have a share of employment in agriculture that exceeds 10 per cent, and 6 municipalities in Norland have shares of employment in agriculture that exceed 15 per cent.

Table 3. Number of municipalities falling within a given range (per cent) of share of employment in agriculture in the northern counties, 2004

Share of employment at county level	< 5 per cent	5–9.9 Per cent	10–14.9 Per cent	> 15 per cent
Nordland: 3.2 per cent	29	5	5	6 *- Sømna (19.5)* *- Vega (16.7)* *- Vevelstad (23.8)* *- Hattfjelldal (18.1)* *- Beiarn (16.1)*
Troms: 2.2 per cent	17	6	2: *- Balsfjord* *- Kåfjord*	None
Finnmark: 2.5 per cent	15	3	1: *-Kautokeino*	None
Northern region: 2.7 per cent	61	14	7	6

3.3.3 Infrastructure: construction and transportation

The construction and transportation sectors employ the greatest share of the workforce (relative to other climate sensitive sectors) in all three counties. The majority of the northern municipalities have shares of employment in the 5-9.9 per cent range for both the construction and the transportation sectors (tables 3 and 4). Within the construction sector, 7 municipalities have shares of employment in the 10-14.9 per cent range. Within the transportation sector (table 4), which here includes land, sea, and air transport and employment in transport-related industries, 5 municipalities have shares of employment in the 10-14.9 per cent range.

Table 4. Number of municipalities falling within a given range (per cent) of share of employment in the "construction" sector in the northern counties, 2004

Share of employment at county level	**< 5 per cent**	**5–9.9 Per cent**	**10 –14.9 per cent**
Nordland*:* 6.8 per cent	10	33	2 *- Balangen (14.9)* *- Beiarn (11.2)*
Troms: 6.8 per cent	1	20	4 *-Kåfjord (10.6)* *- Storfjord (12.2)* *- Blasfjord (11.6)* *- Lavangen (13.7)*
Finnmark: 7.1 per cent	5	13	1 *-Kvalsund (12.5)*
Northern region: 6.8 per cent	16	66	7

Table 5. Number of municipalities falling within a given range (per cent) of share of employment in the transportation sector in the northern counties, 2004

Share of employment at county level	**< 5 per cent**	**5–9.9 per cent**	**10–14.9 per cent**
Nordland*:* 6.3 per cent	15	27	3 *- Evenes (13.7)* *- Rodøy (10.0)* *- Alstahaug (10.3)*
Troms: 5.7 per cent	8	16	1 *- Bjarkøy (10.3)*
Finnmark: 5.8 per cent	7	11	1 *- Gamvik (10.2)*
Northern region: 6.0 per cent	30	54	5

3.3.4 Tourism: Hotels and restaurants

When examining the variability in share of employment in the hotels and restaurants sector at the municipal level, we see less variation than for the agriculture and fisheries sectors. A large majority of municipalities in the three counties have shares of employment in the range of 1-4.9 per cent. More municipalities in Finnmark county fall in the 3-4.9 per cent range compared to Troms, where more municipalities fall in the 1-2.9 per cent range. Only two municipalities – Vågan and Moskenes in Nordland -- have shares of employment in the hotels and restaurants sector that exceed 5 per cent. Both municipalities are located in the Lofoten islands.

Table 6. Number of municipalities falling within a given range (per cent) of share of employment in the "hotels and restaurants" sector in the northern counties, 2004

Share of employment at county level	< 1 per cent	1–2.9 per cent	3–4.9 per cent	> 5 per cent
Nordland*:* 3.3 per cent	2	24	17	2 municipalities *- Vågan (5.6)* *- Moskenes (5.1)*
Troms: 3.7 per cent	0	18	7	None
Finnmark: 3.8 per cent	0	5	14	None
Northern region: 3.5 per cent	2	47	38	2

3.3.5 Electricity supply

Of the three northern counties, the electricity supply sector currently employs the greatest share of the workforce in Nordland, and the only municipalities having shares of employment greater than 3 per cent in this sector are found in Nordland. The share of employment in this sector is below 1 per cent for the majority of municipalities in Troms and Finnmark counties.

Table 7. Number of municipalities falling within a given range (per cent) of share of employment in the electricity supply sector in the northern counties, 2004

Share of employment at county level	< 1 per cent	1–1.9 per cent	2– 2.9 per cent	> 3 per cent
Nordland*:* 1.1 per cent	22	14	6	3 municipalities *- Hemnes (3.0)* *- Gildeskål (3.6* *- Hamarøy (3.8)*
Troms: 0.8 per cent	16	9	0	None
Finnmark: 0.9 per cent	11	8	0	None
Northern region: 1.0 per cent	49	31	6	3

4 Gross value added in climate sensitive sectors

4.1 Regional and County overview

Although the share of people employed in sectors sensitive to climate change is a useful indicator of the relative vulnerability, or sensitivity, of northern municipalities to climate change, the indicator by itself says little about the relative economic importance of the different sectors. Table 8 shows the gross value added for sectors sensitive to climate change across the three counties. From an economic perspective, it is clear that the most important sectors are transportation, electricity and water supply, and fisheries, with the construction and engineering sector also emerging as important. The hotels and restaurant sector is somewhat important, while agriculture is of less economic importance, at the county level.

Table 8. Gross value added across climate sensitive sectors, by county. Prices are in million NOK, 2002.

	Nordland	**Troms**	**Finnmark**	**Total**	**Share of total (%)**
Agriculture	470	186	100	756	1.3
Fisheries	2,395	1,201	1,190	4,786	8.5
Electricity	2,964	1,396	435	4,795	8.5
And water supply					
Hotels and restaurants	888	718	351	1,957	3.5
Transportation[5]	3854	2115	791	6760	12.0
Construction and engineering	2279	1561	714	4554	8.1
Total	26,383	21,380	8,562	56,325	100

Source: Statistics Norway

Figures 7 through 10 below show the economic importance of the climate-sensitive sectors in terms of their share of gross value added in the three northern counties in 2002.

[5] The figures here are an amalgamation of the data for the categories “innenriks sjøfart (”, “transportmiddelindustri” and “transport ellers”

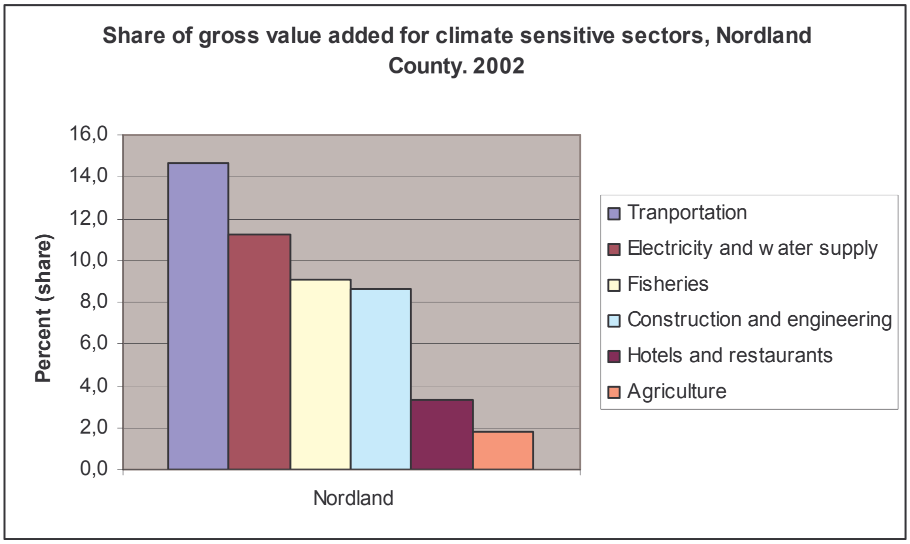

Figure 7. Share of gross value added among climate sensitive sectors in Nordland County, 2002. Source: Statistics Norway

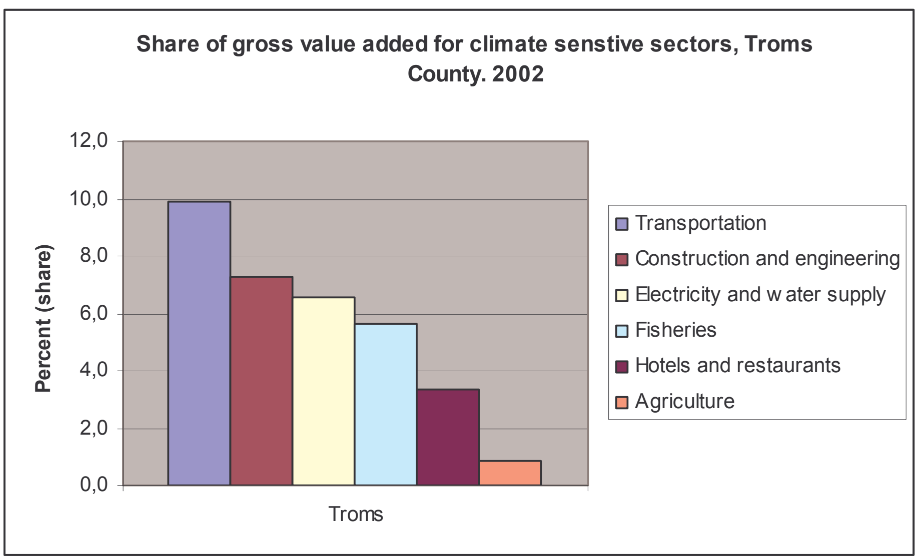

Figure 8. Share of gross value added among climate sensitive sectors, Troms County, 2002. Source: Statistics Norway

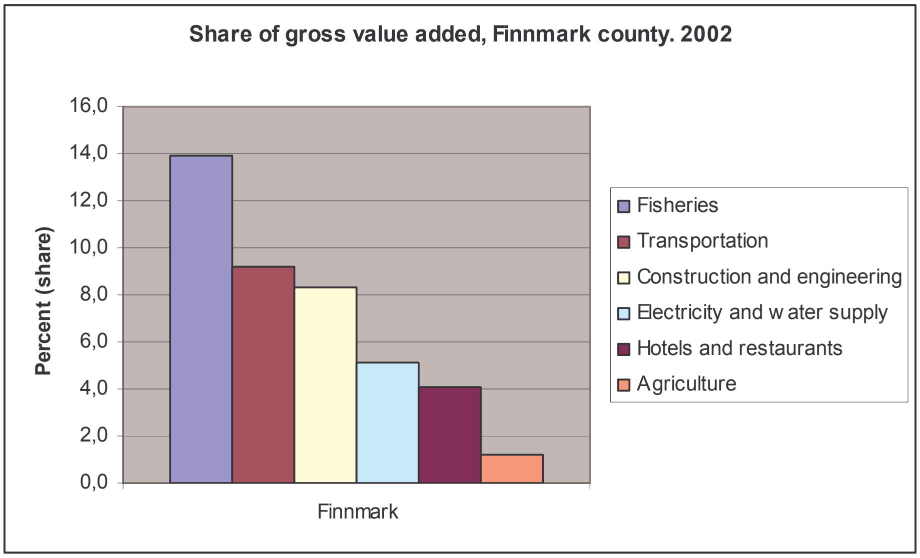

Figure 9. Share of gross value added among climate sensitive sectors in Finnmark County, 2002. Source: Statistics Norway

Again, as with data on employment, the question of scale in terms of share of value generated by different climate sensitive sectors is very important. There will be municipalities for which the sectors sensitive to climate change will undoubtedly be economically more important than what the county average suggests, and thus detailed data at the municipality level would show a different picture.

5 Additional Vulnerability Factors

5.1 Tourism:

5.1.1 County- and municipal-level vulnerability factors

The data presented below is for the county level only. Municipal figures for "kind-of-activity units" and employment can be obtained from Statistics Norway after filing a written application/request and depending on the intended application/use of the data. There is a fee of 3000 kroner.

An overview of figures for the hotels and restaurants sector (table 9), cultural services (table 10), and activities of travel agencies (table 11) in the three northern counties shows that Nordland county has the largest number of establishments (kind-of-activity units), employed persons, turnover, and value added across the sectors.

Table 9. Hotels and Restaurants. Principle figures, by county. Local kind-of-activity units (KAUs). 2002

	Nordland	Troms	Finnmark	Norway
Local KAUs	686	387	246	11 196
Employment (average number of persons during the year)	3983	3550	1516	89 413
Turnover (exclusive of VAT) (1 000 kroner)	1 752 537	1 409 024	700 882	41 610 491
Personnel costs (1 000 kroner)	591 190	508 652	231 489	14 247 174
Production value (1 000 kroner)	1 711 766	1 372 882	676 766	40 786 832
Value-added (at factor cost) (1 000 kroner)	706 185	564 601	280 486	17 076 329
Investments (1 000 kroner)	56 705	48 953	15 626	1 751 000

Source: Statistics Norway, Structural Transport and Tourism Statistics, 2002

Table 10. Cultural Services. Principle figures, by county. Local kind-of-activity units. 2002.

	Nordland	Troms	Finnmark	Norway
Local KAUs	81	61	38	2 182
Employment	250	199	168	9 379
Turnover (1 000 kroner)	181 374	150 509	126 713	10 207 247
Personnel costs (1 000 kroner)	75 886	60 503	58 073	3 258 030
Production value (1 000 kroner)	181 228	150 202	126 686	10 144 872
Value-added (1 000 kroner)	78 608	63 322	61 596	4 108 925
Investments (1 000 kroner)	15 568	11 573	12 434	561 050

Source: Statistics Norway, Structural Transport and Tourism Statistics, 2002

Table 11. Activities of travel agencies. Principle figures, by county. Local kind-of-activity

	Nordland	Troms	Finnmark	Norway
Local KAUs	206	97	127	3491
Employment	1455	801	693	28 078
Turnover (1 000 kroner)	1 734 337	1 219 383	706 056	79 541 656
Personnel costs (1 000 kroner)	439 825	249 959	222 517	9 864 315
Production value (1 000 kroner)	1 729 370	1 216 894	703 243	77 860 446
Value-added (1 000 kroner)	503 749	261 166	212 263	17 176 586
Investments (1 000 kroner)	46 453	136 636	22 549	1 957 612

Source: Statistics Norway, Structural Transport and Tourism Statistics, 2002

In addition to number of establishments, number of people employed, and turnover and production value, additional data at the **county level** is available for:

- Number of guest nights spent in hotels, huts, holiday dwellings, and camping sites, by nationality of the guests and by month (1995-2005)
- Number of beds occupied for hotels and similar establishments, by month (1995-2005)
- Guest nights in hotels and similar establishments by purpose of the visit and month

5.2 Agriculture

5.2.1 County overview and municipal variation

Table 12. Key agricultural figures, 2004

	Agricultural area in use, decares	Agricultural areas as a % of total land area[6]	Average number of decares per inhabitant	Number of agricultural holdings in use	Holdings < 100 decares in size (%)	Holdings > 300 decares in size (%)
Nordland	592 219	1,6	2.5	2985	25	21
Troms	265 651	1,1	1.8	1462	29	16
Finnmark	97 681	0,2	1.5	438	22	30
Norway	10 266 200	3,4	2.2	55 507	33	16

[6] Total land area excludes here freshwater areas, so it is not a measure of the total area in each county, but of total terrestrial land area. Freshwater areas can be added.

Table 12, above, shows that the greatest total agricultural area, average number of decares per inhabitant and number of holdings are found in Nordland, followed by Troms and Finnmark. Most agricultural holdings in all three counties are between 100 and 300 decares in size. Holdings in Troms are generally smaller in size than holdings in Nordland and Finnmark, and a lower proportion of holdings are less than 100 decares in size in all three counties, compared to for Norway as a whole. Finnmark has the highest proportion of holdings greater than 300 decares in size – the share of holdings in this class is double the average share for the country as a whole.

5.2.2 Type of agricultural areas and crops grown

Grain and oil-seed crops (barley, wheat, oats and "other grain and oil-seed") are only cultivated in Nordland, and to fairly small extents. Cultivated meadows and pastures make up the large majority of agricultural areas across the counties (78-81%), and potatoes are grown in small quantities in all three counties. "Open fields" are present in the three districts, and these make up the second largest agricultural areas. The area of surface-cultivated land as a percentage of total agricultural land in use is very low in all counties, but is highest in Nordland (16.5%).

Data on types of crops grown and area are also available at the municipality level.

5.2.3 Number of holdings keeping livestock (convert also into percentage of total holdings)

The number of holdings keeping livestock is highest in Nordland, followed by Troms and Finnmark. In Nordland, the largest number of holdings are registered for cattle (2016), followed by dairy cows (1679), sheep (1647), hens (257), breeding pigs (157) and goats (122). In Troms the largest number of holdings are registered for sheep (1114), followed by cattle (725), dairy cows (544), goats (260), hens (124) and breeding pigs (59). In Finnmark the largest number of holdings is registered for cattle (269), followed by sheep (262), dairy cows (236), hens (45), breeding pigs (21) and goats (12).

Table 13 shows how agricultural figures vary at the municipality level.

Table 13. Number of municipalities for which agricultural area exceeds 5 per cent of total land area[7], 2004

County	Number of municipalities for which agricultural areas > county average	Number of municipalities for which agricultural area/total land area > 5 per cent	Number of municipalities for which agricultural area/ total land area > 10 per cent
Nordland	23	8	4
Troms	12	1	0
Finnmark	5	0	0
Total	40	9	4

[7] Statistics not available for publication for Træna, Værøy and Moskenes municipalities in Nordland; Torsken and Berg municipalities in Troms county; and Loppa, Hasvik, Måsøy, Berlevåg and Båtsfjord municipalities in Finnmark.

Even though agricultural land on average makes up a small percentage of total land area in the three counties, four municipalities in Nordland – Altashaug, Herøy, Vega and Sømna -- have agricultural areas that account for more than 10% of the total land area in their respective municipalities.

5.2.4 Number and size of agricultural holdings

Total number of holdings varies at the municipality level from 8-147 in Nordland, 5-242 in Troms, and 4-124 in Finnmark. Calculations for the number of holdings falling into different size categories at the municipal level can not be done – this data is not currently available.

5.2.5 Holdings with livestock

At the municipal level, the number of holdings keeping livestock of any kind varies from 2 to 113 (or 67.6-100 percent of all holdings) in Finnmark; 5-224 (78.9-100 per cent of all holdings) in Troms, and 8-173 (78.6 to 100 percent of all holdings) in Nordland.

5.3 Electricity supply

Table 14 gives an overview of electricity production from hydropower in Nordland, Troms and Finnmark counties. Nordland is ranked second in Norway after Hordaland County in terms of electricity production from hydropower (SSB). Although there remains a technical and economical potential for larger hydropower developments in northern Nordland, the actual scope of new hydropower developments is limited due to the protection of a number of watersheds from development. The focus within the region has therefore shifted towards small-scale hydropower development (50 kW-10 MW).

Table 14. Production of electricity from hydropower in the northern counties, 2001-2003. TWh

County	2001	2002	2003
Nordland	14.9	17.4	16.2
Troms	2.6	2.8	2.6
Finnmark	1.6	1.5	1.3
Total	19.0	21.7	20.0

Source: Statistics Norway

Transmission capacity is already constrained in northern Norway, and would require expansion if further energy resources were to be utilized. Table 15 shows the existing electricity cables in km at the end of 2003. Nordland clearly holds the largest share of electricity cables among the northern counties.

Table 15. Electricity cables, 2003, km

County	Air	Earth	Sea
Nordland	19,114	6,072	610
Troms	10,649	3,789	206
Finnmark	8,466	1,581	112
Total	38,229	11,442	928

Source: Statistics Norway

5.4 Base socio-economic indicators

The following data are available for municipalities on SSB's web pages and could be usefully analysed as a first approach in a top-down vulnerability assessment for understanding and measuring "adaptive capacity".

For example, a larger share of the population in Finnmark live in urban settlements (73%) compared to Troms (65%) and Nordland (66%). In addition, population density is much lower in Finnmark, at 1.5 inhabitants per square km, compared to 6, 1 in Nordland and 5.9 in Troms. In terms of employment in primary, secondary and tertiary industries, Nordland has the highest proportion of population employed in primary industries (13.5%), followed by Finnmark (11.3%) and Troms (10.3). The national figure is 9 per cent. Nordland also has a higher proportion of its population employed in secondary industries compared to Troms and Finnmark, while Finnmark has a slightly higher proportion of its population employed in tertiary activities compared to Troms and Nordland.

Text Box 1. Base socio-economic indicators

Population figures

- Population living in urban versus rural settlements
- population structure (age)
- demographic projections
- population density

Education figures

- Education level of the workforce, by sex
- Pupils receiving special education

Economic figures

- Free revenues per inhabitant
- Gross expenditure per sector
- Net operating result as a percentage of operating revenues
- Net lending per inhabitant
- Central government transfers as a percent of gross operating revenues
- Sales and rental revenues as a percent of operating revenues

Labour and income figures

- Employed 16-74 year olds as a percentage of population /by sex)
- Registered unemployment as a percentage of population (by sex)
- Proportion of disability pensioners
- Gross income per inhabitant
- Employment by industry (primary, tertiary, and service sector, per cent)

Health and social care

- Proportion of children 0-17 years in child protection registers
- Social benefit recipients per 100 inhabitants (20-66 years)
- Man-years for doctors per 10 000 inhabitants
- Proportion of people 80 and older living in institutions
- Proportion of people 80 years and older receiving home care

6 Case Study of potential vulnerability indicators for the Fisheries Sector

As highlighted in the first sections of this report, the fishery sector is important, both in terms of employment and income, as well as in cultural terms, for a number of municipalities in northern Norway. It is also a sector that is highly sensitive to the impacts of climate change. The authors of chapter 13 of the ACIA report conclude that a moderate warming of mean ocean temperatures is likely to "improve conditions for some of the most important commercial fish stocks…due to enhanced levels of primary and secondary production resulting from reduced sea-ice cover" (Vilhjálmsson et al., 2005: 692). Changes in ocean temperatures are also expected to increase the extent of habitat for certain fish species, including cod and herring (ibid). Climate change is also likely to result in changes in species composition, and a number of studies have shown that the growth rate, time to maturity, and reproductive, and recruitment rates of different fish species are at least partly dependent on temperature (ACIA 2005; Drinkwater, 2006, IMR, 2006)

Potential indicators of vulnerability to climate change for fisheries:

1. Number of full-time fishermen

Table 16 shows that there were about 6,100 people registered with fishing as the main occupation in Nordland, Troms and Finnmark in 2004. Of these, over 50 percent were registered in Nordland. Across the three counties, full-time fishing accounts for 2.3 to 3.7 percent of the total labor force.

Table 16. Number of full-time fishermen (registered as main occupation) in the northern counties in 2004. Source: Directorate of Fisheries

	Number of fishermen (main occupation)			% of total employment	Decrease, %	
County	**1990**	**2000**	**2004**	**2004**	**2004-1990**	**2004-2000**
Nordland	4,670	3,363	3,195	2.9	-31.6	-5.0
Troms	3,418	2,139	1,759	2.3	-48.5	-17.8
Finnmark	1,994	1,363	1,150	3.7	-42.3	-15.6
Total	10,082	6,865	6,104	2.8	-39.5	-11.1

This information is also available at the municipality level for all three counties. The figures show that fishing is a very important source of employment for some municipalities. For instance, fishing accounts for 25-31 percent of total employment in the municipalities Røst, Flakstad, Moskenes and Verøy (all in Lofoten, in Nordland).

2. Number of part-time fishermen

Fishing can also be important through part-time fishing. Table 17 shows that in 2004 there were about 1,550 part-time fishermen in Nordland, Troms and Finnmark. These are fairly evenly spread over the three counties, but that in terms of employment, it is relatively more important in Finnmark. It is worth pointing out that a significant share of the decrease in the number of part –time fishermen has occurred after 2000.

Table 17. Number of part-time fishermen. Source: Directorate of Fisheries

	Number of fishermen (main occupation)			% of total employment	Decrease, %	
County	1990	2000	2004	2004	2004-1990	2004-2000
Nordland	1,463	1,115	620	0.6	-57.6	-44.4
Troms	1,334	1,143	564	0.7	-57.7	-50.7
Finnmark	662	686	365	1.2	-44.9	-46.8
Total	3,459	2,944	1,549	0.7	-55.2	-47.4

This information is also available at the municipality level for all three counties. The figures show that part-time fishing is a very important source of employment for some municipalities. For instance, 42 and 20 percent of persons employed in the municipalities of Tranøy and Nordreisa (both in Troms) are part-time fishermen.

3. Catch of fish by species and place of landing

Table 18 shows the catch of fish by species and place of landing for Nordland, Troms and Finnmark in 2002. Nearly 813,000 tones of round fish with a value of about 4,532 million NOK were caught in the three northern counties.

Table 18. Catch of fish by species (tonnes round weight) and place of landing, 2002.

Place of landing	All fish species	Value (million NOK)	Cod	Herring and sprat	Mackerel, capelin etc	Crusta-ceans	Other
Nordland	344,858	2,015	143,674	116,163	72,120	1,540	11,361
Troms	251,984	1,472	91,407	57,789	55,406	40,776	6,606
Finnmark	215,913	1,045	85,636	2,040	119,019	3,932	5,286
Total	812,755	4,532	320,717	175,992	246,545	46,248	23,253

Source: Statistics Norway, Fisheries Statistics 2002-2003: Table 25

This indicator shows that over 40 percent of the total fish weight and value is landed in Nordland. However, there are differences between the fish species that become particularly interesting when climate change alters the composition and location of fish species. For instance, 45 percent of the cod and 66 percent of herring and sprat are landed in Nordland. Troms tends to land 20-30 percent of the fish species, but it lands 88 percent of the crustaceans. Finnmark lands only 1 percent of the herring and sprat and 9 percent of the crustaceans, but nearly half of the total mackerel and capelin catch.

This information is also available at the municipality level for all three counties. For instance, the statistics show that cod is landed in a relatively scattered pattern. The largest cod landing is in the municipality of Tromsø, which lands nearly 10 percent. The majority of the herring landing is concentrated in the six municipalities of Bodø, Træna, Lødingen, Verøy, Tromsø and Berg. Almost 78 percent of the mackerel and capelin are landed in the four municipalities of Bodø, Tromsø, Vadsø and Nordkapp while over 60 percent of the crustaceans are landed in the municipality of Tromsø.

4. Catch of fish by species and fishing ground

In 2002, a total of 2,739,843 tonnes of round weight fish were caught in Norway. Of this, 67 percent was caught offshore (outside the 12 n. mile zone). Table 19 shows that the three most northern counties account for a majority of the Norwegian total coastal fisheries catch, the exception being for crustaceans. The statistics show that cod is predominantly caught in Nordland and Finnmark, herring and sprat only in Nordland while mackerel and capelin are mostly caught in Finnmark. Similar information at the municipality level is not available in the fishery statistics from Statistics Norway.

Table 19. Catch of fish by species (tonnes round weight) and coastal fishing ground, 2002

Fishing ground	All fish species	Cod	Herring and sprat	Mackerel, capelin etc	Crusta-ceans	Other
Nordland	528,532	100,239	421,081	416	507	6,288
Troms	34,088	29,755			241	4,092
Finnmark	199,838	78,026		115,861	664	5,287
Total for 3 counties	762,458	208,020	421,081	116,277	1,412	15,667
Total coastal	890,563	242,444	465,572	150,859	9,578	22,111

Source: Statistics Norway, Fisheries Statistics 2002-2003: Table 19

5. Catch of fish by species and place of registration of the vessel

Focusing on the place of registration of the vessels instead of the place of landing and fishing ground shows a somewhat different picture (table 20). Nordland is still the dominant county, but vessels from Finnmark catch more than vessels from Troms in terms of the total catch, cod, herring and sprat, and mackerel and capelin. Vessels from Finnmark catch more herrings and sprat than the place of landing figures suggest, and it is clear that Troms is less dominant in terms of the catch of crustaceans as particularly vessels from Finnmark are involved.

It is worth pointing out that the totals for the three counties tend to be lower than the totals based on place of landing (the exception is herring and sprat). This indicates that vessels from other counties and countries land fish in Nordland, Troms and Finnmark counties. Information on catch according to the registration of the vessel is available at the municipality level and has recently been prepared for the years 1979-81 and 2001-2006 by statistics Norway for a separate project for CICERO. This type of information would add useful insight and important nuances to in-depth vulnerability studies for the fisheries sector and communities that depend on fisheries in Northern Norway.

Table 20. Catch of fish by species (tonnes round weight) and place of registration of the vessel, 2002.

Place of landing	All fish species	Cod	Herring and sprat	Mackerel, capelin etc	Crusta-ceans	Other
Nordland	400,008	146,863	117,415	115,746	9,731	10,254
Troms	183,195	79,983	40,991	41,045	15,024	6,151
Finnmark	202,156	83,607	42,716	64,578	5,485	5,770
Total	785,359	310,453	201,122	221,369	30,240	22,175

Source: Statistics Norway, Fisheries Statistics 2002-2003: Table 22

6. Number and type of fishing vessels

Table 21 shows that there were about 4,700 fishing vessels operating in northern Norway in 2004. Nordland is the county with the most vessels and most decked vessels are shorter than 28 meters. Information on vessels by type and length at the municipality level is not available in the fishery statistics from the Directorate of Fisheries. Such information is, however, important for place-based studies of fisheries economics and in order to determine adaptive capacity and adaptation options, for example in terms of assessing the "fit" between existing fishing technology, mobility, etc., and projected climate and biophysical changes.

Table 21. Vessels by type, length (meter) and county, 2004

	Open vessels		Decked vessels												
County	<10	10-	<10	10-	15-	21-	28-	30-	35-	40-	45-	50-	55-	60-	Total
Nordland	263	0	952	615	182	87	0	3	1	3	5	7	2	7	2,127
Troms	444	0	509	319	66	33	0	1	1	5	6	5	2	2	1,393
Finnmark	258	0	451	347	55	26	1	0	2	3	6	2	1	4	1,156
Total	965	0	1,912	1,281	303	146	1	4	4	11	17	14	5	13	4,676

Source: Directorate of Fisheries

7. Fish processing

The land-based side of the fishing industry is important. Table 22 shows the number of companies and employees in the fish processing industry in 2003.[8] Over 250 companies were operating in northern Norway in 2003. Nordland is the dominant county in terms of companies and employees. Finnmark has more filet companies than Troms, but Troms holds

[8] Some companies operate within several industries. The companies are placed according to the most important activity.

nearly all of the shrimp companies. Fish processing is important for employment. The number of employees is in fact only 1,150 fewer than the total number of full-time fishermen in 2004. It would be very interesting to know where these companies are located, but this is not available from the Directorate of Fisheries. Such information could reveal whether the industry is concentrated in certain areas, or relatively spread out, something that would be necessary information for a vulnerability assessment.

Table 22. Number of companies and employees in fish processing industry, 2003

	Nordland	Troms	Finnmark	Total
Slaughter facilities	15	15	9	39
Conventional production and other landing facilities	79	19	26	124
Shellfish landing facilities	1		3	4
Freezers (filet whitefish and pelagic)	16	8	11	35
Canning facilities	2			2
Shrimp industry	1	7		8
Other processing	9	3	1	13
Additional processing	7	5	2	14
Herring oil and meal facilities	2	1	1	4
Other meal and oil	1	1	2	4
Cod liver oil , fish oil	6			6
Total	139	59	55	253
Number of employees	2340	1300	1300	4940

Source: Ministry of Fisheries, 2004.

8. Aquaculture

In 2004, there were a total of 313 operating salmon and trout concessions in northern Norway (up from 220 in 1994). There were about 750 employees and the first-hand sales were 3,870 million NOK. Since 1994, Finnmark has seen the largest increase in operating concessions and in the sales value (over 700 percent higher sales in 2004). However, it is worth pointing out that although the number of operating concessions and the sales are increasing, the number of employees is in fact decreasing.

Table 23. Aquaculture (salmon and trout) in northern Norway, 2004

	Operating concessions	Employees	First-hand sales (million NOK)
Nordland	154	386	2,071
Troms	84	233	965
Finnmark	75	140	834
Total	313	759	3,870

Source: Directorate of Fisheries

6.1 Critical examination of the selected indicators

At first glance, the number of people with fishing as their main occupation appears to be a good indicator of whether a community could be vulnerable to climate change. However, there are a number of issues that should be considered. It does not take into account that part-time fishing is widespread in northern Norway. Using relative importance (share of total employment) can be misleading as 10% is very different from one municipality to another. Also important is that the number of fishermen is steadily declining. From 1990 to 2004, there are 40 percent fewer fishermen in all three counties combined. The decline is also evident if 2004 is compared to 2000. Other important issues are alternative sources of employment, the mobility of the labor force (e.g. where fishers actually live and pay taxes) and the level of unemployment. The number of people involved in for instance aquaculture and fish processing is also important.

The place of landing could be interpreted as where the fish is landed for processing, or for transport to another municipality for processing. This does not necessarily mean that fishing is not important for a municipality with no or a low share of fish landing. This indicator should therefore be used in combination with other indicators. The indicators showing the catch of fish by the fishing ground, the registration of the vessel and the type and number of fishing vessels are useful at the county level but not so much at the municipality level. The mobility of the fishing fleet does not make this a particularly useful indicator to determine communities' vulnerability to climate change. Since 90 percent of the fish landed in Norway is exported (ACIA, 2005), knowing more about the land based industry is important. Aquaculture has become important in terms of production quantity and sales value, but less important in terms of employment. Table 24 summarizes the main strengths and drawbacks of the various vulnerability indicators discussed in this short desk study of the fisheries sector in northern Norway.

Table 24. Strengths and drawbacks of selected vulnerability indicators for the fisheries sector in northern Norway.

Indicator	Strengths	Drawbacks
Number of fishermen (full-time and part-time)	Directly related to dependence on the natural resource base. Importance for employment (both absolute and relative). Statistics for municipalities available.	Relative importance can be misleading Work force composition changes, decreasing trend. Says nothing about alternatives.
Catch by species and place of landing (in tonnes live weight and value)	Directly related to the natural resource base. Distinguishes between species. Statistics for municipalities available.	Related to where the fish will be processed, but transport can make indicator misleading. Mobility of fishing fleet can also mislead. Significance of vessels from other counties and countries?
Catch by species and fishing ground (in tonnes live weight and value)	Directly related to the natural resource base. Gives an indication of the importance of different fish species in terms of value and quantity of catch	Mobility of fishing fleet can also mislead. Statistics for municipalities not available.
Catch by species and registration of the vessel (in tonnes live weight and value)	Directly related to the natural resource base.	Mobility of fishing fleet can also mislead. Statistics for municipalities not available.
Number and type (length, etc) of fishing vessel		Mobility of fishing fleet can also misleading. Statistics for municipalities not available.
Fish processing (number and type of plants)	Important for export and employment.	Concentrated in certain areas?
Aquaculture: value, catch and employment	Increasing importance for production and sales. Promising prospects	Decreasing trend in employment. How much of the values remain locally?

The indicators discussed here are not on their own sufficient to determine whether municipalities, communities or settlements are vulnerable to climate change through second-order effects on the fisheries. The indicators could perhaps be used to screen the municipalities and then a selection of municipalities could be further analyzed in combination with a set of additional, local factors and information, as discussed in the section below.

6.2 Additional vulnerability factors

Indicators such as number of people employed in fisheries and fisheries-related industries, size and value of catch of different fish species landed at different sites, and number and size of vessels by place of registration provide a good indication of the relative importance of fisheries to different counties and municipalities. The vulnerability of communities to climate change depends on the adaptive capacity of people, sectors and regions. The adaptive capacity is determined by internal and external factors. Such factors as policy making, "wealth, technology, education, information, skills, infrastructure, access to resources and management capabilities" all affect the ability of different actors to adapt to a changing climate (McCarthy, Canziani et al., 2001).

With respect to fisheries in northern Norway, Lindkvist (1999) defines "dependent" and "independent" fishing communities on the basis of the availability of livelihood options other than fishing, and not only as a function of the number of people employed in fishing and fishery-related activities, the value or size of catch, or the size or extent of the fishing fleet. Lindkvist argues that "dependency" on fisheries is "socially embedded within each local community and spatial in nature" (1999: 3). He goes on to explain that while some communities offer only limited opportunities for engagement in industries other than fishing, in others – particularly in larger centres or towns, "fishing activities represent only one out of many local industrial activities. These places are not dependent on fisheries…" (ibid: 5). Nonetheless, the areas that Lindkvist defines as "fisheries–independent" are often the very places where modern fishing enterprises (comprising offshore fishing activities, modern factory trawlers and large processing plants) and production systems are concentrated, and thus where political power and decision-making rest.

It is therefore evident that additional indicators of vulnerability are needed to assess vulnerability to climate change at local levels. Such indicators would complement the regional and sectoral figures and statistics presented above. Examples of additional methods and factors to consider when conducting assessments of local vulnerability in fisheries-dependent regions are:

- Qualitative and quantitative assessments of alternative sources of local employment and income sources
- Assessments of unemployment levels among fishermen (relative to municipal, county and national figures)
- Mapping of local managerial and institutional competence (both the organisational, and the social infrastructure related to fisheries)
- Indicators put forward by local actors themselves based on identification of local needs, capacities and constraints
- Local 'vulnerability' maps
- Assessment of awareness, perceptions and interpretations of climate change at the local levels, and of preparedness for dealing with changes (municipal planning and policy dialogues; economic and political will to take a proactive approach to adaptation)

It is important to consider present and future economic, as well as climate, trends, in northern communities as part of a holistic vulnerability assessment. For example, the number of aquaculture plants and sites is projected to increase substantially in northern Norway in the coming decades (ACIA 2005:703). Moreover, ongoing structural adjustments in the fish processing industry in Finnmark have led different municipalities to concentrate on different fish products and processing techniques, and to organise them under different management regimes (Fløysand and Lindkvist, 2000). These ongoing economic changes, in addition to the status of management regimes for fisheries in the Northeast Atlantic (Barents and Norwegian Seas) will affect, and interact with, the relative exposure, vulnerability and adaptation of northern communities to future changes in climate.

Adding to the complexity, marine biologists point out that warming of the Arctic sea waters may not necessarily lead to an increase in the northern extent of commercially important northern fish stocks, since biophysical interactions and feedbacks in Arctic marine ecosystems are complex, and still relatively difficult to project over long time periods.

Warmer Atlantic waters flowing into the Barents Sea bring nutrients and food for northern fish stocks. If the direction and strength of ocean currents in the Arctic change significantly, the recruitment, habitat and species composition of key commercial fish species are likely to change significantly (the relates to the uncertainty in the projections, poor understanding of underlying driving forces of marine ecosystems)

Finally, a number of authors point out that management regimes in large marine ecosystems are likely to have a greater impact than the effects of climate change on northern fisheries (ACIA, 2005). In this context, a multiple stressors approach to be critical to understanding vulnerability to climate change (e.g. Tyler et al.,2007*)*.

The complexity of factors and interactions between biophysical, social, economic, political, legal and institutional contexts and changes in the fisheries sector in the context of climate change should not be diminished. Rather, satisfactory methods of capturing the complexity must be developed in order to conduct comprehensive analyses of socio-economic vulnerability and present and future adaptive capacity to climate change in Norway's northern regions.

7 Next steps

Different approaches yield different answers to the question of which Norwegian municipalities are more or less vulnerable to climate change. In their assessment of regional vulnerability to climate change in northern Norway, Groven *et al.* (2006), provide a comprehensive overview of available recent and historical data in Norway that could be used as indicators to determine municipal vulnerability to climate change. The authors then use this data to rank municipalities' vulnerability to climate change. Our report takes a different approach – it analyses two potential indicators of municipal vulnerability to climate change and shows how the same indicator yields different answers at different scales of analysis, and that different indicators yield different answers to the same question. Given the limitations of any top-down vulnerability assessment to pinpoint local vulnerability and adaptation factors, the authors argue that there is a clear need to make greater efforts to engage community representatives and decision-makers in vulnerability and adaptation research processes in northern Norway, both to ensure that the items analyzed are pertinent to community members and to ensure the relevance and applicability of the research to decision makers. A fundamental next step in the vulnerability assessment methodology developed by Vestlandsforsking and CICERO would be to compare the results achieved through their respective desk studies with selective studies of the realities and priorities surrounding climate change vulnerability and adaptation in specific locales. It is important to identify how community members and governance structures at the local level deal with social, economic and environmental changes in real time, so that analyses of adaptive capacities and adaptation options can be applicable to actual decision-making structures, authorities and policies. Rigorous analysis of policies and decision making should be undertaken as part of the vulnerability assessment, contributing to the direct policy relevance of the results.

Additional next steps of a place – and context - based vulnerability assessment could include:

1. Documenting prioritised local vulnerability factors (place – and context – specific)
2. Identifying how communities are sensitive to the combined or interactive effects of change in climate and to the interactions with changes in socioeconomic and bio-physical conditions.

3. Identifying how social, economic and biophysical conditions are expected to change with time
4. Assessing the ability of local communities to manage changing conditions (current adaptive capacity).
5. Identifying past adaptive strategies.
6. Identifying how social, cultural, economic, and political processes operating at multiple scales may affect adaptive capacity to changing climatic conditions: barriers, opportunities and constraints to adaptation
7. Assessing what further adaptations might be needed in a local context, and what can be done to enhance a community's adaptive capacity.

Figure 25 shows the relationships between the main categories of information needed in a vulnerability assessment of this type. The researchers first document past and current exposure-sensitivities and adaptation strategies in order to identify the conditions that are of particular relevance to the community and to describe the ways in which communities have managed those conditions. These provide the basis for estimating future vulnerability (both exposure-sensitivity and adaptive capacity), assessing the likelihood of changes in conditions pertinent to the community, characterizing the scope and limits to adaptive capacity, and drawing on scientific predictions of change in natural and social systems. The assessment of future risks and prospects for adapting provides the basis for collaboratively identifying initiatives that could enhance the capacity of the community to adapt (Smit, Hovelsrud & Wandel, 2008:6)

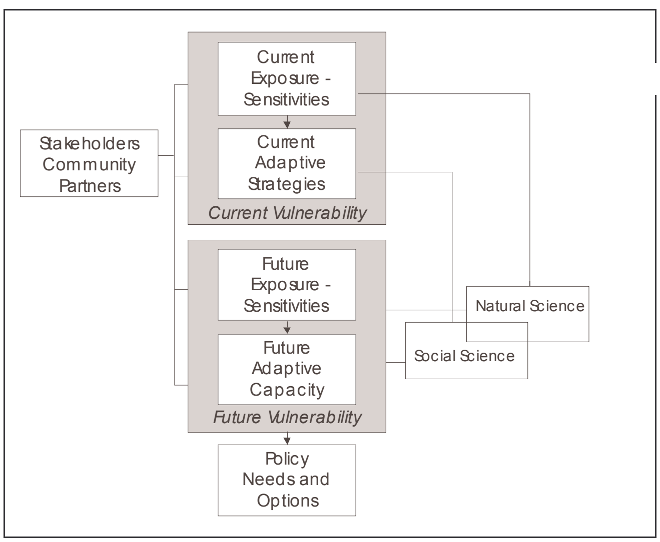

Figure 25. Key Elements in Vulnerability Assessment

There are a number of challenges in arriving at a better understanding of socio-economic vulnerability and adaptation to climate change. These include:

- Challenges associated with capturing spatially and temporally dynamic social, demographic, ecological, economic and institutional processes in a vulnerability assessment

- Deciding on methods and approaches for identifying the most relevant local vulnerability and adaptation indicators, and involving stakeholders
- Linking socioeconomic data with downscaled climate scenarios
- Tackling the inherent uncertainty in climate change projections
- Setting climate change impacts, adaptation and vulnerability into appropriate social, economic, environmental, cultural and institutional contexts
- Dealing with the issues and public concerns that *really count*, not only those that are *easy to count*
- Methodological challenges of integrating social and natural science perspectives, and finding a balance between qualitative and quantitative data

8 Conclusion

In this study we have analysed various top-down indicators of vulnerability to climate change, focusing on northern Norway and the climate-sensitive sectors identified by the NorACIA working group and concluding with an in-depth study of vulnerability indicators in the fisheries sector. Climate change is a global concern, but the effects will be felt and dealt with at the local level, and must therefore be addressed in this context, while also considering the links between the societal scales. With the limitations contained in a desk-top study as a backdrop, we can venture to say that regions, communities and economic sectors that depend on primary industries such as fisheries, agriculture, electricity supply, construction, transportation and tourism for income, employment, recreation and cultural identity are likely to be particularly sensitive to climate change. However, vulnerability to climate change is not only a function of exposure and sensitivity to current and expected changes, but also relies on the capacity to adapt to changing conditions.

We have shown that 'vulnerability' -- in terms of share of employment and gross value added in climate sensitive sectors -- varies with scale. While in northern Norway, counties as a whole may appear to have a low sensitivity to climate change from the perspective of having a low proportion of the workforce employed in a given climate-sensitive industry, at the municipal level dependence on the employment and income from climate-sensitive industries varies widely, with some municipalities being highly dependent on employment in a given sector compared to other municipalities and other sectors. A focus on communities rather than municipalities is likely to change the picture once again, adding even more nuance and detailed information to the assessment. The fact that vulnerability is highly scale-dependent makes it necessary to conduct investigations at a variety of levels.

This report has shown that there are clear drawbacks and limitations to assessing vulnerability to climate change via top-down approaches that rely only on aggregated, and available statistical data. The fisheries sector in northern Norway provides a good example of the complexity of processes and states that are not captured well in aggregated data. Fisheries are highly seasonal, and the resource in question – the different fish stocks – are highly mobile. The success of fishing and livelihoods for fishers moreover depends on interactions between complex biophysical, climatic, and institutional and legal settings. A focus on the quantity and value of "landed catch" of different species, even at the municipal level, says nothing meaningful about where the fish was caught, or whether the profits from the landings stay in the region of landing, or follow the fishermen back to the place of registration of the vessel, if this happens to be his place of residence.

The complexity of issues affecting the fisheries sector and the dynamic processes it encompasses suggests that a more fruitful approach to understanding vulnerability to climate change in this sector would be to combine an understanding of the economic, social, and biological responses of the fisheries sector to climate change with other important framing factors such as management regimes and the legal framework within which the fisheries operate. What are the implications of international agreements and treaties for natural resource-dependent regions and groups *within a context of future climate change*; what market opportunities and constraints are likely to emerge or disappear as a result of climate change? What resources and options can local communities and regions draw on now to deal with changes to the natural resource base and a dynamic and in some cases, unpredictable, institutional environment. What resources and options will be needed in the long run?

As the section on next steps and our findings point out, there is a need to actively engage local people and stakeholders in assessments of vulnerability and adaptation to climate change. Local vulnerability and adaptation indicators and factors should be identified and documented in collaboration with local stakeholders to improve the analysis and its applicability to local decision making processes. This agenda provides a framework for further collaboration between CICERO, Vestlandsforskning and additional partners under Theme Group 4 of the NorACIA work programme for 2007.

In summary, a multi-scale approach to assessing the vulnerability and adaptive capacity of different groups and industries in northern Norway is needed. Vulnerability studies must not ignore the importance and relevance of 'demand-driven' qualitative analyses and their potential to flesh out the data and indicators suggested in 'supply-driven' quantitative assessments that rely only on aggregated and existing data. Qualitative investigations and identification of local indicators should be coupled with analyses of actual and potential responses to climate change in real contexts. Finally, analyses of the socio-economic impacts of and potential responses to climate change at different scales should consider the importance of social, economic, biophysical, cultural and institutional structures in governing options for responses to climate change.

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