Norsk Geografisk Tidsskrift–Norwegian Journal of Geography, 2016
http://dx.doi.org/10.1080/00291951.2016.1194317

Routledge
Taylor & Francis Group

A bridge over troubled water: A contextual analysis of social vulnerability to climate change in a riverine landscape in south-east Norway

Vegard Gundersen, Bjørn Petter Kaltenborn & Daniel R. Williams

Vegard Gundersen, Norwegian Institute for Nature Research, Fakkelgården, NO-2624 Lillehammer, Norway; Bjørn Petter Kaltenborn, Norwegian Institute for Nature Research, Fakkelgården, NO-2624 Lillehammer, Norway; Daniel R. Williams, Rocky Mountain Research Station, United States Forest Service, Fort Collins, CO 80526, USA

ABSTRACT
Local communities in the Gudbrandsdalen region in Norway are increasingly exposed to climate-induced hazards such as floods and landslides. A core question is how community members respond to climate change and what factors contribute to more resilient communities. The authors used a contextual approach to analyze data from semi-structured interviews along five dimensions. In Gaustad Muncipality they found that individuals' motivation to adapt to climate change depended largely on subjective values such as identity, place attachment, cultural values, and social networks among individuals, which means it is crucial that strategic plans for adaptation to climate change at different policy levels are experienced as relevant by community members. While the studied community has experienced heavy floods in river systems and streams, little evidence of adaptation was observed. Instead, they appeared to adopt coping strategies. Landowners may have limited incentives to adapt to climate change due to contraproductive policy measures such as economic compensation for direct losses without requiring improved practices. Effective adaptation to climate change on the local level is likely to require making compensation mechanisms contingent upon landowners showing willingness to change from coping to adaptive practices, as well as a contextualized approach integrating local and scientific forms of knowledge.

ARTICLE HISTORY
Received 11 March 2015
Accepted 23 May 2016

EDITORS
Kerstin Potthoff, Catriona Turner

KEYWORDS
adaptation, local knowledge, community resilience, river system, rural community

Gundersen, V., Kaltenborn, B.P. & Williams, D.R. 2016. A bridge over troubled water: A contextual analysis of social vulnerability to climate change in a riverine landscape in south-east Norway. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* Vol. 00, 00–00. ISSN 0029–1951.

Introduction

The social and ecological effects of climate change depend to a large extent on the *vulnerability* of social and ecological systems to the effects of climate change (Janssen & Ostrom 2006), such as flood hazards, which is the theme of this article. In turn, vulnerability is strongly influenced by complex interactions of factors such as historical land use development, spatial planning, current management regimes, and policy guidelines. A contextual approach to social vulnerability is particularly relevant to our research, which focuses on vulnerability as the result of an interplay among many place-specific factors that result in unequal exposure to risk and create different capacities to respond (for a review see Murphy et al. 2015). Vulnerability, risks, and responses cannot be understood independently of larger social, economic, political, and cultural changes, but only as interrelations between different scales (e.g., local versus national and/or international trends) (e.g., Zahran et al. 2008; Amundsen et al. 2010). Past political decisions and established managerial practices induce a *path dependence* that constrains the extent to which social and ecological systems can adapt to the changing climate (Peters et al. 2005; Preston et al. 2013). Moreover, uncertainties about the climate change risks and the potential effectiveness and costs of comprehensive management and policy revision may act as barriers to adequate adaptation and strengthening of resilience to such risks (Barton & Dervo 2009; Kates et al. 2012).

Vulnerability, resilience, and adaptive capacity

The terms used here to describe "vulnerability," "resilience," and "adaptive capacity" are defined in different ways by different research communities (e.g., Gallopin

CONTACT Vegard Gundersen vegard.gundersen@nina.no

2006; Smit & Wandel 2006). Although people know intuitively that vulnerability means a potential for harm, and that resilience and adaptive capacity implies resisting or recovering from harm, the above-mentioned three terms are fairly abstract. They are generally treated as complementary or at least related, reflecting the different concerns of each research community. We define *social vulnerability* as the emergent exposure and sensitivity of a social actor or group to adverse events or processes (e.g., hazards such as floods, fires, and landslides) that cause changes within a social-ecological system (Fig. 1) (Füssel & Klein 2006; Jansen & Ostrom 2006). Figure 1 shows the contextual vulnerability framework and theoretical background to this present article, with five dimensions outlined from analyses of the empirical material in the literature (e.g., O'Brien et al. 2007; Buikstra et al. 2010; Magis 2010; Amundsen 2012). *Adaptive capacity* is the dynamic set of capabilities and resources that actors can mobilize to respond successfully to threats, events, or processes (Gallopin 2006; Smit & Wandel 2006; Nelson et al. 2007). The concept of resilience is in some ways similar to the idea of adaptive capacity. According to Pelling (2003, 48), resilience involves:

> [the] ability of an actor to cope with or adapt to hazards stress. It is a product of the degree of planned preparation undertaken in the light of a potential hazard, and of spontaneous or premeditated adjustments made in response to felt hazard, including relief and rescue.

A contextual approach to social vulnerability and adaptive capacity to flood hazards is based on how local people live and act in a community in a landscape (Murphy et al. 2015). Here, we focus on adaptive capacity as a contribution to the emerging field of analyses of the social factors that influence social vulnerability. Landscapes are diverse and can be repositories of historical, ritual, cultural, and spiritual meanings, as well as social and personal identities and emotional memories. Through a bottom-up perspective based on individual experiences, we examine how these factors are interlinked with climate and environmental change among a group of community members in Gausdal Municipality (hereafter also referred to as Gausdal), a rural municipality in Oppland County in south-east Norway. Vulnerability assessment has roots in at least three different, but to some extent related, research communities: climate change impacts, hazards and disasters, and sustainability (Gallopin 2006). Originally, our main approach was to study how climate change impacts the local community. However, during fieldwork it became apparent that the main community concerns were hazards caused by floods and the constraints to sustainable river management, since in 2011 and 2013 there had been two severe floods in the study area.

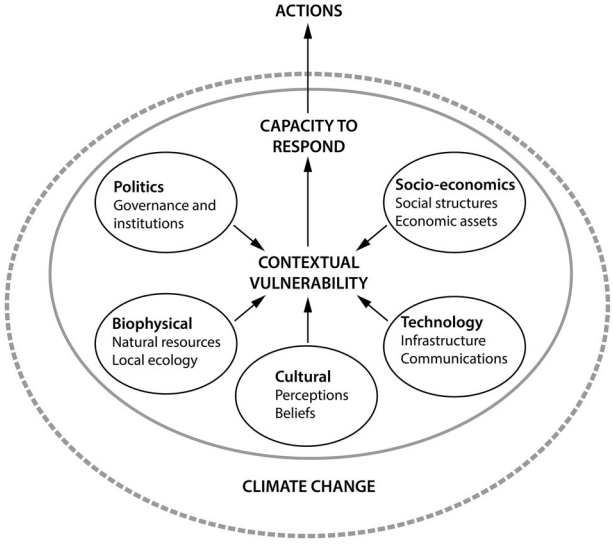

Fig. 1. Context-oriented theories of social vulnerability and adaptive capacity

Flood hazards and river management in Gudbrandsdalen

Several communities in Gudbrandsdalen (including Gausdal Municipality) in south-east Norway have repeatedly been affected by flooding and numerous small-scale landslides. The river basin of the river Gausa is protected by law from hydroelectric developments. Riparian areas along the watercourse are of high value for biodiversity and ecosystem services. The river has a trout population of international significance (Kraabøl & Arnekleiv 1993; 1998). These values conflict with the priorities of landowners and farmers, who are more concerned about coping with high precipitation events by increasing the drainage capacity of the river through lowering and channeling the river and by constructing flood embankments to secure the present uses of the landscape. These practices include the removal of considerable amounts of gravel from the riverbed and both increasing the existing extensive floodwalls and constructing substantial new floodwalls. While adaptation to flooding in central Europe increasingly employs transformative measures such as decommissioning underperforming flood protection infrastructure and letting rivers flood more naturally (Ebert et al. 2009), measures in Norway have thus far mainly involved the continuation of established land uses by "taming" rivers through additional engineering strategies aimed at preventing lateral movements of water across floodplains and wetlands (Kelman & Rauken 2012). Unfortunately, this approach has decreased the water storage capacity of rivers and threatened the dynamic nature of the

floodplains that originally made the affected areas hotspots of biodiversity and desirable for agriculture (Poff et al. 1997; Tockner & Stanford 2002; Museth et al. 2011). Historically, the river Gausa meandered more freely through the valley (Gausdalen) and large areas of floodplains (Kraabøl & Arnekleiv 1993), but since then its flow has more or less altered into a channel, with agricultural land lining the riverbanks. Consequently, current management strategies appear to increase the magnitude of floods. Understanding adaptation in particular places such as Gausdal requires a holistic contextual approach to the factors that motivate adaptation. This may lead to engagement among the community members in discussing priorities, activities, and strategies, which may ultimately lead to improvements in their quality of life in a changing climate (Amundsen 2012).

Vulnerability and adaptation in Gausdal Municipality

Few Norwegian studies have provided detailed analyses of how local inhabitants perceive climate change and the consequences for local communities, including opportunities for adaptation (e.g., Amundsen et al. 2010; Amundsen 2012; 2015). Hence, the main objective of our research was to gain a broad understanding of the key factors of community vulnerability to climate change, particularly flood hazards, in an inland riverine landscape, and to analyze this in the context of constraints to local adaptation to future hazards resulting from climate change. Our framework situates community vulnerability and adaptive capacity as the outcome of five interacting contextual dimensions including socio-economic, technological, cultural, biophysical and political factors, which were found to be particularly relevant to Gausdal Municipality. We used a contextual and qualitative approach through interviews with residents in the municipality, covering a range of social and natural conditions, and not merely factors that are either directly or clearly related to climate change. We centered the data collection on three research questions:

1. How do local inhabitants react to climate change, particularly flood hazards?
2. To what extent do the residents consider climate change a threat to their community and what do they propose as useful actions to mitigate this threat?
3. What do the study participants perceive as the main constraints to future adaptation to climate change in their community?

A contextual approach to social vulnerability

As O'Brien et al. (2007) argue, a key difference in how social vulnerability is conceptualized involves a distinction between an outcome approach, which focuses solely on actual losses, and a contextual approach, which focuses on the conditions, processes, and contextual dynamics that lead to loss. In particular, outcome-oriented approaches frame vulnerability narrowly as a function of exposure to climate change impacts, whereas contextual approaches focus on the interactions among a multitude of multiscaled social, political, economic, institutional, and biophysical conditions that contribute to vulnerability in a particular place or landscape. In particular, contextual approaches examine institutional constraints, social and economic barriers, and underlying historical processes, and draw attention to the different vulnerabilities and capacities these processes produce. Compared to outcome-oriented approaches, context-oriented studies are generally more complex since they examine the various ways that vulnerability and adaptation are constrained or enabled (Murphy et al. 2015).

Contextual approaches to vulnerability draw attention to adaptation challenges associated with governance issues, psychosocial and cultural limits, place-dependent social learning, and global processes. In terms of governance at the community level, adaptation measures need to take into account the will of local citizens, landowners, non-governmental organizations, and local governing bodies (Amundsen et al. 2010). At the local level, the relevance, credibility, and legitimacy of different actions to local communities are critical to the formulation of potential adaptation actions (Wall & Marzall 2006; Zahran et al. 2008). At the same time, a number of studies have shown the importance of larger scale governance issues in shaping adaptive actions at the local scale (Pahl-Wostl 2009; Wyborn et al. 2014).

A contextual approach to vulnerability can highlight social, psychological, and cultural limits to adaptation. Local willingness to address vulnerabilities is influenced by values, interests, and political ideologies (Adger 2006). Perceptions of climate change shape how individuals, communities, and societies view risk and vulnerability, and thus their willingness to take adaptive actions (Shackley & Deanwood 2002; Tucker et al. 2010). If local flooding is viewed skeptically as part of natural variability, the need for adaptive actions might not be considered very important.

Contextual approaches to vulnerability have also emphasized the importance of social learning when addressing climate risks (Collins & Ison 2009).

Social learning refers to the establishment and functioning of informal networks within communities and the capacity of such networks to learn from and respond to local changes such as floods. Local experimentation, community-scale communication, and shared reflection on local practices are critical elements for knowledge production that can fill the gaps between formal governance institutions (Krasny et al. 2011).

In addition, contextual approaches to vulnerability often explore the ways that local adaptive capacity and vulnerability are connected to global processes (Amundsen 2012). Issues of scale add another layer of complexity to vulnerability assessments, as the processes enabling or constraining adaptation are often spatially or temporally removed from localities (Wyborn et al. 2014). Adger et al. (2009, 150) state that the "vulnerability of specific individuals and communities is not geographically bounded but rather is connected at different scales, so that the drivers of their exposure and sensitivity are inseparable from large-scale processes of sociocultural change and market integration." In the title of the present article we use the word 'bridge' not only as a physical attribute destroyed by floods but also as a metaphor for the process of bringing people together in a local community and to learn from one another.

In a globalized world, almost all social, ecological, economic, and cultural systems have external drivers at different scales and levels (Cumming et al. 2006). Thus, it is critical to understand the multiscalar dimensions driving vulnerability and adaptive capacity.

The five dimensions we use here—socio-economic, technological, cultural, biophysical, and political—are derived from the empirical material and also reflect findings in earlier studies (Fig. 1) (O'Brien et al. 2007; Buikstra et al. 2010; Magis 2010; Amundsen 2012). The dimensions are not discrete or independent themes, but for us they functioned as a way to structure the data collection and analyze the interviews. The community vulnerability dimensions overlap with the factors that are important for adaptive capacity and that are enacted through adaptation.

Methods and data collection

The inland valley system

The rural parts of south-east Norway are relatively sparsely populated. The Gudbrandsdalen region is characterized by small and medium-sized towns as well as farms scattered throughout the landscape below the timberline. Alpine areas contain many summer farms, often situated in clusters. Historically, these formed part of the transhumance system of moving domestic livestock up into the mountains in the summer to utilize the grazing resources. Today, only a few summer farms serve their original purpose. The majority of these farms have been converted into recreational homes or have been abandoned and merely reflect former times when animal husbandry and forestry were the mainstay of rural communities.

Since the number of active farms is constantly decreasing, most people who do not move to urban centers are employed in the public sector or in local services and craft businesses. As elsewhere in Norway, fairly large segments of the population engage in different recreational and sports activities, as well as a wide spectrum of organized cultural events during their leisure time (Odden 2008). Many also fill much of their leisure time by volunteering in local non-profit organizations. Participation in recreational activities and particularly in former subsistence-type activities such as hunting and fishing are considered crucial for maintaining rural traditions and identity (Skogen & Krange 2003; Öian 2013).

We chose Gausdal Municipality in the mountain region in south-east Norway as a well-suited region for examining community adaptation to climate change (Fig. 2). The study area encompasses a gradient from highlands to lowlands in the riverine landscape in Gausdal Municipality. The municipality covers 1192 km^2, and has a population of 6227 (Statistics Norway 2016). The population has remained at a steady level of 6000–7000 inhabitants since the mid-1960s (Statitistics Norway 2016). The main income sources in the primary sector of the economy are based on dairy, timber, and meat production, as well as different forest products and the wood processing industry in the secondary sector of the economy. The local economy also relies on the tourism industry, with hotels, apartment complexes, rental cabins, and infrastructure related to alpine and cross-country skiing.

Data collection

We gathered data through in-depth, semi-structured interviews, supported by document analyses of municipality policy and management plans. We complemented these with a search for relevant reports in local newspapers. Interviews were conducted between September and November 2013 with 21 individuals (age range 26–77 years) representing diverse stakeholders, including local organizations, local officials, engaged individuals, and a set of different actors in primary and secondary industry: farming (6), tourism industry (2), ski resort development (2), angling (2), hunting (2), local industry (2), tour guiding (1), municipality administration (1), mountain management (1), forest management (1) and local residents (1).

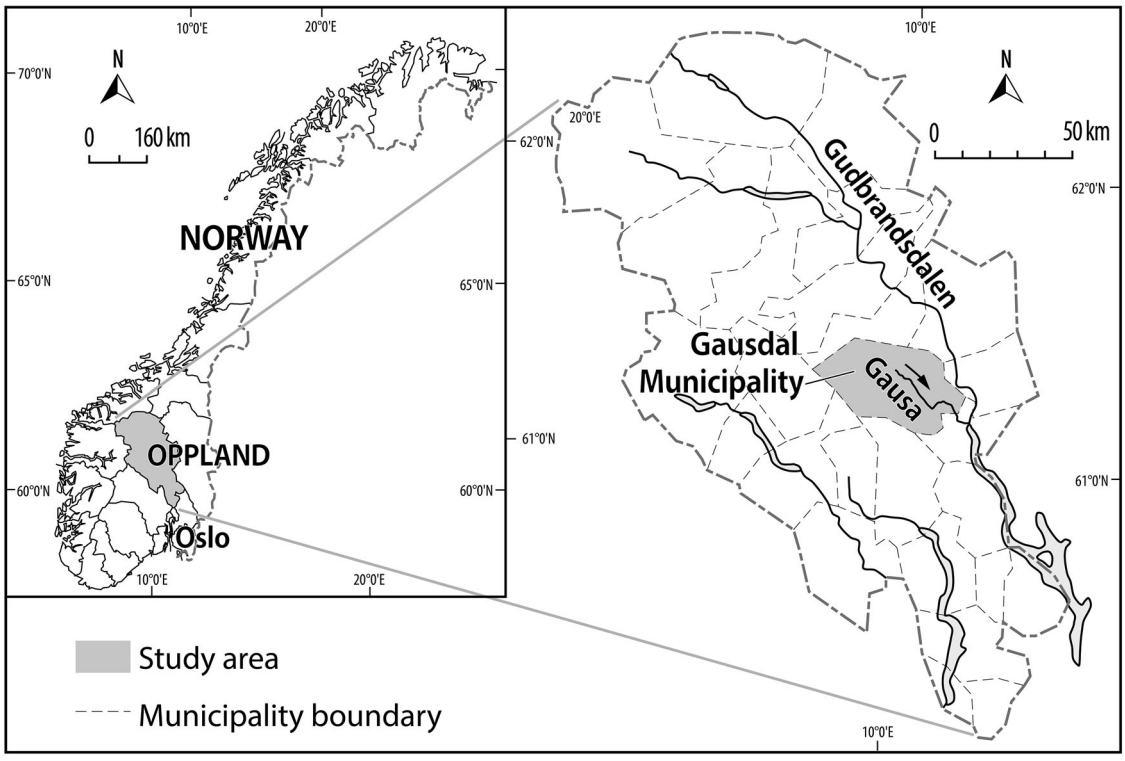

Fig. 2. Gausdal Municipality in Oppland County, south-east Norway

The participants were selected strategically by identifying individuals holding key positions in local institutions. The main selection criterion was their place of residence. The sample of participants was not statistically representative of the population of Gausdal Municipality, but provided a high level of content diversity in terms of expected preferences regarding landscape values, as well as sociodemographic characteristics.

A total of 11 participants were recruited by telephone and agreed to be interviewed either at home or at work. Additional participants were selected through snowballing (i.e., individuals were asked to name other relevant persons we could contact). The interviews were audiorecorded. An interview guide was used to ensure that the same themes were covered in all of the interviews. The participants were asked about their past experiences of the place in which they lived, what they valued about the particular place in which they lived or worked, the main changes they had observed in their surroundings, the community activities in which they participated, their relationship to the natural environment, and, in particular, how they interacted with other members of their community. The two most recent severe flood hazards were mentioned immediately by all participants when they were asked about landscape or climate change, and the floods in the river Gausa and its tributaries became the main focus of all interviews. The participants were also asked about what changes they had observed and were prompted to talk about social, economic, political, weather, and climatic conditions. They were challenged to predict the potential consequences of these changes and how they envisaged the municipality in the future (Table 1).

We developed three different scenarios to illustrate potential alternative futures for terrestrial and aquatic ecosystems in the study area (Table 2). The scenarios were based on the descriptions outlined by Murphy et al. (2015), and described the diversity of the observed and predicted climate change impacts, such as changing precipitation patterns and transformations in the landscape that might occur within the next 20 years (Førland et al. 2007). When preparing the written descriptions of the scenarios we used publications on landscape history, local research reports, expert knowledge, official documents, and local newspapers. The purpose was to formulate descriptions of possible future scenarios similar to those utilized in scenario planning at either landscape scale or community scale (Chapin III et al. 2010). The scenarios were designed to make local climate change impacts more tangible, while explicitly acknowledging uncertainty (Tompkins et al. 2008; Van Aalst et al. 2008; Wyborn et al. 2014). The written descriptions of the three scenarios contained 246, 298, and 272 words respectively. The descriptions of the scenarios were sent to the participants in advance, with the request that they should be read and reflected upon them prior

Table 1. Structure, themes, and analytical dimension discussed during the interviews

Main structure of the interview guide	Participants	Personal opinions about climate change	Personal experiences of climate change	Vulnerability to future changes	Present adaptations	Future adaptations
Aims	Background information relating to the participants	Identified opinions on climate change and the causes	Identified personal experiences of changes caused by climate change	Perspectives on what will happen in the future and the community's vulnerability to future changes	Identified individuals' and the local community's adaptations (coping mechanisms) to changes	Perspectives on how individuals and the local community might adapt to changes in the future
Aspects discussed during the interviews along five dimensions: socio-economic, technological, cultural, biophysical, and political	Background Attachments, social networks and roles in the local community Main changes in the landscape, attitudes to the changes, and main causes of the changes	Opinions about the theme and causes Interest in, engagement in, and knowledge of climate change at global and local levels	Observed changes in the landscape, in livelihoods, and in the local community Direct and indirect causes of the observed changes The influence on their own life	Responses to and discussions about three scenarios illustrating potential alternative futures for terrestrial and aquatic ecosystems in the study area, as well as evaluate the realism and possible consequences of the scenarios for the local community Level of vulnerability of the local environment, community, and livelihood Level of conflicts	Specify the participants' adaptations and their reasons for those adaptations Identify the persons and institutions responsible for local adaptations Identify crucial factors for adaptations, and how the solution works	Why adapt? Possibilities Different solutions to the same phenomena Barriers, constraints, and benefits relating to adaptations The role of governance and cooperation Who are the decision-makers?

to the interview. The scenarios provided background information for the participants, but the scenarios were rarely discussed directly during the interviews. Given that two severe floods had recently occurred in Gausdal Municipality, the participants tended to focus on these types of hazard, and the scenarios provided a basis for reflections on the range of impacts (positive or negative) of climate change. Recorded statements in the interviews were categorized along the five dimensions: socio-economic, technological, cultural, biophysical, and political. Similarities and differences between the participants and between their statements were analyzed for each dimension.

All interviews except one were conducted at the participants' homes or offices. During or immediately following the interview, each participant and the interviewer conducted an on-site inspection of the local landscape in order to find concrete examples and explanations of phenomena of interest. Furthermore, we carried out Internet searches of municipal websites and regional government websites, as well as sites relating to the tourism industry, farming, and different outdoor activities that could be relevant to the case study. Information sources included policy documents, public statistics, and newspaper articles. Public documents and newspaper articles gave insights into recent processes of change, the different actors in Gausdal Municipality, and how environmental changes had been dealt with.

Table 2. The three different scenarios used in the interviews

Scenario	Climate	Summarized
"Some like it hot"	Warmer and drier in all seasons, with perennial drought	"hot and dry"
"The seasons are a changin'"	Warmer in all seasons, earlier snowmelt, with more winter precipitation (as snow and/or rain)	"seasonal change"
"Feast or famine"	High inter-annual climate variability with hot, dry years followed by cool, wet years (increasing the frequency of extreme events such as floods or droughts)	"increased variability"

Community vulnerability and adaptation to climate change and floods along five dimensions

The participants were reasonably well informed about the climate change discourse. They had reflected on it and most of them had fairly good factual knowledge about climate change. However, most of them expressed views that bordered on climate change denial, but at the same time they could not quite dismiss the phenomenon. They perceived climate change as an abstract and distant concept in the sense that it was defined by experts and was not likely to affect them in any particular way. Especially the elderly (i.e., those over 60 years of age) were able to recollect historical climate-induced events that illustrated the dynamics of nature and climate. However, when the participants focused on specific episodes in the valley, such as floods and landslides, they could not rule out the possibility of climate change.

Climate change has been predicted to have an especially large impact on northern regions such as Norway and to trigger different types of societal consequences (Føreland et al. 2007; Amundsen 2012). One participant stated: "Suddenly it's getting warmer in Norway." According to some of the participants, some of the positive effects of warmer climates related to well-being in the summer season as well as improved conditions for forestry and agricultural production. A warmer climate would mean less snow in the valleys and increasing snow cover in the mountains (Førland et al. 2007). The two participants representing ski resort development stated that increased snow layers in the mountains are welcomed by the economically important snow-based ski tourism in Gausdal Municipality. Other participants considered that floods would be adequately handled by the municipality. However, farmers' opportunities for agricultural production would be threatened by floods. Thus, there were many diverging opinions about the impacts of climate change, depending on the participants' positions. In summary, while some might see a given risk as *acceptable*, others might see the same risk as *tolerable* because some measures can be taken in order to control it, and others still might consider the risk *intolerable* because it threatens fundamental values (Dow et al. 2013).

Socio-economics

Human, social, cultural, political, economic, and natural resources are the cornerstones of communities' adaptive capacity (Flora et al. 2004). The ways in which these are engaged in a community will affect that community's vulnerability (Magis 2010). The main concerns of the participants in our study related to aspects of well-being and the viability of the place in which they lived, including income and employment opportunities in the future. The main challenge for Gausdal Municipality is the decreasing profitability in the primary industries—forestry and farming. Most of the farms have increased their hectarage of agricultural land in production since the 1970s, and consequently the amount of farmland has increased in Gausdal Municipality. At same time, the income from the primary sector has decreased. However, the farmers claimed that the farmland in Gausdal is fairly robust for most kinds of weather situations, due to the diverse terrain, permeability, and vegetation types. Several of the active farms have additional pastures in the mountains. In recent decades many farms have been either abandoned or consolidated into larger units. Across Norway, the number of farms decreased by 25% in the decade 2003–2013, and by 75% since 1965 (Statistics Norway 2015). Recent floods have caused problems for many farms by damaging crucial infrastructure and agricultural land on the floodplains. An additional problem for some of the farmers has been the loss of topsoil, which is an especially important component for slowly decomposing agricultural systems in the higher northern latitudes of Norway (Lundekvam et al. 2003). One participant said: "Everything is possible to repair, except washed out topsoil. I have had problems sleeping for a month [due to] thinking about the reduced production potential at the farm for the next generation." The six participants involved in farming noted that although the farms were rich in natural resources (e.g., agricultural land, forest land, and mountain pasture) they were struggling with lower income in the primary industry sector, which made it difficult to recruit people to run the farms. Many farmers expressed major concerns about the future of their farm, its economic potential, and whether the farms would be kept within the family.

Secondary industries in Gausdal Municipality (e.g., several sawmills and dairies), are also highly dependent on activities in the primary sector. The participants considered the municipality well situated in terms of natural resources, large land areas, available jobs, participation in community activities, organized activities for children and adults, cultural events, and public services. The natural resources in the municipality are particularly important in terms of employment, as stated by one participant:

> The land resources have been the basis for early settlements in Gausdal and will continue to be the basis for employment in the future, despite that the primary industry is not trendy in the society today, it will hopefully be highly valued to manage a piece of land in the future. (our translation)

Still, many inhabitants work in the nearby town of Lillehammer.

The demographic trends indicate decreasing populations in many of the rural municipalities in the region, as well as an increasing proportion of elderly people. However, this has not been the case in Gausdal Municipality. Many participants mentioned a municipality-initiated campaign to stimulate settlements at numerous farms that have been vacated since the 1990s. Working against population decline in the community seemed to be a common goal expressed by all participants, who described it as a key challenge for future community sustainability. Maintaining population stability is the key to keeping the social networks in small villages alive.

Technological infrastructure and communications

Most of the study participants mentioned the impacts of floods on infrastructure, including paved roads, forest

roads, bridges, dams, and culverts. Several also mentioned that the Global System for Mobile Communications (GSM) network collapsed in the municipality during the floods in 2011 and 2013, causing a very problematic situation for the municipality and for individuals. Almost all of the participants told stories about dramatic scenes and how they personally were involved and affected when the main river and its tributaries flooded. They explained the situation in words, by looking at photos, and through field visits to areas where the damage to bridges, culverts, and roads was still visible. Most of the participants were frustrated about the situation, especially because the same thing happened at exactly the same places in 2011 and 2013. However, most of them mentioned that anything can be repaired using modern technology such as large excavators and trucks. Compensation was given to repair property damaged by flooding in 2011 but the repairs were destroyed by the flooding in 2013. The national fund for natural damage, Statens naturskadefond, was established in 1961, and became the Norwegian Natural Perils Pool (Norsk Naturskadepool) in 1990. The fund was established with the aim of providing compensation for damage caused by natural hazards and to contribute to protective measures against such impacts. The main purpose of the fund is to restore infrastructure to its pre-damage state.

Interestingly, all participants mentioned Storofsen, a particularly heavy rainfall event in 1789 that caused extreme floods and landslides in Gausdal Municipality and in the wider Gudbrandsdalen region. The flooding destroyed a significant number of farms as well as infrastructure. Several of the participants pointed out signs of damage caused by Storofsen that were still visible as landslides along the hillsides in Gausdal. During field visits the participants explained how farms had been destroyed and later rebuilt in safer locations. Several mentioned that Storofsen was a relatively small flood compared to one earlier in history, which had been discovered by archaeologists. Harrowing stories about Storofsen are still passed from one generation to the next, as a vehicle for deeper understanding of the dramatic forces in nature and long-term landscape dynamics. One elderly participant stated: "Dynamic climate and catastrophes are a natural part of nature. It has always been like that." Stories about such past events contribute to a common identity linked to the place and a sense of being part of a longstanding community that faces challenges to overcome dramatic changes in the landscape.

However, some catastrophes can be caused by human error. In 1976 a dam used for log floating in the mountains broke and caused major damage along the river Roppa, a tributary of the river Gausa. The event happened on Constitution Day (17th of May), when most members of the community participated in parades and celebrations in the town center. Many homes were swept away by the flash flood, but no lives were lost since few people were at home at the time. Historical events such as earlier floods demonstrate the dynamics of nature, and that extreme situations can occur irrespective of climate change. In the local discourse this can be interpreted as a form of optimistic bias, as events are thought to have been worse in the past or in other places, and anything can be repaired given sufficient resources and technology.

The participants expressed a firm belief that new technology could cope with many of the challenges resulting from climate change. In general, farmers have shifted from grain production to grass production (for dairy and meat), which is more resilient to changing weather conditions. Drought is seldom a problem in Gausdal, and given the shift in production most of the farmers no longer have to maintain elaborate and costly irrigation systems. For much the same reason, most farmers have shifted how they store their harvested crops, from silos to bales. Although silos can be used for dry grass, humidity is less of an issue when grass is stored in bales. Another adaptation has involved the use of larger farming equipment, which has enabled more efficient use of time during unstable weather conditions. A few farmers shared the use of machinery, but this practice is far from common in the valley (i.e., Gausdalen). The floods in 2011 and 2013 had prompted some farmers to invest in additional equipment such as excavators for carrying out repairs and work to prevent future impacts from flooding and landslides.

Cultural perceptions and beliefs

Most of the participants had grown up in Gausdal Municipality and had lived in the area for many years. They had experienced landscape changes during their lifetime and particularly how large tracts of open grazing fields and mountain areas had become overgrown by trees through natural afforestation processes. In addition, the forests areas had become much denser and the timberline had risen. There was a certain amount of sentiment in the elderly people's recollections as the landscapes had been more open during their childhood and there had been greater diversity in human activities and domestic animals utilizing the landscapes. The participants explained that the changes had been due to shifts in the primary industry from small-scaled multifunctional agriculture to large-scaled single-production regimes.

Gausdal has had a long tradition of local management, either by landowners' families who have lived on

and used farms for centuries or by local managers and workers. This tradition has been maintained at many of 228 farms in the municipality, especially the larger farms that are still in active use today. Local people have acquired considerable local and contextual knowledge connected to the place in which they live, and they hold a range of non-utilitarian values relating to their own properties that have been passed down through generations. Some of the participants told the same stories, which indicates an identity-making process linked to place. The participants followed closely what happened in their neighborhood, and anything unusual was reported to other community members. As a collective practice, this included behavior such as being, making, using, starting, practicing, regarding, perceiving, defining, discussing, and being involved in a place—all of which are elements of forming social networks in a particular place (Amundsen 2012). Care and stewardship of places includes most of what we do and do not do in places (Gundersen & Mäkinen 2009), and some negative practices associated with neglecting, ignoring, and giving up were mentioned by some interviewers. Many of the participants emphasized the utilitarian values of landscape and that the natural resources should be utilzed to their maximum production level to secure the livelihoods of those living in the community. In this context, overgrown fields were considered signs of neglect, an untapped resource, and a potential loss of income to individuals and the community.

Political social networks

The community in Gausdal Municipality has overcome challenges in the past and to some extent has demonstrated its capacity to adapt and learn about river management. Many community members engage in activities to increase their well-being and sense of place, typically in different types of *dugnader* (voluntary collective work on projects) in the local community, which also carries important cultural meaning and strengthens social bonds and networks (Amundsen 2012). Some of the farmers help each other with technical equipment and labor to repair damage to bridges, culverts, drainage pipeline systems, and replacing topsoil after floods. One participant expressed in humorous terms that the flooding is "Never as bad as it is good for something, and I have become better known among my neighbors because of the floods." Several participants claimed that it was like "good old times" when there were far more people working and carrying out work in the landscape, because after the floods in 2011 and 2013 there was so much to talk about with regard to restoring the landscape and how they could accomplish this together. According to one elderly person who compared the current situation, including activities concerning the restoration of the landscape, with the 1950s and 1960s, when there were far more workers practicing traditional farming methods, there were "activities and work, no matter where you looked." Participation in an informal institution such as a *dugnad* involves more than the actual work done, as it builds and reinforces social networks. In the Gausdal community *dugnader* are still widely practiced to maintain green areas, sports facilities, playgrounds, community buildings, and to remove litter along roads. The community members are also involved in a number of different local associations (e.g. hunting, fishing, recreation, and agriculture) and sports clubs. Buikstra et al. (2010) argues that social networks are the most prevalently dimension of community resilience. Social networks can be described as activities and processes that support and build collaboration between people, and include community groups and voluntary work. The term community networks refers to how community groups and informal groupings constitute a support network that active agents know they can draw on to realize their ideas.

The participants mentioned networks and social relations as important for their well-being: "To meet and talk with people, [and] to exchange news and happenings from the district gives me a feeling of being a member of a larger community and contributes to my well-being." Most of the participants perceived the availability of essential services in the community, such as grocery stores, postal delivery, schools, and nurseries, which are important meeting places, as salient for the functioning of sparsely populated areas such as Gausdal. Recent municipal-level discussions about closing down schools and nurseries have fueled concern and debate, which has further contributed to strengthening social networks.

Although social learning is central to vulnerability, it is challenged by the fact that future challenges may differ from challenges experienced in the past (Adger et al. 2011). In this context learning is understood as a continuous process of adaptive management, testing ideas, and rejecting or accepting further experiences in a social-ecological frame (Berkes et al. 2003). During our interviews, learning was directly addressed, but many of the participants mentioned the importance of learning when talking about cooperation, river management, and adaptation to climate change. Some of the farmers mentioned that for them learning had implied critical evaluation of both their own actions and roles and their neighbors' actions and roles, both during and after the floods in 2011 and 2013. In this context, reflexivity

involves the capacity to respond to changes in the river system and their causes. Some participants demanded public meetings (*bygdamøter*) to discuss the challenges of river management, emphasizing that such meetings might lead to the development of new ideas that could be tested in a learning process. One participant observed: "The farmers in the valley need a common meeting place for developing new ideas on cooperation over river management, to learn from past failure and try out new things."

Local biophysical resources

Among many of the studied community members, there seemed to be a shared understanding of how scientific knowledge has led to changes in management practices over the years (e.g., in trout management, agriculture, forestry, maintenance of infrastructure). Many of the fundamental changes that have occurred in the agricultural landscapes successively since the 1950s were mentioned in the interviews by most of the participants. These changes included the transformation from small-scale diverse agriculture to large-scale monoculture in the valley, from semi-open to dense forests on the hillsides and overgrown pastures and grazing land in the mountains. The participants mainly used negative terms to describe the transition with regard to the visual aspects, ecological consequences, and consequences for the community. Compared to when most people worked in agriculture, few are employed in this sector today. As one farmer said: "Working as a farmer today is lonesome, and we only meet neighbors by chance at the grocery shop." Not only has there been a decline in the number of active farms but also traditional agricultural practices that were place-based, small scale, and relied on local experience and knowledge have been replaced by practices that require skills that are mechanized, universal, expert-driven, and based on scientific research. The former localized knowledge of how to adapt small-scale, diverse production to a specific environment has been replaced by standardization and oversimplification of knowledge (Stewart et al. 2013).

The change in knowledge is reflected also in the solutions to other problems, such as how to cope with floods and other climate-induced hazards. Whereas in the past it was common practice to let the river flood and to maintain river embankments and bridges, today measures are increasingly implemented to change the water flow. Bends in the river have been straightened, gravel removed from the riverbed, vegetation cleared along the riverbanks, and higher embankments constructed. These changes have provided easier access for further alterations to the river, increased the water flow, and resulted in greater impacts downstream (e.g., higher flood peaks, increased water flows, and more frequent small landslides). Some of the participants mentioned these changes as cases of scale mismatch, since individual landowners thought only about their own concerns and not about what happened farther down the river. The current river management regime raises important questions as to how knowledge and ideas can be passed on from farmers skilled in former agricultural practices to those practicing modern management methods as well as how new concepts can be integrated and shared among farmers. This illustrates that adaptation is dependent on the willingness and ability to incorporate new ideas as well as traditional knowledge in a more or less continuous process of shaping an adaptive form of management (Collins & Ison 2009).

Since the floods in 2011 and 2013, it has become easier for the landowners to obtain rapid authorization from the environmental authorities to alter the river channel. Some landowners have undertaken such interventions without the necessary permits from the authorities. According to the participants, the community perceived the benefits of flood mitigation measures as considerable, and there was a shared understanding within the community that flood hazards could be avoided in the future. Their opinion is legitimized by the fact that there had been a long tradition of manipulating the river corridor to facilitate timber harvesting and log floating down the river. The practice ended in the 1960s, but was still a vivid memory among many of the elderly. The current physical and hydrological interventions to the river course are highly controversial among ecologists and hydrologists due to several factors related to the effects of the altered state of the river flow on the biodiversity and trout population.

Constraints to adapting to climate change

Gausdal Municipality is rich in human, social, and natural capital, in common with other places in Norway (O'Brien et al. 2004). However, the main challenge is how to make Gausdal Municipality an attractive place in which to live while using local nature resources, as well to create new jobs and to be a forward-oriented society with the main purpose of avoiding rural depopulation. According to the participants, the inhabitants of Gausdal Municipality would be able to adapt to future climate-induced changes in much in same way as they have adapted to social and environmental changes in the past. Since it is difficult to predict hazards caused by climate change, both regarding when they will happen and what type of damage will be caused, the inhabitants of Gausdal Municipality rely on practical flexibility and

coping strategies rather than proactive adaptations such as regime shifts in, for example, agriculture and river management (Amundsen 2012).

The expectation of warmer summers and shorter winter seasons was welcomed by many of our participants, who perceived the climate in Norway as dynamic due to seasonal variation and long-term trends of change. Hazards such as floods and landslides were repeatedly mentioned as having occurred at least as early as the 1930s, and they mainly attributed these events to natural causes and forces. This could be one reason why some were skeptical about the concept of human-induced climate change and potentially negative effects. Despite recent severe floods, the participants questioned whether these had been caused by climate change. Especially the elderly stated that the observed weather was perceived as more or less within the natural range of variability. According to Forbes (2013), communities that are used to large variations in climate have a larger range of adaptation options and are less vulnerable to changes. Our participants shared the notion that the community had a high capacity to adapt to future changes, based both on how it had coped with hazards and environmental variability in the past and that it had strong natural and human resources.

Another important constraint to adaptation to climate change is the mechanisms of the Norwegian Natural Perils Pool whereby most natural caused hazards impacts are covered by state-funded insurance and agricultural land is restored to its pre-impact state as far as possible (Norsk Naturskadepool 2016). This is clearly a maladaptive practice in the sense that it removes considerable responsibility away from the individual landowner and often prevents necessary adjustments to land use practices. Most of the participants largely ignored issues of ecological sustainability, wise management, and technological capability. Rather, the constraints to coping with flood hazards were perceived by the participants in our study as more a matter of sufficient public economic resources and construction equipment. These factors contributed to a false sense of security for the inhabitants and reduced their motivation and incentives to increase their resilience to future hazards through improved land use planning and practices.

The socio-ecological dimensions analyzed in this article are interlinked in terms of how they contribute to community vulnerability. Place attachment means commitment to respond to the challenges facing a community. However, attachment to place works both for and against adaptation (Dale et al. 2008; Hulme 2009; Amundsen 2015). Long-term involvement with a place and bonding to that place leads to affection and concern for the immediate surroundings, but it also contributes to a romanticized past and resistance to change regarding path dependence on former political decisions and management practices. Some of our participants called for increased use of accumulated local knowledge of river management. To date, the local flood mitigation measures have been short-term coping strategies rather than long-term adaptation. Sense of place is part of long-standing coping traditions through shared concepts of local identity and well-being being contingent upon landscapes that are familiar and providers of economic income and good livelihoods (Gundersen & Mäkinen 2009; Murphy et al. 2015). Among the most prominent place connections for the inhabitants of Gausdal Municipality are the longstanding bonds with each farm and a former way of life that is rarely found today. The fact that former ways of rural life are perceived as threatened, combined with resistance against the ongoing rationalization and restructuring of the entire agricultural sector, has created social forces that seem to work against adaptation. Reducing the vulnerability of local communities such as Gausdal to climate change effects would require degrees of openness and reflexivity in responses to new challenges that are scarce today.

When discussing climate change all participants mentioned the increasing probability that floods in the lowland valley would be the "new normal," and this perspective dominated the interviews. The impacts of the 2011 flood were more or less repeated by the 2013 flood, and we were unable to identify any significant differences in the response to these floods. Despite the potential for damage reoccurring, such as the loss of topsoil from inundated flood plains, it was clear that some of the actions had been either maladaptive or at best merely coping mechanisms. In the short term, this might be perceived as beneficial by landowners since it produces media-friendly scenes of repeated natural hazards that attract political attention as well as economic and technological support.

Furthermore, there has been a scale mismatch between single stakeholders' strategies and community-level strategies to manage flooding from the river Gausa, which has also constrained adaptation. For example, the farmers have acted in accordance with national trends of rationalizing the landscape to a production modus, neglecting small-scale dynamics and adaptation to hazards such as floods. This type of maladaptation—using standardization and oversimplification of knowledge (e.g., drainage of channels, construction of flood embankments, removal of riverbank vegetation, removal of gravel from the riverbed), on a property unit basis—is driven by the goal of draining the water away from properties as fast as possible. However, elderly farmers talked also about

small-scale adaptation to floods in the past that had allowed the river to flood without causing damage and had avoided flooding in crucial places. Today, large-scale construction measures carried out farther up in the river system to avoid floods have consequences for inhabitants farther down the river.

Scale mismatches also pertain to social learning and networks. There are few, or no functional public venues suited to informing residents about climate change challenges and possible solutions to such problems. Traditional meeting places are disappearing and even the discourse on community work (i.e., *dugnader*) is not as common as it was for the transmission of knowledge between the inhabitants. Learning by doing (i.e., adaptive management and continuous change) may be important in future to overcome multiple factors at interlinked scales in river management. National and international policy trends will continue to affect the room to maneuver locally and in this context learning about how policies at different scales (e.g., national strategies for rationalizing agriculture and small-scale adaptations to river management) affect each other will be essential to the communities' capacity to deal with future change.

Conclusions

While community residents in Gausdal Municipality have experienced heavy floods in river systems and streams for some time, we observed little evidence of adaptation. Instead, community members appeared to adopt coping strategies. The management of the riverine landscape in the studied municipality is a classic case of complexity, uncertainty, scale mismatches, and to some extent conflict between land use goals as well as local and scientific knowledge. Current management is largely based on a narrow instrumental approach characterized by decontextualized and generalized concepts of flood management, including technical modification of the main river channel and the tributaries, rather than adapting the land use to changing environmental conditions. These maladaptations and modifications of the main river and its tributaries are maintained by public subsidies through the national fund for natural damage assistance (Norwegian Natural Perils Pool). The results of our study suggest that a more sustainable management regime would require involving more local knowledge on the natural dynamics of the river system, as well as a more holistic approach to the socio-ecological values within the Gausa catchment area. A more contextualized approach would require social and cultural science input and synthesis in order to document relevant socio-ecological values and the consequences of prioritizing different sets of values for concrete river management actions. Improved river management will also require stakeholder deliberations about land use objectives, landowner responsibilities, and appropriate adaptation measures. We envisage that this should include efforts in three areas. First, local historical knowledge should be used, for example concerning how the community formerly rotated and allocated land use in the valley floor to increase resilience to natural hazards. This type of adaptive management and learning process was part of our participants' accumulated contextual knowledge about the former management of the river system. Second, farmers and other stakeholders who are directly affected by river management should request venues for social learning and cooperation on the challenges resulting from climate change. Third, in terms of scale mismatches, there is a need for local and regional area plans that include ways to incorporate more holistic knowledge into socio-ecological systems, such as the human dimension on freshwater ecology, hydrology, and biodiversity in future management strategies.

The important question to address is what constraints the development of a shared understanding of the need to respond more dynamically to environmental change through learning, communication, and new policies? The results of our study discussed in this article demonstrate the need for multiple perspectives on how to increase communities' capacity for adaptation to climate change. Increased social learning among stakeholders is probably one of the key factors in achieving effective adaptation in the future. However, it will not happen without institutional arrangements, arenas, and processes that recognize and include the diversity of stakeholders relevant for river systems such as the one in Gausdalen.

Acknowledgements

The research was funded by a grant from the US Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA. Kari Sivertsen, Norwegian Institute of Nature Research, is thanked for her help with preparing the Figures.

References

Adger, W.N. 2006. Vulnerability. *Global Environmental Change* 16, 268–281.

Adger, W.N., Eakin, H. & Winkels, A. 2009. Nested and teleconnected vulnerabilities to environmental change. *Frontiers of Ecology and Environment* 7, 150–157.

Adger, W.N., Barnett, J., Chapin III, F.S. & Ellemor, H. 2011. This must be the place: Underrepresentation of identity and meaning in climate change decision-making. *Global Environmental Politics* 11(2), 1–25.

Amundsen, H., Berglund, F. & Westskog, H. 2010. Overcoming barriers to climate change adaptation: A question of multilevel governance? *Environment and Planning C: Government and Policy* 28, 276–289.

Amundsen, H. 2012. Illusions of resilience? An analysis of community response to change in northern Norway. *Ecology and Society* 17, 46.

Amundsen, H. 2015. Place attachment as a driver of adaptation in coastal communities in Northern Norway. *Local Environment* 20, 257–276.

Barton, D. & Dervo, B.K. 2009. *Nytte-kostnadsanalyse av flomvern: En metodevurdering med eksempel fra Skarvvollene*. NINA Rapport 464. Trondheim: Norwegian Institute for Nature Research.

Berkes, F., Colding, J. & Folke, C. 2003. *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Buikstra, E., Ross, H., King, C.A., Baker, P.G., Hegney, D., Mclachlan, K. & Rogers-Clark, C. 2010. The components of resilience: Perceptions of an Australian rural community. *Journal of Community Psychology* 38, 975–991.

Chapin III, F.S., Carpenter, S.R., Kofinas, G.P., Folke, C., Abel, N., Clark, W.C., Olsson, P., Smith, D.M.S., Walker, B., Young, O.R., Berkes, F., Biggs, R., Grove, J.M., Naylor, R.L., Pinkerton, E., Steffen, W. & Swanson, F.J. 2010. Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution* 25, 241–249.

Collins, K. & Ison, R. 2009. Living with environmental change: Adaptation as social learning. *Environmental Policy and Governance* 19, 351–357.

Cumming, G.S., Cumming D.H.M. & Redman, C.L. 2006. Scale mismatches in social-ecological systems: Causes, consequences, and solutions. *Ecology and Society* 11, 14.

Dale, A., Ling, C. & Newman, L. 2008. Does place matter? Sustainable community development in three Canadian communities. *Ethics, Place & Environment* 11, 267–281.

Dow, K., Berkhout, F., Preston, B.L., Klein, R.J.T., Midgley, G. & Shaw, M.R. 2013. Limits to adaptation. *Nature Climate Change* 3, 305–307.

Ebert, S., Hulea, O. & Stroble, D. 2009. Floodplain restoration along the lower Danube: A climate change adaptation case study. *Climate and Development* 1, 212–219.

Flora, C.B., Flora, J.L. & Fey, S. 2004. *Rural Communities: Legacy and Change*. Boulder, CO: Westview.

Førland, E.J., Alfnes, E., Amundsen, H., Asvall, R.P., Benestad, R., Debernard, J., Engen-Skaugen, T., Hanssen-Bauer, I., Harstveit, K., Haugen, J.E., Hovelsrud, G.K., Isaksen, K., Jaedicke, C., Kronholm, K., Kvambekk, S., Lacasce, Å.J., Roald, L.A., Sletten, K. & Stalsberg, K. 2007. *Climate Change and Natural Disasters in Norway: An Assessment of Possible Future Changes*. Oslo: Norwegian Meteorological Institute.

Forbes, B.C. 2013. Cultural resilience of social-ecological systems in the Nenets and Yamal-Nenets Autonomous Okrugs, Russia: A focus on reindeer nomads of the tundra. *Ecology and Society* 18, 36.

Füssel, H.M. & Klein, R.J.T. 2006. Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change* 75, 301–329.

Gallopin, G.C. 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* 16, 293–303.

Gundersen, V. & Mäkinen, K. 2009. Aldo Leopold and stewardship: Lessons for forest planning and management in the Nordic countries? *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* 63, 225–232.

Hulme, M. 2009. *Why We Disagree about Climate Change: Understanding Controversy, Inaction, and Opportunity*. Cambridge, MA: Cambridge University Press.

Janssen, M.A. & Ostrom, E. 2006. Resilience, vulnerability, and adaptation: A cross-cutting theme of the International Human Dimensions Programme on global environmental change. *Global Environmental Change* 16, 237–239.

Kates, R.W., Travis, W.R. & Wilbanks, T.J. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences of the United States of America* 109, 7156–7161.

Kelman, I. & Rauken, T. 2012. The paradigm of structural engineering approaches for river flood risk reduction in Norway. *Area* 44, 144–151.

Kraabøl, M. & Arnekleiv, J.V. 1993. *Telemetriundersøkelser over Gausaørretens vandringer i Lågen og Gausa*. Status for prosjektarbeidet 1992. Zoological Notes 5. Trondheim: Norwegian University of Science and Technology.

Kraabøl, M. & Arnekleiv, J.V. 1998. *Registrerte gytelokaliteter for storørret i Gudbrandsdalslågen og Gausa med sideelver*. Rapport i Zoologisk serie 1998-2. Trondheim: Norwegian University of Science and Technology.

Krasny, M.E., Lundholm, C. & Plummer, R. 2011. *Resilience in Social-ecological Systems: The Role of Learning and Education*. New York: Routledge.

Lundekvam, H.E., Romstad, E. & Øygarden, L. 2003. Agricultural policies in Norway and effects on soil erosion. *Environmental Science & Policy* 6, 57–67.

Magis, K. 2010. Community resilience: An indicator of social sustainability. *Society and Natural Resources* 23, 401–416.

Murphy, D.J., Wyborn, C., Yung, L. & Williams, D.R. 2015. *Key Concepts and Methods in Social Vulnerability and Adaptive Capacity*. General Technological Report RMRS-GTR-328. Fort Collins, CO: Rocky Mountain Research Station.

Museth, J., Johnsen, S.I., Walseng, B., Hanssen, O. & Erikstad, L. 2011. Managing biodiversity of floodplains in relation to climate change. *International Journal of Climate Change Strategies and Management* 3, 402–415.

Nelson, D., Adger, W.N. & Brown, K. 2007. Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environmental Resources* 32, 395–419.

Norsk Naturskadepool. 2016. *Statens naturskadefond*. http://www.naturskade.no/no/hoved/naturskader/statens-naturskadefond/ (accessed 4 May 2016).

O'Brien, K., Sygna, L. & Haugen, J.E. 2004. Vulnerable or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. *Climate Change* 64, 193–225.

O'Brien, K., Eriksen, S., Nygaard, L.P. & Schjolden, A. 2007. Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy* 7, 73–88.

Odden, A. 2008. *Hva skjer med norsk friluftsliv? En studie av utviklingstrekk i norsk friluftsliv 1970–2000*. PhD thesis. Trondheim: Norwegian University of Science and Technology.

Öian, H. 2013. Wilderness tourism and the moralities of commitment: Hunting and angling as modes of engaging with the natures and animals of rural landscapes in Norway. *Journal of Rural Studies* 32, 177–185.

Pahl-Wostl, C. 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change* 19, 354–365.

Pelling, M. 2003. *The Vulnerability of Cities*. London: Earthscan.

Peters, B.G., Pierre, J. & King, D.S. 2005. The politics of path dependency: Political conflict in historical institutionalism. *Journal of Politics* 67, 1275–1300.

Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E. & Stromberg, J.C. 1997. The natural flow regime. *Bioscience* 47, 769–784.

Preston, B.L., Dow, K. & Berkhout, F. 2013. The climate adaptation frontier. *Sustainability* 5, 1011–1035.

Shackley, S. & Deanwood, R. 2002. Stakeholder perceptions of climate change impacts at the regional scale: Implications for the effectiveness of regional and local responses. *Environmental Planning and Management* 45, 381–402.

Skogen, K. & Krange, O. 2003. A wolf at the gate: The anti-carnivore alliance and the symbolic construction of community. *Sociologia Ruralis* 43, 309–325.

Smit, B. & Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16, 282–292.

Statistics Norway. 2015. *Strukturen i jordbruket, 2015, førebelse tal*. https://www.ssb.no/jord-skog-jakt-og-fiskeri/statistikker/stjord/aar/2016-01-07 (accessed 1 May 2016).

Statistics Norway. 2016. *Folkemengde og befolkningsendringar, 1. januar 2016*. https://www.ssb.no/befolkning/statistikker/folkemengde/aar-per-1-januar/2016-02-19?fane=tabell&sort=nummer&tabell=256001 (accessed 1 May 2016).

Stewart, W.P., Williams, D.R. & Kruger, L.E. 2013. *Place-based Conservation: Perspectives from the Social Sciences*. Dordrecht: Springer.

Tockner, K. & Stanford, J.A. 2002. Riverine flood plains: Present state and future trends. *Environmental Conservation* 29, 308–330.

Tompkins, E.L., Few, R. & Brown, K. 2008. Scenario-based stakeholder engagement: Incorporating stakeholders' preferences into coastal planning for climate change. *Journal of Environmental Management* 88, 1580–1592.

Tucker, C., Eakin, H. & Castellanos, E.D. 2010. Perceptions of risk and adaptation: Coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change* 20, 23–2.

Van Aalst, M.K., Cannon, T. & Burton, I. 2008. Community level adaptation to climate change: The potential role of participatory community risk assessment. *Global Environmental Change* 18, 165–79.

Wall, E. & Marzall, K. 2006. Adaptive capacity for climate change in Canadian rural communities. *Local Environment* 11, 373–397.

Wyborn, C., Yung, L., Murphy, D.J. & Williams, D.R. 2014. Situating adaptation: How governance challenges and perceptions of uncertainty influence adaptation in the Rocky Mountains. *Regional Environmental Change*. DOI: 10.1007/s10113-014-0663-3

Zahran, S., Brody, S.D., Vedlitz, A., Grover, H. & Miller, C. 2008. Vulnerability and capacity: Explaining local commitment to climate-change policy. *Environment and Planning C: Government and Policy* 26, 544–562.