

## 🔗 Falling between the Cracks of the Governing Systems: Risk and Uncertainty in Pastoralism in Northern Norway

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**ABSTRACT:** Rapid and interacting change poses an increasing threat to livelihoods and food production, and pastoralists in Nordland, northern Norway, are at a crossroads both economically and culturally. Some of these changes are localized and pertain to changing weather and grazing conditions caused by climate change and land fragmentation. Others, driven by national management policies and governance specifically related to predators, are poorly adjusted for the different and localized contexts. The pastoralists are inherently adaptive and have a long history of responding well to variable changing conditions. This is now changing with the continued increasing pressures from many directions. The central government systematically ignores pastoralists' traditional knowledge and enforces narrow sector policies to be implemented at regional and local levels. We address the effect of how institutional, physical, and societal constraints challenge pastoralists' prospects for sustainable adaptation. Our results show how pastoralists' livelihoods become compromised and potentially threatened because they are forced to respond in ways that they know are counterproductive in the long run. Adaptation outcomes are affected by different approaches and epistemologies that are situated across scale and context in terms of regional and national regulations versus local empirical reality among the pastoral communities. This study concludes that radical change is needed toward a more holistic governance in which multiple knowledge systems are integrated to ensure sustainable adaptation at all levels. This study is based on extensive and long-term fieldwork among reindeer herders and sheep farmers in Nordland, through a collaborative process of knowledge coproduction.

**KEYWORDS:** Social Science; Climate change; Adaptation; Indigenous knowledge

### 1. Introduction

The viability and continuity of Nordic pastoralist livelihoods depend on healthy human–animal–ecosystem interactions and the ability for pastoralists to carry out culturally and locally important land-use practices (Bjørklund 2013; Brännlund 2015; Risvoll and Hovelsrud 2016; Löf 2013). Globally, rapid and interacting change poses an increasing threat to food systems (Fanzo et al. 2018) and for the sustainability of pastoral landscapes and the cultural and natural systems they support (Díaz et al. 2019; Axelsson-Linkowski et al. 2020; Landauer et al. 2021). While pastoralists through millennia have developed complex strategies based on transmitted learning, knowledge, and praxis, the increase in cascading and cumulative effects pressure the pastoralists' ability to successfully adapt (Axelsson-Linkowski et al. 2020; Riseth et al. 2021; Löf 2014; Helle and Jaakkola 2008).

In Norway, sheep farming and reindeer husbandry are forms of pastoralism practiced in a diverse and changing landscape, from high mountains and deep valleys to fjords and coastlines (e.g., Risvoll 2015; Riseth and Tømmervik 2017). Reindeer husbandry is practiced by the Indigenous Sámi people, most of whom live in the northern regions of Norway. Sheep farming is

generally spread throughout the country, and common for both animal species is that they can graze on high alpine pastures that are not utilized for other food production.

Changes to the framework conditions of pastoralists have emerged from multiple historical processes and legacies and manifest in current relations and struggles of power over the resources, livelihoods, and traditional knowledge as a valid knowledge system. Increasingly, pastoralists must defend their livelihoods and rights and respond to multiple and interacting drivers of change (Risvoll 2015; Riseth et al. 2018; Hovelsrud et al. 2020; Landauer et al. 2021; Löf 2013). These are due to 1) climatic and environmental changes, 2) encroachments and disturbances from human activities, and 3) institutional constraints. First, the climate is changing more rapidly in the Arctic than elsewhere. In the Nordic countries, the annual average temperature has consistently been warming since the 1990s, and projections indicate an increasingly warmer and wetter weather and a higher frequency of extreme weather events (Hanssen-Bauer et al. 2015). Impacts from climate change on pastoralism constitute adverse weather events and changing snow and ice conditions creating ice crusts that reduce pasture access in winter (caused by freeze–thaw events) (Riseth and Tømmervik 2017; Risvoll and Hovelsrud 2016; Moen 2008; Vikhamar-Schuler et al. 2016; Vuojala-Magga et al. 2011) increased risk of diseases (Tryland et al. 2019; van Oort et al. 2020; Riseth et al. 2020). A common environmental change is increasing predator populations causing more predation on grazing animals (Risvoll and Kaarhus 2020; Sjølander-Lindqvist et al. 2020; Rasmus et al. 2020). Second, encroachments and disturbances on pasturelands from

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human activities (e.g., roads and railway lines, wind- and hydro-power installations, mining, cabins, tourism) are increasingly fragmenting the pastoral landscapes, reducing mobility in herding and the animals' access to pastures; often with detrimental impacts on grazing animals (Larsen et al. 2017; Österlin and Raitio 2020; Risvoll and Hovelsrud 2016; Anttonen et al. 2011; Eira et al. 2018). Last, both reindeer husbandry and sheep farming are to a large extent influenced by government regulations and international agreements, such as predator management and competing land use. These regulations and agreements frequently change and are often fragmented and disconnected from the local level (Sjølander-Lindqvist et al. 2020; Riseth et al. 2018; Bjärstig et al. 2020; Larsen et al. 2017). By fragmented governance we mean that governance systems are sectorized, where different authorities with their own internal rationality are responsible for implementing different policies and international agreements (Sjølander-Lindqvist et al. 2020; Johnsen 2018).

Research has shown that pastoralists' traditional- and experience-based knowledge and responses are largely ignored in management decisions (Risvoll and Kaarhus 2020; Löf 2016; Sarkki et al. 2021). Failing to integrate different knowledge systems limits the pastoralists' options to adapt sustainably [Axelsson-Linkowski et al. 2020; Sjølander-Lindqvist et al. 2020; Eira et al. 2016; Arctic Monitoring and Assessment Programme (AMAP) 2017; Risvoll and Hovelsrud 2016]. In this article we ask how consequences of multiple drivers of change and fragmented governance affect adaptation and subsequently long-term sustainability of Nordic pastoralism. This study shows how impacts from predator management and land fragmentation are currently tremendous challenges facing the pastoralists and in need of scrutiny.

We begin by outlining the conceptual framing and method before we describe the historical and ongoing trends of modernization and rationalization of pastoralism in Norway. We continue with a brief description of national management in terms of carnivores, supplementary feeding, and land fragmentation before we continue with our findings, discussion, and concluding remarks.

## 2. Conceptual framing

When we address challenges with high levels of uncertainty and when consensus on norms and standards on how to address this uncertainty is lacking, we need better tools than standardized statistical methods (Strand and Oughton 2009). This is the case with the challenges associated with the grazing animal–predator coexistence and the conflicts arising in relation to predator management (Risvoll and Kaarhus 2020; Sjølander-Lindqvist et al. 2020). These are deep cultural, economic, and emotional conflicts riddled with uncertainty, and a singular scientific approach is insufficient to address the range of interlinking factors signifying such conflicts. We align with others who argue that stakeholders' participation and inclusion of different knowledges are needed, preferably combined with a reflexive focus on the knowledge-creating process (Funtowitz and Ravets 1993; Björkan and

Rybråten 2019). Reflexive research and governance entail explicitly addressing research focus, including different knowledges and epistemologies (Adriansen 2020; Björkan and Rybråten 2019). This study is grounded in a process of knowledge coproduction, and we align with the notion that coproduction of knowledge will benefit from a culturally sensitive approach (Dannevig et al. 2020). Through conversations, interviews, and participatory observations over the past decade (i.e., Risvoll and Hovelsrud 2016; Risvoll and Kaarhus 2020; Hovelsrud et al. 2020; Sjølander-Lindqvist et al. 2020), we have defined research questions together with herders and farmers and continued an iterative dialogue throughout the analysis and preparation of this article. Such sensitivity may help bridge the cultural divide between policy makers, livelihood practitioners, and researchers (Risvoll and Hovelsrud 2016; Risvoll and Kaarhus 2020; Hovelsrud et al. 2020; Sjølander-Lindqvist et al. 2020), which is critical when addressing issues of conflicts associated with large carnivores and grazing animals inhabiting the same area.

Epistemological and ontological challenges likely arise when different knowledge systems meet (Löfmarck and Lidskog 2019). Complementing and understanding diverse knowledge systems can provide new and advanced insights and increase the capacity to understand challenges and responses (Tengö et al. 2014; Dannevig et al. 2020). We also need to be attentive to power relations when connecting science and traditional and locally based knowledge systems (Agrawal 1995; Tengö et al. 2014; Löf 2013). These power relations are often reinforced through institutions, politics, and norms and affect the level of trust in the decisions taken. Trust between stakeholders, rightsholders, and management across levels and scale is a critical component of cross-fertilization and coproduction of knowledge (Löfmarck and Lidskog 2019; Sarkki et al. 2021), and trust in decision-makers may influence how the pastoralists respond to risk and crisis (e.g., Hovelsrud et al. 2018; Kapucu 2008). Behind issues of trust are processes of knowledge interaction, which often include a forced uptake of technoscientific knowledge by Indigenous communities, and where traditional and local knowledge must be validated by science to be deemed useful (Löfmarck and Lidskog 2019; Tengö et al. 2014). It is also increasingly accepted that local context is critical for understanding and developing climate adaptation strategies (Westskog et al. 2017), yet there is still a significant gap between the principle and the actions taken to ensure inclusion of local and traditional knowledge (AMAP 2017, 219–252; Agrawal 1995; Inga 2008; Roturier 2009; Huntington 2011; Riseth et al. 2011; Sandström 2015).

We align with a definition of adaptation commonly applied to studies of climate change impacts on communities, livelihoods, and sectors (e.g., Hovelsrud and Smit 2010). It broadly addresses adjustments in coupled natural and human systems in response to actual or expected (climate) stimuli or their effects and may moderate harm or exploit opportunities (Smit and Pilifosova 2001; Adger et al. 2007). Adaptation has in the past two decades increasingly been analyzed as a process emerging from multiple and interacting stressors and cumulative change (AMAP 2017, and references therein). This is a useful approach for this study, where the pastoralist livelihoods are under multiple pressures

and where adaptation to one stressor may have unintentional effects and lead to a need for adaptation in other aspects of pastoralism (e.g., Risvoll 2015; Horstkotte et al. 2020). Adaptation processes and options are shaped by barriers, limits, opportunities, and governance (AMAP 2017, 219–252; Barnett et al. 2015; Hovelsrud and Smit 2010; Schipper and Burton 2009). Adaptation becomes a context dependent process shaped by a series of factors, including the level of exposure and sensitivity to an impact, how the community is structured and rigged to respond to exposures, national guidelines and support and local capacity to respond (e.g., AMAP 2017, 219–252). This is illustrated in studies from northern Norway where adaptation processes at the community level may be driven by place attachment, social networks and trust, local and experiential knowledge, engaged individuals, and perception of risk (Amundsen 2015; Hovelsrud et al. 2018).

According to Eriksen et al. (2011) and Brown (2011) adaptation measures are sustainable when contributing toward social equity and environmental integrity. Eriksen et al. (2011) suggest four main principles for realizing sustainable adaptation: 1) recognize the context for vulnerability, including multiple stressors; 2) acknowledge that different values and interests affect adaptation outcomes; 3) integrate local knowledge into adaptation responses; and 4) consider potential feedbacks between local and global processes. We find that these are useful for how we organize our empirical findings and approach the study. Further, we align with the notion that adaptation measures are never neutral and that there are trade-offs and that outcomes will be positive for some and negative for others (e.g., West and Hovelsrud 2010; Karlsson and Hovelsrud 2015). We have modified the first three principles suggested by Eriksen et al. (2011) for application in this study. First, our focus is not strictly on adaptation to climate change, but we consider vulnerability of pastoralism in the context of institutions and decision-making. Second, we do acknowledge that different approaches, interests, and values affect adaptation outcomes. Third, we are attentive to the role of local knowledge in local adaptation and in predator management and land fragmentation.

Despite the evidence that the local context is critical for ensuring climate adaptation, Norway's policy approach is one size fits all. This does not necessarily resonate with the adaptation goals and concerns at the local level and sets the stage for conflict (Westskog et al. 2017; Risvoll 2015). This is pertinent for the current study where the adaptation strategies of pastoralists are many and vary according to exposures to particular and localized stressors (i.e., predators, challenging grazing conditions, competing land use). In the sections below, we will discuss how selected national regulations and frameworks are not tailored to the empirical reality of the reindeer herders and sheep farmers.

### 3. Method

This article is guided by a case study design, which is useful for generating explanatory knowledge and allows for deeper understanding of complex and situated phenomena (Potette

et al. 2010). Both reindeer herders and sheep farmers depend on the same outfields for pastures, and while we acknowledge that there are major differences both in practice and culture, we designate the two as pastoralists in this study.

The study is based on extensive and long-term fieldwork among reindeer herders and sheep farmers in Nordland County, northern Norway (see Fig. 1).

The period of research has consisted of a collaborative and iterative process throughout various stages from design to data collection and analysis. We have used multiple methods for data gathering, including semistructured interviews, informal conversations, participant observations, and written sources such as policy documents, peer-reviewed gray literature, and other relevant documentation. Interviewees represent a range of ages (from 28 to 75 years of age) and include both women and men.

Research interactions are based on ongoing conversations over time that are embodied, placed, and formed by the agencies of people that are directly involved and engaged in pastoralism. The data were collected from 2015 to 2020 by semistructured interviews and conversations with reindeer herders (9; 3 females and 6 males) and sheep farmers (9; 4 females and 5 males), participation in seminars and board meetings, and participant observation of pastoralists' practices. We attended nine regional predator committee meetings between 2016 and 2018 as observers. Interviews with relevant actors and agencies were carried out in spring 2018, winter 2019 and in 2020. Interviews included one representative from the Norwegian Nature Inspectorate (NNI), two representatives from municipalities in Salten, Nordland, two representatives from the county governor, two representatives from the regional reindeer herding association, one representative from the regional sheep farming associations, one representative from the regional "small farmer association" and four representatives from the regional predator committee. We have discussed and engaged with most of these actors on multiple occasions and in different contexts throughout the study. Our meetings and interactions with the pastoralists have been open ended but have been centered around themes such as human–nature interactions; multiple changes (biophysical and social changes) and cumulative effects and responses, adaptations, and limits; and challenges and opportunities.

In addition, the study builds on conversations, dialogue, and practical interactions between the first author and some of the pastoralists during the past 10 years (starting in 2011–21). This dialogue and collaboration have taken place in various forms and different arenas such as seminars and meetings, phone calls, emails, and in the pastoralists' working environment in corral migrations, a slaughterhouse, a pastoralist's homestead, town hall meetings, and board meetings hosted by the county governor. Sometimes the meetings have been planned and organized, for example, observation by some of the researchers in board meetings. Other times the contact has been more ad hoc when a herder may invite the first author to activities such as calf marking, migration, or corral work. As the pastoralists plan their daily chores according to seasonal changes and based on a changing and unpredictable weather, factors like flexibility, time, and availability on behalf of researcher are crucial for interactions to take place. Such a diverse fieldwork process based on continuity has been possible



FIG. 1. Map showing Nordland County in Norway and the Salten region zoomed in. Source: H. Lundberg/Analyse&Tal.

in this study because the first author lives in close proximity to the pastoralists in this case study. The “researcher presence” over time in the pastoral communities has allowed for a deeper and nuanced understanding of the pastoralists’ perspectives and contextual setting, as well as an increased awareness and more in-depth understanding of seasonal and annual changes based on pastoralists’ knowledge and experiences (see also, e.g., Risvoll 2015; Hovelsrud et al. 2020; Risvoll and Kaarhus 2020). It has built a knowledge base for capturing some of the stories and perspectives from pastoralists that at times get interrupted in one setting but where the conversations have continued with the same pastoralists in another setting (Cruikshank 1990).

The information gathered and the knowledge coproduced from the meeting points between researchers, pastoralists, and other key actors have mostly been written down as notes

at the meetings or directly after. The latter is relevant when interactions take place outside in the fields or in corrals where note taking is impractical. The authors have shared and discussed notes and reflections with pastoralists and other actors. The pastoralists have been involved in the analysis through discussions in an iterative process whereby they were active agents (Wright et al. 2012), which has enabled us to better understand the intricacies of multiple pressures and responses across scale. It is not only the researchers that have gathered information from the pastoralists; the pastoralists themselves have initiated unsolicited contact to discuss different concerns and to suggest new angles or topics and directions for the research.

Bringing different knowledges together in an iterative manner provides a solid basis for knowledge coproduction, and we are better equipped to understand the complexity of the

pastoralists' interactions and engagements with the multiple and interacting stressors.

#### 4. Background and contexts

Nordland has great variations in topography, bedrock, and climate and provides a diverse range of habitats such as mountains, fjords, coastline, marshes, and coniferous forests. The region has a sub-Arctic climate, with considerable changes in a short distance between oceanic and continental climate. The terrain is characterized by a very steep gradient from the mountains and glaciers and down to the ocean level. These characteristics create shifting snow conditions during winter and unpredictable spring arrival and fresh and nutritious pastures at different altitudes during summer. Soils are rich in limestone that provides nutritious fodder for sheep and reindeer throughout the summer, which allows for high lamb and calf weights.

Grazing and agriculture in northern Norway are characterized by short growing seasons (Kvalvik et al. 2011), although these are expanding with climate change. Grass production and grazing livestock are the most feasible production forms given the high-latitude climate (Skogen 2014). The fodder quality is high because of the fertile soils and sprouting pastures, and favorable for breeding healthy lambs and reindeer calves (Austrheim et al. 2008). Winter temperatures have increased by about 2°C, and snow cover is projected to be reduced significantly or disappear entirely along the coast in northern Norway, while it will likely increase in the high mountains (Hanssen-Bauer et al. 2015). Spring and autumn are about 1.5°C warmer than normal. The snow season is shorter, precipitation increasingly falls as rain that changes the hydrology and type and access to vegetation. When snow combine with more rain the number of freeze-thaw events will increase. This is likely to create more incidents of "locked pastures" (Vikhamar-Schuler et al. 2016), characterized by ice crusts that form by freeze-thaw cycles creating hard layers of snow and ice that are difficult for reindeer to dig through creating more challenging grazing winter conditions (Riseth et al. 2011; Riseth and Tømmervik 2017; Risvoll and Hovelsrud 2016).

##### a. Governing pastoralism in Norway

The implementation of international policy instruments depends on the interpretation within each country's government. Sjølander-Lindqvist et al. (2020) show how the large carnivore policy sector values the knowledge system of natural science with focus on statistical measurement and models. In contrast, pastoralists have a more holistic approach to the interlinked social and environmental context (Sjølander-Lindqvist et al. 2020; Risvoll and Kaarhus 2020).

##### 1) SHEEP FARMING

Norwegian sheep farms are largely family owned. The Norwegian sheep farms are spread throughout the country and commonly located in sparsely populated areas, either close to mountains or the coast. The average farm has approximately 130 animals during the summer. Eighty percent of the income

from sheep comes from the meat; the remainder is from wool (Skonhoft et al. 2010). There has been a large reduction in sheep farms over the past decades (Thoresen 2018) and a moderate reduction in the number of sheep in the outfields during the past years. In 2020, approximately 1.9 million sheep and lambs grazed in the Norwegian outfield pastures (Statistics Norway 2021). In Nordland, the number of sheep farms have steadily declined over the past three decades, whereas the average number of sheep on each farm has increased to approximately 90 000 animals (Nordland County Governor 2021). Sheep farmers have grazing rights in the commons connected to the location of their farm, and these rights are increasingly challenged in areas with predators (Risvoll et al. 2016). The Norwegian Food Safety Authority can prohibit grazing in specific areas if the livestock losses are severe or likely to be so (Austrheim et al. 2008). Since the 1940s the national agricultural policies have been developed within a dominant "production discourse," shaped by continuous modernization and rationalization processes and primarily informed by science-based perspectives on meat production (see Risvoll and Kaarhus 2020). The agricultural sector in Norway is run by a large bureaucracy providing subsidies, incentives, and compensation for maintaining active and technologically advanced agriculture (Bjørkhaug and Rønningen 2013; Skogen 2014). The interactions between the state and farmers' interest organizations are well regulated (Skogen 2014). Market price support, import protection, and budget support (Kvalvik et al. 2011) are based on production, land use, region, and flock size and are settled through annual negotiations between interest organizations and the state with close links to the political system. Sheep farmers' perceptions, adaptive strategies, and alternatives for action are interpreted within these national institutions. In the 1960s–70s, sheep farming involved many households in rural communities, each had relatively few sheep that typically grazed near cultivated infields and in the nearby commons. Today sheep commonly graze at higher altitudes and farther from the farms. A change in agricultural policy in 1975 laid the foundation for an increase in the number of sheep farmers, and along with it an increase in the number of sheep (Jaren and Løvstad 2001).

##### 2) REINDEER HUSBANDRY

Reindeer (*Rangifer tarandus*) is a migratory species that inhabits the Arctic and sub-Arctic regions of the Northern Hemisphere. Nomadism is the traditional basis of Sámi reindeer herding characterized by movement over vast areas along migration routes (Sara 2009). Reindeer husbandry in Norway is regulated through the Reindeer Husbandry Act (LOV-2014-03-28-9). Reindeer husbandry takes place on both state-owned and privately owned land, and close to 40% of Norway's land area is used for reindeer herding. Reindeer herders' rights to land are based on old customary rights (Allard 2015), and according to national legislation, reindeer husbandry in Norway is the exclusive right of the Sámi people, except for a few concession areas in southern Norway where both Sámi and Norwegians own reindeer. The Sámi reindeer husbandry area is divided into six regions and

extends from Finnmark in the far north of Norway to Innlandet County (formerly Hedmark) in the south. These regional areas are further divided into 72 summer and year-round grazing districts and additionally 10 districts that are being used as autumn and winter pastures. Nordland County consists of 12 reindeer herding districts and 41 *siida* shares<sup>1</sup> within these. Reindeer herding conditions depend on natural pastures, the balance between summer and winter pasture capacities, and the winter grazing conditions. The latter are generally challenging in our case study region, primarily due to climate variability and pressures from predation (e.g., Risvoll and Hovelsrud 2016). Despite excellent summer pastures, official statistics show that the annual slaughter production in Nordland is only between one-half and two-thirds of the national average (Landbruksdirektoratet 2020).

Reindeer pastoralism is older than any national border, and when the first border was established between Sweden–Finland and Denmark–Norway in 1751 the border treaty included a special addendum, the Lap Codicil, guaranteeing the Sámi way of life by allowing free passage over the border (Pedersen 2008). One-and-a-half centuries later, nation-state constellations had changed, and further colonization left the Sámi as victims for nationalistic settler expansion. The Codicil is not terminated but is in practice substituted by grazing conventions and other bilateral agreements that limit cross-border reindeer herding and obstructing access to adequate pasture landscapes (Ravna 2010; Riseth et al. 2016).

Since the late nineteenth century and up to the 1960s, the Norwegian government promoted a policy based on an assumption that reindeer herding was a primitive tradition that would collapse when encountering modern society (Ravna 2019). Although their formal rights were weak, reindeer herders were largely de facto “masters of the mountains” until the 1960s–70s, and their land use was rarely challenged by competing users or governmental interventions. A new paradigm based on narrow natural science perspectives won hegemony both in Norway and Sweden (Riseth 2006; Johnsen and Benjaminsen 2017; Röver 2021), and in 1976, the Sámi Reindeer Herders Association of Norway (NRL) achieved a formal position akin to agriculture by signing the “Main Agreement for the Reindeer Husbandry Industry” (Landbruksdepartementet 1976) together with the now Ministry of Food and Agriculture. The overarching goal was increased meat production, and accordingly, improved income and welfare, but with two serious drawbacks: a strict top-down government through the Reindeer Husbandry Act (Riseth 2006; Johnsen and Benjaminsen 2017), and formal land rights were weak while competition over pastureland from external users increased heavily (Björsting et al. 2020). This continues to threaten the flexibility of reindeer herding (Riseth 2021). Herding practices have changed through time (Fjellheim 1995, p. 77) and earlier intensive practices of keeping animals close together caused increased risk of infections and diseases.

<sup>1</sup> There is no land ownership connected to reindeer husbandry, but, since the eighteenth century, reindeer herders have kept official user rights to the herding districts. This practice is regulated through a system of licenses referred to as “*siida* shares” (*siida*-andeler).

This led to a transition toward more extensive herding practices (Tryland 2012; Riseth et al. 2020). Herding is at the cusp of yet again changing into more intensive practices such as supplementary feeding (Tryland et al. 2021), which will be discussed below.

### b. Managing large predators

The Bern Convention Norway has an international responsibility to manage and maintain viable populations of the large predators such as lynx (*Lynx lynx*), wolverines (*Gulo, gulo*), wolves (*Canis lupus*), and brown bears (*Ursus arctos*) and birds of prey such as the golden eagle (*Aquila chrysaetos*) and sea eagles (*Haliaeetus albicilla*). Norway has changed its governance of large predators significantly during the past decades, and international conventions on biodiversity protection have attained more influence (Hansson-Forman et al. 2018; Risvoll and Kaarhus 2020). Simultaneously, this development has caused major dilemmas locally, and conflicts related to predators in the Nordic countries have increased dramatically (Dressel et al. 2015). When reindeer numbers are drastically low due to losses from predators (Åhman et al. 2014; Rasmus et al. 2020), too few females pose a serious risk for herd collapse.

The Predator Agreement of 2011 was supported by all political parties in the Norwegian Parliament. It emphasizes biological and ecological knowledge as a major basis for predator governance toward achieving desired population goals. The Agreement clarifies regulations of predator population goals and hunting licenses. It states that local actors, particularly from the pastoral sectors, should be involved in population registration and represented in local hunting teams, and it emphasizes the importance of knowledge transfer to local communities about carnivores’ habitats and behavior (Stortinget 2010). The Agreement provides the legal basis and mandate for the work of the regional predator committees but has no specific provisions for how to integrate local knowledge in decision-making. This institutional solution moves responsibility away from the local level and contradicts traditional pastoral values and practices for keeping predator levels at a reasonable level by taking out individuals that threaten pastoral viability.<sup>2</sup> The contrast to current practice when pastoralists are overruled as actors is formidable.

Recent evaluations of the regional predator management argue that the underlying assumptions for the abundance models are failing (e.g., Kränge et al. 2016; Mattisson et al. 2015; Strand et al. 2019), and Risvoll and Kaarhus (2020) show how local pastoralists disagree.

### c. Governmental regulations and directives for supplementary feeding

Crisis preparedness in animal husbandry is largely about supplementary feeding. Crisis funds are set up nationally and by herding districts to assist reindeer herders. Such funds are critical for herders when pastures are inaccessible, such as in winter 2020, when many herding districts experienced large amounts of snow and freeze–thaw events. After several years

<sup>2</sup> Unpublished interview material (author Riseth).

of catastrophic grazing conditions, the government collaborated with the Reindeer Herders Association on a crisis preparedness plan, where supplementary feeding is a proposed strategy to protect pastoralists' livelihoods and animal welfare and secure the survival of the flock (Norwegian Agriculture Agency 2017, 2020). This is an adaptive strategy that is necessary in times of pasture crises and has emerged across the Nordic countries to prevent animals from starving (Horstkotte et al. 2020; Ubani et al. 2020). Reasons for feeding are reduced or inaccessible pastures due to, for example, locked pastures, high predator pressure, expanding land use, and structural constraints such as the lack of a Reindeer Grazing Convention<sup>3</sup> between Norway and Sweden (Horstkotte et al. 2020; Turunen and Vuojala-Magga 2014; Risvoll and Hovelsrud 2016).

The historical and ongoing structural changes and efficacy measurements have also made Norwegian sheep farming dependent on supplementary feeding (Bay-Larsen et al. 2018). Other than mineral licks, the sheep are ideally not fed supplements during summer. Winter feeding primarily occurs inside barns with roughage and grain concentrates. Most farmers produce as much as possible of the silage themselves and buy the grain (Risvoll 2015). The animal feed industry is constantly searching for new sources of high-quality protein, and the hoof and mouth disease outbreak forced reduced imports (Risvoll 2015).

#### *d. The grazing animals need for connected pasturelands*

Multiple studies show that reindeer avoid areas with anthropogenic activities for up to several kilometers and females with calves are particularly sensitive to encroachments (Skarin and Åhman 2014; Anttonen et al. 2011). The herder's ability to adapt to animal avoidance behavior by using alternative pastures and migration routes is limited (e.g., Risvoll and Hovelsrud 2016; Eira et al. 2018).

The Planning and Building Act (PBA) stipulates that reindeer husbandry is included in land-use plans in purpose provision section 3–1c: plans shall “secure the natural basis for Sámi culture, business basis and community life.” It is no coincidence that the wording is close to the “Sámi section” in the Constitution (section 108). This provision is specified in the Sámi Parliament's planning guide (Sámi Parliament 2010) applicable to the entire planning process. Impact assessment processes [*konsekvensutredninger* (KU)] are a central part of case processing, including the overall effects of impacts (Ministry of Climate and Environment and Ministry of Local Government and Modernization 2017, section 21), because it is important to understand both 1) how each new intervention changes the operating conditions of reindeer husbandry and 2) how the effects of intervention are amplified by other change processes and activities (predators, climate, and human activity).

<sup>3</sup> The Norwegian/Swedish Reindeer Grazing Convention, regulating cross-border reindeer migration, ended in 2005, and the states have not yet ratified a new convention. The consequence is that some herding districts are unable to utilize their traditional winter pastures across the Swedish border. Governmental financial support is available for purchasing feed when traditional pastures in Sweden are inaccessible (Horstkotte et al. 2020).

Reindeer migrations in Nordland have traditionally (before 1750) been winter pastures in the borderlands between Norway and Sweden during winter, then movement toward the Norwegian coast during summer. These patterns gradually changed after 1750 as reindeer herders have (e.g., Risvoll 2015). Under good winter grazing conditions, the reindeer herd can move through the landscape grazing on the available resources. The herders can monitor the herd through “edge herding” with snowmobile or skis to make sure that the reindeer do not disperse. During edge herding, carnivore tracks near the herd can easily be discovered, and the human presence near the herd is predator deterrent and can reduce loss. In difficult winter grazing conditions, a traditional measure is to let the reindeer spread in small herds over larger grazing areas to secure enough fodder. Under these conditions the herders cannot carry out effective “edge herding” and the reindeer are exposed to predators.

## 5. Findings and discussion

Two circumstances stand out as particularly challenging for pastoralists in this study (see map). The first pertains to the uncertainty and grief resulting from the ongoing and major losses of sheep and reindeer to predators, such as lynx, wolverines, and eagles. The second pertains to the increasing land encroachments from human activities and infrastructure resulting in landscape fragmentation, with large implications for the movement and health of grazing animals in the landscape. Several reindeer herders and sheep farmers pointed a severe reduction of access to pastureland over the past two decades, and that they are left with few options to sufficiently secure their animals. They describe a situation in which they are trying to handle several pressures simultaneously, but their hands are tied by structural and managerial constraints to the extent that their livelihoods are at stake.

### *a. Pastoralism is shaped by predators and predator management*

Reindeer herders and sheep farmers point to insufficient and rigid regulatory frameworks that do not capture the empirical reality of their livelihoods or the interconnectedness of pastoralism to the dynamics of the landscape and nature (Risvoll 2015; Bay-Larsen et al. 2018; Löf et al. 2022). Reindeer and sheep are highly dependent on the seasonal pastures and pastoralists emphasize that they have always adapted to the dynamics of weather conditions, carnivore abundance, and human activities in the pastoral landscape. Their knowledge and praxis on how to respond have developed through generations, but the changes are becoming greater in rate and magnitude. Both herders and farmers report heavy losses; 20%–50% of the flock each year is not uncommon. Reindeer herding districts in Nordland have experienced dramatic reduction in the number of reindeer and production of meat over the last few years, as one young herder noted, “The number of animals spirals down all the time. This is a serious situation. You cannot live with reindeer husbandry when you have such large losses”; the reason is that they lose 30%–40% of the reindeer to predators (authors' own translation).

The herder was particularly worried about the low number of females in the flock, which is risky in terms of reproduction. They further note that they have great difficulty in documenting these losses due to what they perceive as strict and rigid methods that are not well suited for the dynamic landscape that they live and operate in. A realistic count of predators is critical from the pastoralists' point of view because hunting licenses are issued based on registered family groups of the different predators in the region. This form of top-down management is illogical to the pastoralists. Reindeer carcasses are hard to find. Wolverines, for example, usually hide their prey. If found, there are often few remains left of the dead reindeer, and it becomes difficult to document what caused its death. It is becoming increasingly common to find severe wounds on the reindeer's backs, and often herders suspect that golden eagles are attacking the reindeer. Both sheep farmers and reindeer herders report a significant local increase in golden eagles and sea eagles in the last decade(s). Wounded reindeer often suffer internal infections, making them vulnerable especially toward winter when survival depends on their physical condition.

Nature management are typically based on monitoring wildlife populations according to rigid scientific standards and to fit national abundance requirements. In Nordland County we find that the scientific theory and methods applied to managing predator populations usually do not include pastoralists' use of the same landscape.

Several pastoralists express concerns that they are not being taken seriously by the bureaucrats when reporting findings of wounded and killed reindeer and sheep. Both farmers and herders emphasize that their description of specific cases too often are not considered as true by carnivore managers. Specifically, when their descriptions and interpretations diverge from the national standards, which pastoralists perceive as inappropriate for the local snow and ice conditions, critical for identifying carnivore tracks, and not allowing for variations in how carnivores may attack or kill grazing animals. The registration and documentation of lynx, for example, are based almost solely on snow tracks on a set distance in the landscape defining number of family groups of lynxes. This ignores the local context of steep mountains, fjords, and glaciers that affect predator movements. Further, focus on snow tracks makes it near impossible to document losses to carnivores for official approval for most of the year, according to reindeer herders.

A young sheep farmer gave a recent example of an ewe with her lamb who was found wounded in the mountains near their farm. The ewe was bitten in the neck while the lamb had several small bites in the ear. A veterinarian reported the wounds in the lamb's ear to have been inflicted by young predatory animals. The predator management authorities retorted that they can only determine the cause of wounds if the animal is dead. The upshot is that the presence of this particular predator would not be added to the official knowledge database on predator populations for the region. This limits the documentation of losses through established science-based methods. Both sheep farmers and reindeer herders conclude that the manuals used by the Nature Inspectorate for registering predators are far too rigid and often do not match the local contexts, which is critical to understand the interactions between carnivores and pasture animals and their movement in the landscape. Policies and

institutional structures connected to predator management are experienced by pastoralists as rigid and ignoring their time-tested knowledge—up until now. This conundrum combined with increasing landscape fragmentation are increasingly reducing pastoralists' flexibility to adapt in a sustainable manner. The fact that pastoralists' traditional and experience-based knowledge is not applied or made relevant to address their challenges increases their feeling of uncertainty. Our findings show that the pastoralists often feel incapacitated in the meetings with the authorities as their knowledge and experience of the predator–livestock–landscape interactions are not received as useful or applicable in the science-based method of governance. Instead, they feel deeply frustrated by their gradually reduced ability to continue maintaining ecological and cultural diversity in the outfields. These findings are supported by some studies showing that livelihood practices, cultural aspects and local context are often neglected in natural science and resource management, resulting in less acceptance of regulations and management (see [Dannevig et al. 2020](#)). Other studies such as that of brown bear predation on reindeer calves in Sweden show that close cooperation between researchers and reindeer herders and use of advanced GPS transmitters on both predator and prey (i.e., female reindeer) was able to provide nearly exact documentation of brown bear predation level in space and time ([Karlsson et al. 2012](#)).

#### *b. Pasture fragmentation*

Reindeer herders experience continuous disturbances on their animals from competing land use throughout the year. One reindeer herder noted:

There are developments and activities surrounding us almost everywhere in our herding district. The municipality are now planning development on important peatland pastures. This will push us out into forest areas. We understand that the land is a scarce resource in this municipality. Therefore, we acknowledge that we must give away some pastureland. But we need to be able to move between our seasonal pastures. This is becoming increasingly difficult [authors' own translation].

The challenges from difficult pasture conditions for reindeer and sheep because of fragmentation are exacerbated because of other stressors such as the pressure from predators. Another threat that is emerging with a warmer climate, fragmented pastures, and changing husbandry practices is the risk of diseases due to climate sensitive infections (e.g., [Hovelsrud et al. 2020](#); [Riseth et al. 2020](#)). Some herders fear that reduced freedom for the reindeer to roam across uninterrupted pastures increase the risk of parasite infections, such as brainworm (*Elaphostrongylus rangiferi*). Brainworm is highly dependent on and sensitive to temperature, and warmer weather increases the risk of this disease ([Davidson et al. 2020](#); [Nymo 2019](#)). [Davidson et al. \(2020\)](#) further note that besides climate change, loss of grazing flexibility can also increase the risk of infection. Herders from one reindeer herding district explain that some animals increasingly stay put in smaller pasture areas, and one of the herders noted that they have experienced a small outbreak of sick animals recently in these flocks. These reindeer are hindered to graze more widespread because of increased human activity and fragmentation, and



the herder is concerned that more constraints on movement between seasonal pastures can increase the risk of disease in the herd. Increased fragmentation has gradually made the herd unwilling to pass human-made and natural hurdles in the migration route. As a result, fewer animals make it to the optimal calving land. Human activity in the region is manifold, that is, connected to infrastructure such as cabins, hydroelectric power stations, mining, roads, and railway. Further, both the mountains and coastal areas are widely used by both locals and visitors for activities and traditional practices such as hiking, hunting, fishing, and skiing (Risvoll and Hovelsrud 2016). Both infrastructure and human activities are spread throughout the landscape, and often run right across reindeer migration routes. Even though the outbreaks to date have been small in the study region, the herders we have interviewed express the risk of larger outbreak of this disease because of increased fragmentations of pastures.

Several sheep farmers also fear increased risk for disease when having to keep animals closer together, either in concentrated pastures or close to the barn, before releasing the sheep to the outfields in spring. The government urges farmers to try out multiple measures to reduce losses to carnivores such as delayed release of the sheep to mountain pastures and early mustering in autumn. Several farmers dislike this for several reasons. First, keeping the lambs in cultivated pastures for too long increases the chance of parasites. Moreover, mountain pastures in early spring are extremely high in protein important for the newborn lambs. It is therefore counterintuitive for farmers to keep their flock at home when they know they would do much better in the mountains. It is more costly and less healthy for the animals to stay close to the barn and be fed with supplementary feed.

### c. Supplementary feeding

Supplementary feeding is very common in sheep farming, and it is also increasing in reindeer husbandry in the study region. While sheep farmers have a longer history than reindeer herders of supplementary feeding of their animals, they prefer natural pastures and use as little supplementary fodder as possible. One farmer noted that they produce most of the fodder on the farm. The sheep are fed silage throughout winter. They sometimes use small amounts of pellets, and their aim is for the ewes to have no more than two lambs each. With too much feed, the chance of extra lambs increases, that is, more “bottle-fed lambs.” Bottle-fed lambs require supplementary feed, which again means that the production will move toward higher reliance on imported feed. The farmer noted that, based on her experience, key toward increased sustainability in Norwegian sheep production is to give priority to locally palatable plants. She is critical to present structure where the government is opting for volume and cost-efficient production.

Supplementary feeding has in reindeer husbandry traditionally been a practice strictly to alleviate crises and under migrations. Reindeer prefer natural pastures, but supplementary feeding is increasingly used by several herders as an emergency measure to buffer the unavailability of natural pastures during winter. Supplementary feeding is necessary to avoid hunger when pastures are locked due to ice-thaw events, to protect the reindeer from predators, when pastures have become too fragmented, or the risk of losses is too high due

to encroachments (see also Risvoll and Hovelsrud 2016). There has been little awareness of the potential implications of supplementary feeding, but both herders and farmers point to a number of risks related to a potential loss of traditional knowledge, economic losses, health risks, and threats of risking rights to pastoral land to which they have customary rights. One threat is the possibility of new pathogens being introduced as well as altering the epidemiology and appearance of “old” pathogens. In addition, climate change may contribute to altered ecosystems, including new distribution patterns for of insects that can be vectors for reindeer pathogens (van Oort et al. 2020). Those changes can create new challenges for both reindeer health and the economic and cultural sustainability of the traditional reindeer husbandry (see also Tryland et al. 2021). Many herders also try to avoid supplementary feeding because they experience that feeding prevent the animals from seeking forage by themselves. The scale of feeding also challenges the traditional knowledge, values, and culture with regard to what reindeer husbandry is all about (e.g., Horstkotte et al. 2020; Riseth et al. 2020).

### d. Sustainable adaptation: For whom?

In the theoretical framing section, we set up three interlinked aspects for understanding sustainable adaptation in in our study of pastoralism: 1) adaptation to multiple stressors; 2) that different epistemologies, values, and interests affect the adaptation outcome; and 3) the role of local knowledge in national policy development. First, pastoralists adapt to multiple stressors (e.g., increased frequency of freeze-thaw events in winter, land fragmentation, and increased losses from predators). These stressors threaten cultural values and food security and also reduce profit dramatically. Ironically, supplementary feeding as an adaptative response has the potential to exacerbate the existing stressors, requiring further adaptation. Herders clearly express a need for a safety net or a crisis fund, but it must be flexible enough to handle interlinked structural, environmental, and climatic crisis. The pastoralists’ adaptive strategies and actions are based on their experience and knowledge of pasture conditions, animal movement and the landscape. Currently they have insufficient means to respond to these interacting crises and their concomitant cumulative long-term effects.

Second, it is imperative for the pastoralists that their knowledge is included in the decision-making that directly affects them. Their concerns are about the epistemological mismatch between the official resource management approach and the empirical reality of the pastoralist. The authorities manage predators with technical tools and indicators where contextual factors such as local geography and topography are largely overlooked. These assessments do not include the holistic epistemological approach of the pastoralists, whose knowledge include the interactions between pastoral animals, predators, and the landscape. The official methods for both estimating abundance of predators and determining the predator species killing or wounding cause are technical, with rigid categories for what is included as killed or wounded by a predator. Animal loss recorded as “unknown cause of death” is not included in predator management. Even if pastoralists can identify the

carnivore based on the wounds, they feel that they are most often not heard or worse, mistrusted. The pastoralists have very few options to adapt to secure their animals against predators. Even though Norway today has a twofold policy objective of preserving biodiversity and maintaining traditional local livelihoods, we argue that current predator policy is biased against the pastoralists (Risvoll et al. 2016; Risvoll and Kaarhus 2020). The cards in the implementation play were already dealt when the Sámi in 1990 were recognized as an Indigenous people (Eilertsen and Riseth 2021).

The third aspect of sustainable adaptation is the inclusion and role of local knowledge in decision-making. The discrepancies between pastoralists' knowledge about the local context and that of national management and governing bodies create a lack of trust in official regulations and measures, and in the underlying knowledge base for such decisions. Trust in decision-makers is fragile among pastoralists and influences how the pastoralists respond to risk and crises (see also Hovelsrud et al. 2018). The national decision-making system is not rigged for including pastoralists' knowledge and epistemology and are not tailored to local context. Herders argue that they fall between the cracks in trying to adapt to different types of challenging conditions such as losses to large carnivores and pasture encroachments, both leading to fragmentation that can have detrimental impacts on grazing conditions and animal mobility. Recently the herders expressed their frustration over the lack of understanding between herders and management in a letter to the county governor. They mobilized their traditional knowledge base to gain support for their adaptation strategies that are holistic and contextually relevant. The knowledge horizons of pastoralists and decision-makers differ and so do the approaches to the landscape of pastoralism. This creates mistrust and conflict, which is not conducive for developing sustainable adaptation measures. It is clear from the pastoralists' perspective that the significant low return is a result of the government's predator management. As a consequence, they are on unsustainable trajectories, and their livelihood and culture are at risk.

Supplementary feeding is for both sheep farmers and reindeer herders to various extents used and needed, but it may not in the long run be sustainable for livelihoods whose foundation is the utilization of natural grazing land. This is because it will affect the natural ability of reindeer and sheep to find fodder, it may change the way decision-makers govern land use and will increase exposure to diseases. Supplementary feeding is to some extent supported by the government through financial assistance, which is necessary when herders have no other means to save their herds. However, it is not solving the underlying problems of pastoralists' reduced ability to continue maintaining ecologically and cultural diversity in the pasture landscapes.

## 6. Concluding reflections

The pastoralists need to continuously buffer against the effects of multiple stressors, and ironically and likely inadvertently, the fragmented management system has, instead of facilitating sustainable adaptation, created a situation of potentially

counterproductive paths. In many ways, the national policy challenges cultural values both with respect to pastoralists' coexistence with predators and supplementary feeding as an adaptation. These complex and mismatching interlinkages of pastoralism and national policies negatively affect pastoralists' adaptation options and room to maneuver and may eventually lead to entirely different livelihood practices. One possible scenario is that the sheep farmers are pressed to the point of having to quit altogether and that reindeer herding will transition into a fully domesticated agricultural practice. Both are culturally and socially inappropriate. In this scenario we may lose knowledge and culture with deep roots, and we lose the environmental and climatic benefits of grazing animals.

Our coproduced study shows that radical change is needed toward a more holistic animal husbandry governance where multiple knowledge systems are integrated to ensure sustainable adaptation at all levels. Adaptation outcomes are affected by different approaches and epistemologies that are situated across scale and context in terms of regional and national regulations versus local empirical reality among pastoral communities in Nordland, northern Norway. While adaptation to climate change is important, the vulnerability of pastoralism in this context is also related to structural processes and decision-making for other land-use and environmental issues. Knowledge and values are appropriate as a platform for changing the current governance system. The epistemological divide we have identified limits this opportunity for true coproduction and inclusion.

The epistemology of predator management is frequently at odds with that of pastoralists, and the question remains how the traditional and experience-based knowledge can be used sustainably without reducing these knowledge systems to something to be validated against scientific knowledge, as is currently common. A bridge between this epistemological divide would likely enhance predator management and result in more sustainable adaptation outcomes.

The pastoralists perceive the rigidity of national management regimes for carnivores, together with ongoing land fragmentation as the greatest threats for leaving them with limited prospects for sustainable adaptation. While policies and management focus on specific goals, such as preserving biodiversity through for instance predator management, they do benefit some interests but simultaneously have adverse effects on pastoralists and increase their vulnerability.

A successful management of wildlife–pastoral coexistence should to a greater extent be built on trust and should allow for the flexibility the pastoralists need to adapt to the changes affecting their livelihood. Targeting risks in a fragmented, sectorized manner render adaptation as a risk when not seen in connection with the historical and ongoing rationalization and centralization processes that have changed the pastoralists' system. We have shown that this has serious implications for traditional, local, and Indigenous governance structures and culture. Our study stakes out the direction for further studies on linkages between sustainability and adaptation.

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## REFERENCES

- Adger, N., and Coauthors, 2007: Assessment of adaptation practices, options, constraints and capacity. *Climate Change 2007: Impacts, Adaptation and Vulnerability*, M. L. Parry et al., Eds., Cambridge University Press, 717–743.
- Adriansen, H. K., 2020: Indigenous knowledges and academic understandings of pastoral mobility. *Indigenous Knowledges and the Sustainable Development Agenda*, A. Breidlid and R. Krøvel, Eds., Routledge, 18 pp.
- Agrawal, A., 1995: Dismantling the divide between indigenous and scientific knowledge. *Dev. Change*, **26**, 413–439, <https://doi.org/10.1111/j.1467-7660.1995.tb00560.x>.
- Åhman, B., K. Svensson, and L. Rönnegård, 2014: High female mortality resulting in herd collapse in free-ranging domesticated reindeer (*Rangifer tarandus tarandus*) in Sweden. *PLOS ONE*, **9**, e111509, <https://doi.org/10.1371/journal.pone.0111509>.
- Allard, C., 2015: *Renskötselrätt i Nordisk Belysning*. Makadam, 365 pp.
- AMAP, 2017: Adaptation actions for a changing Arctic: Perspectives from the Barents area. Arctic Monitoring and Assessment Programme Rep., 267 pp.
- Amundsen, H., 2015: Place attachment as a driver of adaptation in coastal communities in northern Norway. *Local Environ.*, **20**, 257–276, <https://doi.org/10.1080/13549839.2013.838751>.
- Anttonen, M., J. Kumpula, and A. Colpaert, 2011: Range selection by semi-domesticated reindeer (*Rangifer tarandus tarandus*) in relation to infrastructure and human activity in the boreal forest environment, northern Finland. *Arctic*, **64**, 1–14, <https://www.jstor.org/stable/23025661>.
- Austrheim, G., A. Mysterud, B. Pedersen, R. Halvorsen, K. Hassel, and M. Evju, 2008: Large scale experimental effects of three levels of sheep densities on an alpine ecosystem. *Oikos*, **117**, 837–846, <https://doi.org/10.1111/j.0030-1299.2008.16543.x>.
- Axelsson-Linkowski, W., A.-M. Fjellström, C. Sandström, A. Westin, L. Östlund, and J. Moen, 2020: Shifting strategies between generations in Sami reindeer husbandry: The challenges of maintaining traditions while adapting to a changing context. *Hum. Ecol.*, **48**, 481–490, <https://doi.org/10.1007/s10745-020-00171-3>.
- Barnett, J., L. S. Evans, C. Gross, A. Kiem, R. T. Kingsford, J. P. Palutikof, C. M. Pickernig, and S. G. Smithers, 2015: From barriers to limits to climate change adaptation: Path dependency and the speed of change. *Ecol. Soc.*, **20**, 5, <https://doi.org/10.5751/ES-07698-200305>.
- Bay-Larsen, I., C. Risvoll, I. Vestrum, and H. Bjørkhaug, 2018: Local protein sources in animal feed—Perceptions among Arctic sheep farmers. *J. Rural Stud.*, **59**, 98–110, <https://doi.org/10.1016/j.jrurstud.2018.02.004>.
- Björstig, T., V. Nygaard, J. Å. Riseth, and C. Sandström, 2020: The institutionalisation of Sámi interest in municipal comprehensive planning: A comparison between Norway and Sweden. *Int. Indig. Policy J.*, **11**, 1–24, <https://doi.org/10.18584/iipj.2020.11.2.10574>.
- Bjørkan, M., and S. Rybråten, 2019: The potential impact of sea lice agents on coastal shrimp in Norway: Risk perception among different stakeholders. *Marit. Stud.*, **18**, 173–187, <https://doi.org/10.1007/s40152-019-00141-6>.
- Bjørkhaug, H., and K. Rønningen, 2013: Crisis? What crisis? Marginal farming, rural communities and climate robustness: The case of northern Norway. *Int. J. Sociol. Agric. Food*, **21**, 51–69, <https://doi.org/10.48416/ijfaf.v21i1.155>.
- Bjørklund, I., 2013: Domestication, reindeer husbandry and the development of Sámi pastoralism. *Acta Borealia*, **30**, 174–189, <https://doi.org/10.1080/08003831.2013.847676>.
- Brännlund, I., 2015: Histories of reindeer husbandry resilience: Land use and social networks of reindeer husbandry in Swedish Sápmi 1740–1920. Ph.D. dissertation, Umeå University, 107 pp.
- Brown, K., 2011: Sustainable adaptation: An oxymoron? *Climate Dev.*, **3**, 21–31, <https://doi.org/10.3763/cdev.2010.0062>.
- Cruikshank, J., 1990: *Life Lived Like a Story: Life Stories of Three Yukon Native Elders*. University of Nebraska Press, 404 pp.
- Dannevig, H., G. K. Hovelsrud, E. A. T. Hermansen, and M. Karlsson, 2020: Culturally sensitive boundary work: A framework for linking knowledge to climate action. *Environ. Sci. Policy*, **112**, 405–413, <https://doi.org/10.1016/j.envsci.2020.07.002>.
- Davidson, R. K., T. Mørk, K. E. Holmgren, and A. Oksanen, 2020: Infection with brainworm (*Elaphostrongylus rangiferi*) in reindeer (*Rangifer tarandus* ssp.) in Fennoscandia. *Acta Vet. Scand.*, **62**, 24, <https://doi.org/10.1186/s13028-020-00524-4>.
- Díaz, S., and Coauthors, 2019: The global assessment report on biodiversity and ecosystem services: Summary for policymakers. IPBES Secretariat Rep., 56 pp., <https://doi.org/10.5281/zenodo.3553579>.
- Dressel, S., C. Sandström, and G. Ericsson, 2015: A meta-analysis of studies on attitudes toward bears and wolves across Europe 1976–2012. *Conserv. Biol.*, **29**, 565–574, <https://doi.org/10.1111/cobi.12420>.
- Eilertsen, S. M., and J. Å. Riseth, 2021: Rovviltforvaltning og rein-driftsnæringen—Hvordan kan todelte målsetting i samsvar med internasjonale konvensjoner praktiseres? *Utmark i endring—frå beitemark til rekreativ koloni*, F. Flemsæter and B. E. Flø, Eds., Cappelen Damm Akademisk, 211–236.
- Eira, I. M. G., M. N. Sara, H. Svarstad, and S. D. Mathiesen, 2016: Å se som en stat eller som en samisk reindeer: To forståelser av bærekraftig reindrift. *Samisk Reindrift, Norske Myter*, T. A. Benjaminsen et al., Eds., Fagbokforlaget, 27–48.
- , A. Oskal, I. Hanssen-Bauer, and S. D. Mathiesen, 2018: Snow cover and the loss of traditional indigenous knowledge. *Nat. Climate Change*, **8**, 928–931, <https://doi.org/10.1038/s41558-018-0319-2>.
- Eriksen, S., and Coauthors, 2011: When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate Dev.*, **3**, 7–20, <https://doi.org/10.3763/cdev.2010.0060>.
- Fanzo, J., C. Davis, R. McLaren, and J. Choufani, 2018: The effect of climate change across food systems: Implications for nutrition outcomes. *Global Food Secur.*, **18**, 12–19, <https://doi.org/10.1016/j.gfs.2018.06.001>.
- Fjellheim, S., 1995: Det Sámiske kulturlandskapet. *Fragment av Sámisk historie. Foredrag Saemien Våhkoe Røros 1994*, S.

- Fjellheim, Ed., Sør-Trøndelag og Hedmark reinsamelag, 58–81.
- Funtowitz, S. O., and J. R. Ravetz, 1993: Science for the post-normal age. *Futures*, **25**, 739–755, [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L).
- Hanssen-Bauer, I., and Coauthors, 2015: Klima i Norge 2100: Kunnskapsgrunnlag for klimatilpasning oppdatert i 2015. Norwegian Meteorological Institute Norsk Klimaservicesenter NCCS Rep. 2/2015, 203 pp., <https://klimaservicesenter.no/kss/rapporter/kin2100>.
- Hansson-Forman, K., E. Reimerson, A. Sjölander-Lindqvist, and C. Sandström, 2018: Governing large carnivores—Comparative insights from three different countries, *Soc. Nat. Resour.*, **31**, 837–852, <https://doi.org/10.1080/08941920.2018.1447179>.
- Helle, T. P., and L. M. Jaakkola, 2008: Transitions in herd management of semi-domesticated reindeer in northern Finland. *Ann. Zool. Fennici*, **45**, 81–101, <https://doi.org/10.5735/086.045.0201>.
- Horstkotte, T., E. Lépy, and C. Risvoll, Eds., 2020: Supplementary feeding in reindeer husbandry—Results from a workshop with reindeer herders and researchers from Norway, Sweden and Finland. Umeå University Doc., 34 pp.
- Hovelsrud, G. K., and B. Smit, Eds., 2010: *Community Adaptation and Vulnerability in the Arctic Regions*. Springer, 335 pp.
- , M. Karlsson, and J. Olsen, 2018: Prepared and flexible: Local adaptation strategies for avalanche risk. *Cogent Soc. Sci.*, **4**, 1460899, <https://doi.org/10.1080/23311886.2018.1460899>.
- , C. Risvoll, J. A. Riseth, H. Tømmervik, A. Omazic, and A. Albiñ, 2020: Reindeer herding and coastal pastures: Adaptation to multiple stressors and cumulative effects. *Nordic Perspectives on the Responsible Development of the Arctic: Pathways for Action*, D. C. Nord, Ed., Springer, 448 pp.
- Huntington, H., 2011: The local perspective. *Nature*, **478**, 182–183, <https://doi.org/10.1038/478182a>.
- Inga, B., 2008: Traditional ecological knowledge among reindeer herders in northern Sweden. Licentiate thesis, Swedish University of Agricultural Sciences, 36 pp.
- Jaren, V., and J. P. Løvstad, Eds., 2001: Delrapport 3 fra forskningsprogrammet bruk og forvaltning av utmark. Norges forskningsråd, 49–60.
- Johnsen, K. I., 2018: Conflicting knowledges, competing worldviews: Norwegian governance of Sámi reindeer husbandry in West Finnmark, Norway. Ph.D. thesis, Norwegian University of Life Sciences, 328 pp.
- , and T. A. Benjaminsen, 2017: The art of governing and everyday resistance: “Rationalization” of Sámi reindeer husbandry in Norway since the 1970s. *Acta Borealia*, **34**, 1–25, <https://doi.org/10.1080/08003831.2017.1317981>.
- Kapucu, N., 2008: Culture of preparedness: Household disaster preparedness. *Disaster Prev. Manage.*, **17**, 526–535, <https://doi.org/10.1108/09653560810901773>.
- Karlsson, J., and Coauthors, 2012: Björnpredation på ren och potentiella effekter av tre förebyggande åtgärder Ett samarbetsprojekt mellan Viltkadecenter, Skandinaviska björnprojektet, Udtja skogssameby och Gällivare skogssameby. Swedish University of Agricultural Sciences Viltkadecenter Rep. 6, 54.
- Karlsson, M., and G. K. Hovelsrud, 2015: Local collective action: Adaptation to coastal erosion in the Monkey River Village, Belize. *Global Environ. Change*, **32**, 96–107, <https://doi.org/10.1016/j.gloenvcha.2015.03.002>.
- Krange, O., J. Odden, K. Skogen, J. D. C. Linnell, H. B. Stokland, S. Vang, and J. Mattisson, 2016: Evaluering av regional rovviltforvaltning. NINA Rep. 1268, 190 pp., <https://doi.org/10.13140/RG.2.1.3797.9769>.
- Kvalvik I., S. Dalmannsdottir, H. Dannevig, G. Hovelsrud, L. Rønning, and E. Uleberg, 2011: Climate change vulnerability and adaptive capacity in the agricultural sector in northern Norway. *Acta Agric. Scand.*, **61B** (Supp. 1), 27–37, <https://doi.org/10.1080/09064710.2011.627376>.
- Landauer M., S. Rasmus, and B. C. Forbes, 2021: What drives reindeer management in Finland towards social and ecological tipping points? *Reg. Environ. Change*, **21**, 32, <https://doi.org/10.1007/s10113-021-01757-3>.
- Landbruksdepartementet, 1976: Om hovedavtale for reindriftsnæringen. Landbruksdepartementet St. Paper 170 (1975–76), 2.
- Landbruksdirektoratet, 2020: Ressursregnskap for reindriftsnæringen. Landbruksdirektoratet Rep. 43/2020, 112 pp.
- Larsen, R. K., and Coauthors, 2016: Kumulative effekter av exploateringer på renskøtsel—Vad behöver göras inom tillståndsprosesser. Naturvårdsverket Rep. 6722, 63 pp.
- , K. Raitio, M. Stinnerbom, and J. Wik-Karlsson, 2017: Sami-state collaboration in the governance of cumulative effects assessment: A critical action research approach. *Environ. Impact Assess. Rev.*, **64**, 67–76, <https://doi.org/10.1016/j.eiar.2017.03.003>.
- Löf, A., 2013: Examining limits and barriers to climate change adaptation in an Indigenous reindeer herding community. *Climate Dev.*, **5**, 328–339, <https://doi.org/10.1080/17565529.2013.831338>.
- , 2014: Challenging adaptability: Analysing the governance of reindeer husbandry in Sweden. Ph.D. thesis, Umeå University, 113 pp.
- , 2016: Locking in and locking out: A critical analysis of the governance of reindeer husbandry in Sweden. *Crit. Policy Stud.*, **10**, 426–447.
- , K. Raitio, B. Forbes, K. Labba, M. Landauer, S. Sarkki, and C. Risvoll, 2022: Reindeer husbandry governance in Sweden, Norway and Finland—Unpacking governance and its challenges from a political and discursive perspective. *Reindeer Husbandry and Global Environmental Change: Pastoralism in Fennoscandia*, T. Horstkotte et al., Eds., in press.
- Löfmarck, E., and R. Lidskog, 2019: Coping with fragmentation. On the role of techno-scientific knowledge within the Sámi community. *Soc. Nat. Resour.*, **32**, 1293–1311, <https://doi.org/10.1080/08941920.2019.1633449>.
- Mattisson, J., J. Odden, T. H. Strømseth, G. R. Rauset, Ø. Flagstad, and J. D. C. Linnell, 2015: Gaupe og jerv i reinbeiteland: Sluttrapport for Scandlynx Troms og Finnmark 2007–2014. NINA Rep. 1200, 45 pp.
- Ministry of Climate and Environment and Ministry of Local Government and Modernization Regulation, 2017: Forskrift om konsekvensutredninger. KU Regulation FOR-2017-06-21-854, <https://lovdata.no/dokument/SF/forskrift/2017-06-21-854>.
- Moen, J., 2008: Climate change: Effects on the ecological basis for reindeer husbandry in Sweden. *Ambio*, **37**, 304–311, [https://doi.org/10.1579/0044-7447\(2008\)37\[304:CCEOTE\]2.0.CO;2](https://doi.org/10.1579/0044-7447(2008)37[304:CCEOTE]2.0.CO;2).
- Nordland County Governor, 2021: Husdyr. Accessed 18 July 2021, <https://www.statsforvalteren.no/nb/Nordland/landbruk-og-reindrift/Husdyr/>.
- Norwegian Agriculture Agency, 2017: Gjennomgang av kriseredskapen i reindriften. Norwegian Agriculture Agency Rep. 30, 90 pp., <https://www.regjeringen.no/contentassets/a34b107c580e48288f48c53b5f2b7dbf/landbruksdirektoratets-arsrapport-2017.pdf>.

- , 2020: Gjennomgang av beitekrisen I reindriften 2020. Norwegian Agriculture Agency Rep. 45, 52 pp., <https://www.regjeringen.no/contentassets/662f61f3e526458b860b804f375b5d86/rapport-gjennomgang-av-beitekrisen-i-reingdriften-2020.jpg>.
- Nymo, I., 2019: Klimasyk rein med mark på hjernen. *Nationen*, 20 November 2019, <https://www.nationen.no/motkultur/faglig-snakka/klimasyk-rein-med-mark-pa-hjernen/>.
- Österlin, C., and K. Raitio, 2020: Fragmented landscapes and landscapes—The double pressure of increasing natural resource exploitation on Indigenous Sámi lands in northern Sweden. *Resources*, **9**, 104, <https://doi.org/10.3390/resources9090104>.
- Pedersen, S., 2008: Lappekodisillen i nord 1751-1859: Fra grenseavtale og sikring av samenes rettigheter til grensesperring og samisk ulykke. *Guovdageaidnu Dieđut* 3, 531 pp.
- Potetee, A. R., M. A. Janssen, and E. Ostrom, 2010: *Working Together: Collective Action, the Commons, and Multiple Methods in Practice*. Princeton University Press, 376 pp.
- Rasmus, S., I. Kojola, M. Turunen, H. Norberg, J. Kumpula, and T. Ollila, 2020: Mission impossible? Pursuing the co-existence of viable predator populations and sustainable reindeer husbandry in Finland. *J. Rural Stud.*, **80**, 135–148, <https://doi.org/10.1016/j.jrurstud.2020.08.017>.
- Ravna, Ø., 2010: Lappekodisillen av 1751 og dens rettslige betydning i dag. *Lov og Rett*, **49**, 392–406, <https://doi.org/10.18261/ISSN1504-3061-2010-07-03>.
- , 2019: *Same- og Reindriftsrett*. Gyldendal, 544 pp.
- Riseth, J. Å., 2006: Sámi reindeer herd managers: Why do they stay in a low-profit business? *Br. Food J.*, **108**, 541–559, <https://doi.org/10.1108/00070700610676361>.
- , 2021: Disappearing flexibility: The story of gielas reindeer herding district. *Stories of Change and Sustainability in the Arctic Regions: The Interdependence of Local and Global*, R. Sørly, T. Ghaye, and B. Kårtveit, Eds., Routledge Studies in Sustainability, Taylor and Francis, in press.
- , and H. Tømmervik, 2017: Klimautfordringer og arealforvaltning for reindriften i Norge: Kunnskapsstatus og forslag til tiltak—Eksempler fra Troms. Northern Research Unit Rep. 6/2017, 62 pp.
- , and Coauthors, 2011: Sámi traditional ecological knowledge as a guide to science: Snow, ice and reindeer pasture facing climate change. *Polar Rec.*, **47**, 202–217, <https://doi.org/10.1017/S0032247410000434>.
- , H. Tømmervik, and J. W. Bjerke, 2016: 175 years of adaptation: North Scandinavian Sámi reindeer herding between government policies and winter climate variability (1835–2010). *J. For. Econ.*, **24**, 186–204, <https://doi.org/10.1016/j.jfe.2016.05.002>.
- , —, and B. Forbes, 2018: Sustainable and resilient reindeer herding. *Reindeer and Caribou. Health and Disease*, M. Tryland and S. Kutz, CRC Press, 23–43.
- , —, and M. Tryland, 2020: Spreading or gathering? Can traditional knowledge be a resource to tackle reindeer diseases associated with climate change? *Int. J. Environ. Res. Public Health*, **17**, 6002, <https://doi.org/10.3390/ijerph17166002>.
- , S. M. Eilertsen, and B. Johansen, 2021: Reindriften sårbarhet (Vulnerability of reindeer husbandry). *Utmark i endring: Frå beitemark til rekreativ koloni (Outfields in Change: From Pasture Land to Recreation Colony)*, F. Flemsæter and B. E. Flø, Eds., Cappelen Damm Akademia, 29–66.
- Risvoll, C., 2015: Adaptive capacity within pastoral communities in the face of environmental and societal change. Ph.D. thesis, University of Nordland, 114 pp.
- , and G. K. Hovelsrud, 2016: Pasture access and adaptive capacity in reindeer herding districts in Nordland, northern Norway. *Polar J.*, **6**, 87–111, <https://doi.org/10.1080/2154896X.2016.1173796>.
- , and R. Kaarhus, 2020: Struggling with ‘clear zoning’: Dilemmas of predator-pastoral coexistence in Nordland, northern Norway. *Indigenous Knowledge and the Sustainable Development Agenda*, A. Breidlid and R. Krøvel, Eds., Routledge, 185–206.
- , G. E. Fedreheim, and D. Galafassi, 2016: Trade-offs in pastoral governance in Norway: Challenges for biodiversity and adaptation. *Pastoralism*, **6**, 4, <https://doi.org/10.1186/s13570-016-0051-3>.
- Roturier, S., 2009: Managing reindeer lichen during forest regeneration procedures: Linking Sámi herders’ knowledge and forestry. Ph.D. thesis, Acta Universitatis Agriculturae Sueciae, 71 pp.
- Röver, C., 2021: Making reindeer. The negotiations of an Arctic animal in modern Swedish Sápmi, 1920–2020. Ph.D. thesis, KTH Royal Institute of Technology, 233 pp.
- Sámi Parliament, 2010: Sametingets planveileder: Veileder for sikring av naturgrunnlaget for Sámiisk kultur, næringsutøvelse og samfunnsniv ved planlegging etter plan- og bygningsloven (plandelen). Sámediggi, Sametinget, 11 pp., [https://sametinget.no/\\_f\\_p1/i01a00d84-bbb4-4469-9445-80c7795a92ca/sametingets-planveileder-2010.pdf](https://sametinget.no/_f_p1/i01a00d84-bbb4-4469-9445-80c7795a92ca/sametingets-planveileder-2010.pdf).
- Sandström, P., 2015: A toolbox for co-production of knowledge and improved land use dialogues. The perspective of reindeer husbandry. Ph.D. dissertation, Acta Universitatis Agriculturae Sueciae, 80 pp.
- Sara, M. N., 2009: Siida and traditional Sámi reindeer herding knowledge. *North. Rev.*, **30**, 153–178.
- Sarkki, S., H. I. Heikkinen, and A. Löf, 2021: Reindeer herders as stakeholders or rights-holders? Introducing a social equity-based conceptualization relevant for indigenous and local communities. *Nordic Perspectives on the Responsible Development of the Arctic: Pathways to Action*, D. C. Nord, Ed., Springer Polar Sciences, Springer, 271–292.
- Schipper, E. L. F., and I. Burton, Eds., 2009: *The Earthscan Reader on Adaptation to Climate Change*. Earthscan, 460 pp.
- Sjølander-Lindqvist, A., C. Risvoll, R. Kaarhus, A. K. Lundberg, and C. Sandström, 2020: Knowledge claims and struggles in decentralized large carnivore governance: Insights from Norway and Sweden. *Front. Ecol. Evol.*, **8**, 120, <https://doi.org/10.3389/fevo.2020.00120>.
- Skarin, A., and B. Åhman, 2014: Do human activity and infrastructure disturb domesticated reindeer? The need for the reindeer’s perspective. *Polar Biol.*, **37**, 1041–1054, <https://doi.org/10.1007/s00300-014-1499-5>.
- Skogen, K., 2014: Utvalgte konsekvenser i rovviltforvaltningen. *Utmark — Tidsskrift for Utmarksforskning*, [https://utmark.org/Portals/utmark/utmark\\_old/utgivelser/pub/2014-1%262%26S/ordin/Skogen\\_Utmark\\_1%262\\_2014.html](https://utmark.org/Portals/utmark/utmark_old/utgivelser/pub/2014-1%262%26S/ordin/Skogen_Utmark_1%262_2014.html).
- Skonhoft, A., G. Austrheim, and A. Mysterud, 2010: A bioeconomic sheep–vegetation trade-off model: An analysis of the Nordic sheep farming system. *Nat. Resour. Model.*, **23**, 354–380, <https://doi.org/10.1111/j.1939-7445.2010.00067.x>.
- Smit, B., and O. Pilifosova, 2001: Adaptation to climate change in the context of sustainable development and equity. *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Cambridge University Press, 879–912, <https://www.ipcc.ch/site/assets/uploads/2018/03/wg2TARchap18.pdf>.
- Statistics Norway, 2021: Husdyrhald (Livestock husbandry). Accessed 1 October 2021, <https://www.ssb.no/jord-skog-jakt-og-fiskeri/jordbruk/statistikk/husdyrhald>.

- Stortinget, 2010: Representantforslag 163 S. Parliament Doc. 8:163 S (2010–2011), 4 pp., <https://www.stortinget.no/globalassets/pdf/representantforslag/2010-2011/dok8-201011-163.pdf>.
- Strand, G.-H., I. Hansen, A. de Boon, and C. Sandström, 2019: Carnivore management zones and their impact on sheep farming in Norway. *Environ. Manage.*, **64**, 537–552, <https://doi.org/10.1007/s00267-019-01212-4>.
- Strand, R., and D. H. Oughton, 2009: Risk and uncertainty as a research ethics challenge. National Committee for Research Ethics in Science and Technology Rep. 9, 42 pp.
- Tengö, M., E. S. Brondizio, T. Elmqvist, P. Malmer, and M. Spierenburg, 2014: Connecting diverse knowledge systems for enhanced ecosystem governance: The multiple evidence approach. *Ambio*, **43**, 579–591, <https://doi.org/10.1007/s13280-014-0501-3>.
- Thoresen, K. S., 2018: Bondelagsleiar: Skandaløst at vi har mista 1400 sauebønder på tjue år. NRK, accessed 23 August 2021, <https://www.nrk.no/vestland/bondelagsleiar-fortviler-over-sterk-reduksjon-i-sauebonder-1.14335956>.
- Tryland, M., 2012: Are we facing new health challenges and diseases in reindeer in Fennoscandia? *Rangifer*, **32**, 35–47, <https://doi.org/10.7557/2.32.1.2279>.
- , C. G. Das Neves, J. Klein, T. Mørk, M. Hautaniemi, and J. Wensman, 2019: Viral infections and diseases. *Reindeer and Caribou — Health and Disease*, M. Tryland and S. Kutz, Eds., CRC Press, 273–303.
- , I. H. Nymo, J. S. Romano, and J. Å. Riseth, 2021: Husbandry and diseases of semi-domesticated Eurasian tundra reindeer in Fennoscandia. *The Management of Enclosed and Domesticated Deer: International Husbandry Systems and Diseases*, J. Fletcher, Ed., Springer, in press.
- Turunen, M., and T. Vuojala-Magga, 2014: Past and present winter feeding of reindeer in Finland: Herders' adaptive learning of feeding practices. *Arctic*, **67**, 135–270, <https://doi.org/10.14430/arctic4385>.
- Ubani, A., B. Åhman, and J. Moen, 2020: Can management buffer pasture loss and fragmentation for Sami reindeer herding in Sweden? *Pastoralism*, **10**, 23, <https://doi.org/10.1186/s13570-020-00177-y>.
- van Oort, B. E. H., G. K. Hovelsrud, C. Risvoll, C. W. Mohr, and S. Jore, 2020: A mini-review of *Ixodes* ticks climate sensitive infection dispersion risk in the Nordic region. *Int. J. Environ. Res. Public Health*, **17**, 5387, <https://doi.org/10.3390/ijerph17155387>.
- Vikhamar-Schuler, D., K. Isaksen, J. E. Haugen, H. Tømmervik, B. Luks, T. V. Schuler, and J. W. Bjerke, 2016: Changes in winter warming events in the Nordic Arctic region. *J. Climate*, **29**, 6223–6244, <https://doi.org/10.1175/JCLI-D-15-0763.1>.
- Vuojala-Magga, T., M. Turunen, T. Ryyppo, and M. Tennberg, 2011: Resonance strategies of Sami reindeer herders in northernmost Finland during climatically extreme years. *Arctic*, **64**, 227–241, <https://doi.org/10.14430/arctic4102>.
- West, J., and G. K. Hovelsrud, 2010: Cross-scale adaptation challenges in the coastal fisheries: Findings from Lebesby, northern Norway. *Arctic*, **63**, 338–354, <https://doi.org/10.14430/arctic1497>.
- Westskog, H., G. K. Hovelsrud, and G. Sundquist, 2017: How to make local context matter in national advice: Towards adaptive comanagement in Norwegian climate adaptation. *Wea. Climate Soc.*, **9**, 267–283, <https://doi.org/10.1175/WCAS-D-16-0063.1>.
- Wright, S., K. Lloyd, S. Suchet-Pearson, L. Burarrwanga, M. Tofa, and B. Country, 2012: Telling stories in, through and with country: Engaging with Indigenous and more-than-human methodologies at Bawaka, NE Australia. *J. Cult. Geogr.*, **29**, 39–60, <https://doi.org/10.1080/08873631.2012.646890>.