



Synthesis

Applying a synthetic approach to the resilience of Finnish reindeer herding as a changing livelihood

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ABSTRACT. Reindeer herding is an emblematic livelihood for Northern Finland, culturally important for local people and valuable in tourism marketing. We examine the livelihood resilience of Finnish reindeer herding by narrowing the focus of general resilience on social-ecological systems (SESs) to a specific livelihood while also acknowledging wider contexts in which reindeer herding is embedded. The questions for specified resilience can be combined with the applied DPSIR approach (Drivers; Pressures: resilience to what; State: resilience of what; Impacts: resilience for whom; Responses: resilience by whom and how). This paper is based on a synthesis of the authors' extensive anthropological fieldwork on reindeer herding and other land uses in Northern Finland. Our objective is to synthesize various opportunities and challenges that underpin the resilience of reindeer herding as a viable livelihood. The DPSIR approach, applied here as a three step procedure, helps focus the analysis on different components of SES and their dynamic interactions. First, various land use-related DPSIR factors and their relations (synergies and trade-offs) to reindeer herding are mapped. Second, detailed DPSIR factors underpinning the resilience of reindeer herding are identified. Third, examples of interrelations between DPSIR factors are explored, revealing the key dynamics between Pressures, State, Impacts, and Responses related to the livelihood resilience of reindeer herding. In the Discussion section, we recommend that future applications of the DPSIR approach in examining livelihood resilience should (1) address cumulative pressures, (2) consider the state dimension as more tuned toward the social side of SES, (3) assess both the negative and positive impacts of environmental change on the examined livelihood by a combination of science led top-down and participatory bottom-up approaches, and (4) examine and propose governance solutions as well as local adaptations by reindeer herders as equally relevant responses to enhance livelihood resilience.

Key Words: *adaptation; cumulative pressures; DPSIR approach; environmental governance; land use; livelihood resilience; pastoralism*

INTRODUCTION

Social-ecological systems (SESs) are nested, multilevel systems that provide essential services to society, such as the supply of food, fibre, and energy (Binder et al. 2013). Recently, the term “resilience” has become one of the key concepts in assessing the continuity and sustainability of SESs (e.g., Folke 2006). Resilience is defined by the amount of change a system can undergo and still retain the same controls on function and structure and by the degree to which the SES is capable of self-organizing and renewing in changing contexts (Walker et al. 2004, Resilience Alliance 2016). The resilience literature often assesses an SES as a single unit of analysis (see Folke et al. 2010). However, such an approach may transfer an ecological way of thinking to social systems. The resilience of livelihoods, governance institutions, and social systems are, however, defined by factors other than those of ecological systems. This has been observed in recent literature (see Biggs et al. 2012, Kofinas et al. 2013), which has also increasingly focused on the social dimensions of resilience (Davidson 2010, 2013, Cote and Nightingale 2012, Bornstein 2013, Hatt 2013, Fabinyi et al. 2014). On the other hand, the specified resilience perspective (see Folke et al. 2010 for divergences between specified and general resilience) aims to answer the following questions: The resilience of what to what? (Carpenter et al. 2001); The resilience for what and for whom? (Armitage and Johnson 2006, Lebel et al. 2006); and How and by whom can resilience be built? (e.g., Kofinas et al. 2013). However, according to Folke et al. (2010), a sole focus on a specified resilience may lead to “narrowing options for dealing with novel shocks and even increasing the likelihood of new kinds of instability.”

We take into consideration the critique toward both general and specified resilience assessments. We retain a holistic focus of general resilience but go into depth regarding the resilience of a specific livelihood. Such an approach can better take into account the role of local agency, empowerment, social interactions, and rights to resource use in resilience assessments without losing sight of the holistic systems view (see Marschke and Berkes 2006, Oparinde and Hodge 2011, Nyamwanza 2012, Tanner et al. 2015). Nature-based livelihoods, such as reindeer herding in Northern Finland, are influenced by and intertwined with the availability and quality of environmental resources and conditions, internal dynamics, policies, markets, and decisions at various levels from the local to the global (Armitage and Johnson 2006). Yet, to various different degrees, local livelihoods also adapt actively and develop responses to contextual changes (de Haan and Zoomers 2005). Livelihood resilience is examined here via the application of the DPSIR (Drivers, Pressures, State, Impacts, Responses) approach, which is used as a guide to identify different components of an SES and their interactions linked to the livelihood (Binder et al. 2013).

The examined SES in Northern Finland encompasses various land uses, including nature-based tourism, nature conservation, mining, forestry, and reindeer herding. Our application of the DPSIR approach helps us identify various pressures on reindeer herding (e.g., land use, climate change, technological development) and map relevant issues by which the reindeer herding livelihood is linked to ecological and surrounding social systems. Also, it allows us to diagnose the current state of reindeer herding resilience and to propose how it may be promoted.

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Reindeer herding is a small-scale livelihood but an emblematic and culturally important subsistence activity for Northern Finland.

We synthesize our extensive previous research to enable a holistic identification of key issues related to the resilience of reindeer herding. This will make a contribution to the previously scattered literature which has focused on reindeer–pasture interactions (Helle and Kojola 2006, Kumpula and Colpaert 2007) or the relationships between reindeer herding and other single land uses (e.g., Heikkinen et al. 2010, 2013, Sarkki et al. 2013*b*). Recent research in natural science that considers the effects of other land users on reindeer pastures has drawn attention to the need for “more comprehensive research and management strategies for the entire reindeer herding environment” (Kumpula et al. 2014:541). We aim to narrow this gap by providing a social science-oriented synthesis of the interactions between reindeer herding and other land uses. Furthermore, the application of the DPSIR approach will provide the means to approach reindeer herding and the surrounding SES with a holistic view, one which takes into account factors that are insufficiently recognized in current land use governance (e.g., the effects of other land uses on condition, fragmentation, and availability of pastures for herders) (e.g., Sarkki et al. 2013*a*).

Our objective is to synthesize various opportunities and challenges that underpin the resilience of reindeer herding as a viable livelihood in Northern Finland. This objective is conceptually operationalized by combining the DPSIR approach with the specified resilience questions (Drivers and Pressures: resilience to what; State: resilience of what; Impacts: resilience for whom; Responses: resilience by whom and how). In order to examine the resilience of reindeer herding in a systematic, holistic, and innovative way, the DPSIR approach is methodologically applied in a three step procedure. First, various land uses, related DPSIR factors, and their relationships (synergies and trade-offs) to reindeer herding are mapped. Second, detailed DPSIR factors are identified as underpinning the resilience of reindeer herding. Third, examples of the interrelations between DPSIR factors are explored, revealing the key dynamics between Pressures, State, Impacts, and Responses related to the livelihood resilience of reindeer herding.

Our approach is innovative in many respects. Finnish reindeer herding has not been previously examined using the combination of the DPSIR approach and a livelihood resilience approach. Such a connection has scarcely been employed elsewhere (for Russia, see Forbes et al. 2009), but it can inform the analysis on the different components of an SES and their interactions. We move the common focus of the DPSIR approach from one-directional impacts caused by global change drivers on local livelihoods (e.g., Robards et al. 2011) to more complex interactions between livelihood, land use, governance, environmental features, and technological developments. This departure is visible, for example, in considering not only formal governance solutions as Responses, but also treating local action and adaptations as Responses in DPSIR language. Furthermore, we assess not only negative impacts but also the benefits of certain changes and Pressures on local livelihoods (e.g., Sparks et al. 2011).

We begin by presenting the DPSIR approach, with the emphasis on how it links to livelihood resilience, followed by an overview section on the study area and material and methods. The Results section maps the DPSIR factors for various livelihoods, and focuses particularly on reindeer herding. Finally, we discuss how the reindeer herding case informs the DPSIR approach when using it to examine livelihood resilience.

THE DPSIR APPROACH

The DPSIR approach has been used as an interdisciplinary analytical tool to assess environmental status and trends in environmental policy literature (e.g., EEA 2001). This approach allows the identification of divergent components within a coupled SES, and provides assumptions on interactions between different kinds of components of an SES (Rounsevell et al. 2010, Sparks et al. 2011).

Drivers and Pressures address the question of resilience to what. The Drivers in DPSIR include political, economic, ecological, demographic, and social factors. These drivers lead to direct Pressures on livelihoods (e.g., increasing competing land use reduces the state and availability of reindeer pastures; climate change caused by CO₂ emissions changes the preconditions for reindeer herding). We adopt Sparks et al.’s (2011) approach to consider Drivers and Pressures under the same dimension to avoid the academic discussion on whether to consider certain change or threat as a Driver or Pressure, and instead focus on direct Pressures.

The State dimension in the DPSIR approach addresses the question of resilience of what. This means that the system upon which resilience is examined should be clearly defined. As commonly applied, the State dimension concerns the ecological state (Sparks et al. 2011). However, to better fit with a livelihood perspective, we modify the State dimension to concern the state of a social-ecological system. This is justified as not only ecological but coupled, as social-ecological system grounds the benefits for reindeer herding (e.g., annual pasture use cycles, social capital, collective herding practices, local knowledge, governance issues) (Heikkinen et al. 2012, Spangenberg et al. 2014). According to Biggs et al. (2012), the resilience of social-ecological systems is enhanced by considering the principles of (1) diversity and redundancy, (2) connectivity, and (3) slow variables and feedback. Here, diversity relates to biodiversity and spatial heterogeneity. Redundancy provides “insurance” by allowing some ecosystem elements to compensate for the loss or failure of another system. Connectivity encompasses the structure and strengths of linkages between the components of a system and refers to the linkages between ecosystems, in which reindeer herding is embedded. The resilience of the system grows when the feedback reinforces the existing state of the slow variables and decreases when the feedback disturbs the existing state (e.g., feedback from increasing land use on quality and availability of pastures) (Biggs et al. 2012).

The Impact dimension assesses the question of resilience for whom. Impacts, from a livelihood perspective, are the possible effects of pressures that represent changes in net benefits for the livelihood (e.g., decreasing pastures lead to lower profitability). Impacts can also be thought of as changes in the interactions between the ecosystem and the livelihood (Sparks et al. 2011),

Table 1. Empirical materials, projects, and publications synthesized for this paper. In the workshops column, the first number is the number of meetings, and $n = X$ is the total number of participants in these meetings.

	Reindeer herder interviews	Administration interviews	Business, activists, or stakeholder interviews	Workshops, hearings, and planning meetings	Questionnaires, Delphi panel
Adaptation models of reindeer herding, 1998–2002, Dissertation (Heikkinen 2002)	33	NA	NA	NA	15
The challenges of modernity for reindeer management (RENMAN), 2001–2004, European Union Fifth Framework Programme (Hukkinen et al. 2006)	45	25	NA	3 ($n = 52$ participants)	Done by other scholars
Effects of reindeer grazing and nature conservation on strict nature reserve Malla, 2001–2005, Academy of Finland (Heikkinen et al. 2010)	23	2	29	4 ($n = \sim 50$ participants)	15 (45 invited to Delphi panel)
Neo-entrepreneurship of reindeer herding, 2004–2007, Academy of Finland (Heikkinen et al. 2007)	20	NA	NA	NA	NA
Human-environment relations in the north, 2007–2012, Academy of Finland (Heikkinen et al. 2011)	9	7	5	NA	NA
“The site strikes back”: participation and forest governance in Northern Finland, 2005–2011, Dissertation (Sarkki 2011)	34	14	13	NA	NA
Vulnerability assessment of ecosystem services for climate change impacts and adaptation (VACCIA), 2009–2011, EU Life+ (Lépy et al. 2014)	1	4	26	7 (128 participants)	14
Different land use activities and local communities in mining projects (DILACOMI), 2011–2013, Tekes Finland (Heikkinen et al. 2013)	8	NA	5	14 (~ 400 participants)	Done by other scholars
Participation of reindeer herding in mining projects, 2011–2013, Thesis (Komu 2013)	8	By other scholars	2	6	NA
Impacts of climate change on Arctic environment, ecosystem services and society (CLICHE), 2011–2015, Academy of Finland (Heikkinen et al. 2013)	11	NA	NA	1 (10 participants)	NA

and as changes in reindeer herding, which also produces benefits for others (e.g., food for large carnivores; serving as tourism attraction) (Heikkinen et al. 2012). The key questions are whether the possible change is desired and voluntary from the herders’ point of view or externally forced (Lépy et al., *unpublished manuscript*), and whether ecological thresholds of available pastures are exceeded.

The Responses address the question of how to enhance resilience. The Responses can be divided into adaptation measures performed by herders, and responses that the governance systems and actors develop to deal with changing contexts. Smit and Wandel (2006:282) define adaptation as “a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity.” This is also true for the livelihood systems and individual reindeer herders. On the other hand, the resilience of governance systems is enhanced by understanding social-ecological systems as complex adaptive systems, by learning and experimentation, by participation, and by polycentricism (Folke et al. 2005, Biggs et al. 2012). Livelihoods are directly linked to governance Responses, such as through land use planning.

STUDY AREA AND MATERIAL AND METHODS

Study area

Reindeer herding is a traditional small-scale livelihood carried out in Northern Finland, and it is practised by both Finns and Sámi people. Even though reindeer herding is characterized by its low productivity and profitability (e.g., Heikkinen et al. 2007), its value as an important part of Sámi culture, its emblematic livelihood of Northern Finland, and its value in tourism marketing is difficult to measure. Reindeer herding, an essential part of the local traditions and economy (Stammler and Beach 2006), serves as a fruitful example of livelihood resilience in a complex social-ecological context because it is directly exposed to land use changes as well as to climatic variations (Helle and Kojola 2008, Lépy et al., *unpublished manuscript*). Thus, reindeer herding cannot be viewed as disconnected from wider social, ecological, economic, technological, and political influences. Challenges brought by these developments include border fences between the nations (Finland, Russia, Sweden, and Norway); the introduction of snowmobiles in the 1970s; overgrazing, which was particularly apparent in the 1980s; climate change; the price of reindeer meat; and the development of other land uses (Forbes et al. 2006).

Table 2. Overview of DPSIR factors for various land users related to Pressures, State, Impacts, Responses, and their relationships to reindeer herding in Northern Finland.

Land users	Pressures toward livelihood	State	Key Impacts	Responses aiming to enhance livelihood	Key trade-offs and synergies with reindeer herding
Reindeer herding	Competing land use; increasing number of predators; rising economic costs; decreasing and ageing workforce; effects of climate change on annual cycle of herding	Diversity and connectivity of pastures; collaborative relationships among herders	Number of reindeer supported by natural pastures; availability of grazing lands; forage supply	Searching for synergies between conservation, tourism, and herding; negotiations with other land users; compensations for predator damages	Synergies: Common activities related to herding; joint meat processing facilities; Trade-offs: Internal competition over pastures
Skiing resorts	Surprising variations in snow cover season; economic depression	Diversity of products in terms of target groups; strong seasonality; connections to markets (e.g., international tour operators, charter flights)	Number of days with snow; usable and attractive environmental features and landscapes	Climate change policies, mitigation and adaptation measures (e.g., artificial snow on ski runs)	Synergy: Growing tourism increases markets for reindeer meat and reindeer-related products Trade-off: Skiing resorts increase infrastructures on reindeer pastures and traffic accidents
Nature-based tourism	Logging; intensive tourism; mining; increasing mass tourism infrastructures; surprising variations in snow cover season	Diversity of products in terms of target groups; connections to markets (e.g., international tour operators, charter flights); quality, connectivity, and diversity of landscapes where tourism activities are arranged	Number of days with snow; usable and attractive environmental features and landscapes; recreation possibilities; number of days with snow	Synergies between ecotourism and conservation—e.g., by sustainable tourism certificates; negotiations with other land users not to deteriorate important landscapes	Synergies: Some herders are developing tourism products and services; reindeer are used in tourism marketing Trade-offs: Snowmobile and husky safari routes are located in reindeer pastures
State commercial forestry	Demands for multifunctional use of forests by nature conservation, tourism, and reindeer herding	Access to logging sites; existence of replacing forest stands if some forests cannot be logged	Timber production	Certifications for sustainable forestry; negotiation structures with other land users; rising bio-economy discourse	Synergies: Forestry roads are also used by herders Trade-offs: Loggings and ploughing deteriorate pastures
Nature conservation	Forestry; mining; mass tourism; hunting; overgrazing by reindeer	Biodiversity; connectivity between high value natural areas; viability of key species	Educational, entertainment, and symbolic values (e.g., existence of charismatic predators)	Protected areas; ecological corridors; hunting regulations; restrictions for land use to minimize ecological impacts	Synergies: Protected areas serve as reindeer pastures Trade-offs: Predator conservation leads to negative impacts on reindeer herding
Mining	Instability in prices of minerals; strengthening environmental regulations	Diversity and proximity of minerals in the ground	Minerals obtained	Legal solutions to attract mining operations; investment support by the state	Synergies: Providing infrastructures and employment opportunities Trade-offs: Loss of pastures; increasing number of reindeer killed in traffic

Traditionally, reindeer herding has been based on natural pastures. This is still the case, especially in Reindeer Herding Cooperatives (RHCs) in the northern reindeer herding area. In the south, an increasing number of herders feed their reindeer inside pens during winter due to the lack of winter pastures and an increasing number of predators (i.e., wolves, bears, lynxes, wolverines) (Heikkinen et al. 2011). The well-being of the reindeer depends on their access to a varied range of alternative pastures. Summer pastures are fast-renewing, and primary economic production is based on the summer growth of the reindeer population. Conversely, winter pastures, ground lichens, and arboreal lichens renew slowly (Forbes et al. 2006). In pasture research, ecologically and economically sustainable reindeer herding is often considered as depending on grazing pressure (reindeer/km²), especially on the winter pastures, which are considered to be the ecologically limiting factor for reindeer

husbandry (Kumpula et al. 2000, Helle and Kojola 2006, 2008). As a consequence of a narrow view focused exclusively on grazing pressure, reindeer herders are sometimes accused in public discussions of overgrazing (Heikkinen et al. 2010). An alternative view is that other land uses are increasing and thus there is a decreasing condition and availability of pastures. This has also been noticed in recent ecological pasture research (Jaakkola et al. 2006, Akujärvi et al. 2014, Kumpula et al. 2014).

Land use conflicts have taken place between reindeer herding and forestry (Sarkki and Heikkinen 2010), reindeer herding and protected areas (Heikkinen et al. 2010, 2012), reindeer herding and predator conservation (Heikkinen et al. 2011), and even tourism and reindeer herding (Sarkki et al. 2013b). Research has also focused on the effects of climate change on reindeer herding (Lépy et al., *unpublished manuscript*), and on proposals to enhance

Table 3. Key DPSIR factors for reindeer herding in Finland.

DPSIR dimension	Focal questions for resilience	Empirical factors relevant for reindeer herding
Pressures	External pressures	<p>Competing land use and decreasing availability of good-quality grazing lands</p> <p>Fragmentation and changing availability of different types of pastures due to other land uses and predators throughout the annual pasture rotation</p> <p>Annually shifting number of predators</p> <p>Weather conditions: temperature, precipitation, frost</p>
	Internal Pressures	<p>Changing status of reindeer herding as a respected livelihood</p> <p>Number of reindeer may exceed the ecological carrying capacity of available grazing lands</p>
State	Diversity and redundancy	<p>Internal competition on grazing lands among herders</p> <p>Number and abundance of certain plant species used by reindeer as fodder in different parts of annual cycles (various shrubs and herbs in the summer; lichens, particularly in winter)</p> <p>Access of herders to alternative pastures</p> <p>Diversity of local knowledge regarding reindeer herding</p> <p>Extent of collective actions also to substitute individuals' practical tasks</p> <p>Diversity and amount of technological and economic resources</p>
	Connectivity	<p>Alternative and substituting sources of income</p> <p>Existence and quality of connections between grazing lands</p> <p>Quality of social relationships between herders</p> <p>Existence and quality of relationships between herders and other land users and policy-makers</p>
Impacts	Slow variables and feedbacks	<p>How much peaceful pastures (slow variable) are decreased due to other land use causing intensification of pasture use (feedback)</p> <p>Whether new generations continue herding (slow variable) and how it is impacted by rather poor profitability of herding (feedback)</p> <p>Whether and how collective identity of herders (slow variable) is reinforced by collective actions in herding practice (feedback)</p>
	Will the impacts cause thresholds to be exceeded: voluntary versus forced development?	<p>Changes in total number and weight of slaughtered reindeer in Reindeer Herding Cooperatives and in subherds owned by individuals</p> <p>Changes in annual communal herding practices</p> <p>Changes in body weights, reproduction, survival, and productivity of reindeer herds</p>

(con'd)

Responses	Policy and governance responses by external actors Implementing and monitoring maximum number of reindeer within Reindeer Herding Cooperatives Financial mechanisms to compensate for losses due to predators, traffic, and other land uses for herders Implementing participatory land use planning (e.g., forestry, conservation, mining, tourism, municipalities): Representative participation: How many herders have the possibility to take part in decision-making forums? Quality of participation: What are the possibilities for herders to genuinely affect decision-making? Adaptation measures undertaken by reindeer herders Supplementary feeding Building and using communal local meat processing facilities Changes in annual pasture usage cycle of herding due to environmental changes Calving inside pens to reduce losses due to predation Development of tourism-related reindeer products (reindeer safaris; trips to familiarize tourists with the work of reindeer herders—e.g. round-ups, earmarking of calves)
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the viability of herding in the face of other intensifying livelihoods and changing contexts (Hukkinen 2008, Heikkinen et al. 2012).

Empirical materials

The empirical materials have been collected since the mid-1990s by in-depth interviews, workshops, media analysis, collaborative meetings, and policy document analysis linked to reindeer herding and other land uses in Northern Finland (Table 1). We did not re-examine the primary materials but made a synthesis based on the previous peer-reviewed articles, reports, and theses.

Analysis methods

We applied the DPSIR approach by using a three-step procedure. The two first steps in the DPSIR analysis were conducted by using general principles of directed content analysis. This is a tool that allows us to organize empirical materials according to a chosen concept or topic, and can be used to extend an existing theory or to provide structured accounts on empirical topics (Hsieh and Shannon 2005). In this case, the DPSIR approach provided predetermined categories which we used to classify the empirical materials. For each DPSIR dimension, we identified detailed reindeer herding-related factors that are relevant for livelihood resilience. In the third step, we used a more inductive approach with the aim of identifying key dynamic interactions between DPSIR factors that are relevant for reindeer herding.

In the first step, the DPSIR approach was applied to gain a holistic picture of the various livelihoods in the study area and to map the Pressures, State, Impacts, and Responses regarding the different land users (Table 2). Pressures were identified according to the answers given by reindeer herders and other land users in interviews on what the key threats and trade-offs with other land uses were. The State dimension for various land users was identified by considering the key features in the social-ecological

system that are essential for the functioning of individual land uses. The Impact dimension was addressed through the key benefits the SES provides for the land users. Governance responses were mapped and assessed regarding how they relate to sustainable land use in Northern Finland and how well they function from the reindeer herders' perspective. In addition, we identified synergies and trade-offs between other land users and reindeer herding. Synergies were identified by tracing land use options and governance solutions that enhance two or more livelihoods simultaneously. Trade-offs were identified firstly by looking at whether other land uses produce negative Pressures on reindeer herding, and secondly by comparing state and benefit dimensions of land uses to identify potential controversies (e.g., timber production is a key benefit for forestry but has negative impacts on the state of reindeer pastures).

In the second step (Table 3), the focus was narrowed to identify key factors that are relevant to the resilience of reindeer herding as a livelihood (c.f. van Oudenhoven et al. 2011, Cabell and Oelofse 2012). Some conceptual distinctions were employed to structure the materials in order to identify the key DPSIR factors. Pressures may be external (e.g., caused by other land uses) or internal, which reveal the degree to which a livelihood can use a system to maintain its viability (UNEP-WCMC 2011). External pressures were mapped based on reindeer herders' views on factors threatening their livelihood. Internal factors were gained from studies that address basically the quantity of reindeers within the limits posited by the pastures' carrying capacity (see Akujärvi et al. 2014, Kumpula et al. 2014). Factors for State were built by identifying herders' statements on the relevant issues for the current social-ecological state of their activity. By doing so, we extended the three principles identified by Biggs et al. (2012) by more socially oriented factors that are still classified under the

three principles. The key question for Impact factors was whether the changes in reindeer herding are preferred by herders or are imposed from outside. Finally, we mapped the perceptions of reindeer herders on the functioning of the governance instruments as Responses. We also looked at current adaptation measures developed by herders to cope with changing contexts.

In the third step, the dynamic character of the DPSIR approach was used. While Tables 2 and 3 display the key DPSIR factors, the dynamic relationships between DPSIR factors remain implicit. Therefore, in step three, we selected two important examples for dynamic DPSIR thinking. One example starts from Pressure and the other from Response factor. The selected examples for Pressure (increasing number of predators) and Response (building small-scale meat processing facilities) were chosen because they emerged from our empirical materials as topical and vital issues for the resilience of reindeer herding. The increasing number of predators is much considered in current public and governance discussions and represents the most acute Pressure on herding in southern areas. The construction of meat processing facilities is a key adaptive action by herders to increase income from meat. We realize that there are also other important and dynamic aspects in reindeer herding. The overview of these other aspects is given in Table 3.

RESULTS

DPSIR factors for interrelated land uses

In order to understand holistically the position of reindeer herding among other interrelated land uses, various DPSIR factors for different land users are mapped in Table 2. Mapping various land uses and their relationships to reindeer herding produces a more holistic understanding of the system than by focusing merely on reindeer herding's relationships to single land users. Furthermore, much of the previous research has focused on one-to-one relationships between land uses and especially on specific problems (e.g., Heikkinen et al. 2010, Sarkki et al. 2013*b*). Table 2 also displays the various synergies between reindeer herding and other land uses (e.g., development of local infrastructures and contribution to viability of rural areas through increasing economic activities by forestry, tourism, and mining), as well as common pressures disturbing various land uses (e.g., mining, effects of climate changes, potentially overly strict environmental regulations) and governance responses that simultaneously benefit various land users (e.g., movement toward multifunctional land use, development of negotiation forums between various land users). However, for example, common pressures are not always straightforward, as previous mining sites may function as attractions for tourists respecting cultural heritage.

Trade-offs are trying to be eased by governance instruments and legal requirements for negotiations between different land users in Northern Finland. For example, forestry in state lands should not pose significant harm for reindeer herding, and herders have possibilities to participate in negotiations on forestry planning, at least in principle (Raitio 2008), and the planning and construction of mining sites is legally required to conduct an environmental impact assessment where the negative impacts on reindeer herding are mitigated (Heikkinen et al. 2013). Furthermore, reindeer losses due to predation and traffic

accidents are compensated for by the state, although herders argue that compensation for predation is inadequate (Heikkinen et al. 2011). While these separate governance responses seem to acknowledge reindeer herding, a key critique by reindeer herders regarding the current situation is not covered. According to herders, various other land users are always requiring compromises from herding, which leads to a wide range of cumulative effects that seriously challenge the viability of the livelihood. In many interviews, herders brought up that they can often cope with negative impacts derived from single instances of other land use types, but when the compromises with and losses due to other land users are put together, they find themselves in a really difficult situation.

DPSIR factors for reindeer herding

Livelihood resilience of reindeer herding can be informed by key DPSIR factors for reindeer herding (Table 3). DPSIR factors are productive in the holistic assessment of livelihood resilience, particularly by also focusing on the social and policy side of the SES. These DPSIR factors build forward from bio-economic reindeer–pasture research (e.g., Pekkarinen et al. 2015) and help overcome a bias in older research that stigmatizes herders as the sole reason for pasture degradation (see Sarkki et al. 2013*a*). Such an approach has had implications on reindeer herding governance, since the maximum number of reindeer for each RHC is defined by the Ministry of Agriculture and Forestry based on the expected carrying capacity of pastures. The distinction between internal pressures (e.g., competition between herders, too large herds) and external pressures (e.g., competing land uses, increasing number of predators) helps in assessing the various roles of herders and external actors in affecting the resilience of reindeer herding. A key criticism by herders toward the existing participatory land use planning processes as smoothly functioning Responses is that herders are “heard but without any possibility to influence” and can make only cosmetic changes in land use governance.

Complex dynamics between DPSIR factors

While providing valuable input on key resilience factors, Table 3 does not show the dynamic connections between resilience factors under a different DPSIR dimension in an in-depth manner. Here, we provide examples of the implications of a key adaptive measure (building meat processing facilities) and a key pressure (increasing number of predators) on complex interactions between different DPSIR dimensions.

A high and increasing number of predators (i.e., wolves, bears, wolverines, lynxes) as a Pressure is especially relevant for the southern and eastern reindeer herding areas in Finland, where it has dramatically reduced incomes for herders (Heikkinen et al. 2011). When reindeer are disturbed by predators, herders are required to search for dead animals in order to be eligible to receive financial compensation. Furthermore, this has complex implications on slow variables and feedback: livelihood identity is changing due to new tasks, and herders have found themselves in a situation where the profitability of herding is no longer based on income from meat but increasingly on compensation paid by the state for predator damage. An alternative is to develop herding practices toward reindeer farming. This changes the logic of the livelihood and the building blocks of herder identity (ways of “doing” the livelihood via daily practices). External governance

Responses include compensation mechanisms and occasionally granting of hunting licenses; adaptive measures include taking reindeer inside pens to avoid predator damage. However, compensation mechanisms for predator damage are, from the herders' point of view, deemed as insufficient and do not acknowledge the time and money spent searching for reindeer carcasses or the higher price of those reindeer selected for breeding (Heikkinen et al. 2012).

Building small-scale meat processing facilities has been an adaptive Response in order to gain a better price from meat. This helps cope with pressures of fluctuating numbers of breeder reindeer due to predator losses and extreme weather events, which results in fewer calves and less meat to sell. Increasing producer prices for meat per kilogram also helps cope with increasing costs of mechanization and supplementary fodder. However, meat processing takes time away from traditional and communal herding work, which is a key component of the livelihood culture of reindeer herding. Thus, the meat processing facilities create a new kind of distinction between those herders working more hours in meat processing and those working with reindeer in the forest. This may be a challenge for social capital and has effects on whether all herders participate in communal herding actions that reify social relations and continue the livelihood culture (Heikkinen et al. 2007). The impacts for individuals practising meat processing may be positive in economic terms, while it may challenge social relations due to an unbalanced distribution of communal herding tasks. Thus, even if adaptive Responses sound like good solutions to enhance the resilience and viability of herding, they may have unanticipated and even negative impacts on the complex livelihood system.

DISCUSSION

Pressures

Regarding pressures, our key finding is that more significant than any single pressure are the cumulative effects created by various individual land uses. This is not a new finding; similar results on cumulative pressures have been reported as key issues for reindeer herding in Russia (Forbes et al. 2009) and northern Europe (Pape and Löffler 2012). However, policy and governance experiments to cope with such cumulative impacts are scarce. One such example is in Canada, where the issue of cumulative pressures is formally recognized by policy actors, for example, in environmental impact assessments; however, Aboriginal people have claimed there to be a poor assessment of cumulative pressures on caribou (Gunn et al. 2014). This is an advancement compared to reindeer herding in Finland, where individual land uses take into account reindeer herding (e.g., through compromises in land use negotiations), but there is still a governance gap regarding managing cumulative pressures. In fact, previous scenario exercises on reindeer herding even depicted that cumulative pressures and potential future responses to the increasing number of predators and pasture fragmentation in southern and eastern RHCs may lead to a new kind of livelihood system, not based on meat production but on financial compensations and incentives (Heikkinen et al. 2012). On the other hand, in northernmost Finland, land use rights between the state and indigenous Sámi are the subject of intense debate. Stronger recognition of Sámi land rights could lead to other land users having to pay compensation for fragmenting pastures.

Furthermore, in the south, the cumulative pressures on natural pastures (fragmentation, predators) have already led to increasing practices to farm and feed reindeer within pens during winter (Heikkinen et al. 2011, 2012). Such issues highlight key questions for livelihood resilience: what kind of state of livelihood system are the responses actually promoting (e.g., predator compensations promote herding reindeer increasingly for feeding predators and not for sale as human food), and whether the responses are actually covering cumulative pressures (how to cope with the necessity of multiple compromises with other land uses; how well compensations cover total costs of predation).

The second key finding on Pressures is that both internal and external Pressures must be acknowledged. Looking only at internal Pressures has sometimes led to stigmatizing herders in public discussions by accusing them of over exploiting the pastures for bigger profits. This can marginalize reindeer herders by seriously questioning their credibility as neutral providers of policy-relevant knowledge on their livelihood (Sarkki et al. 2013a). Thus, considering only internal Pressures and neglecting external Pressures is not an apolitical act, as shown by critiques of Hardin's (1968) tragedy of the commons thinking (Dietz et al. 2003, Kyllönen et al. 2006). On the other hand, forestry discussions are often based only on forestry's internal performance, not on its effects on other livelihoods as an external Pressure. There are long traditions in Finland of "colonizing" northern resources without listening to local herders: in 2015, RHCs and Sámi people were not even consulted when planning new law on Metsähallitus (Finnish State Forestry enterprise) regarding the management and logging of state-owned forests, which cover most of the lands within the reindeer herding area.

State

The critique toward social-ecological resilience literature stresses that the social side remains under theorized (Davidson 2010, Cote and Nightingale 2012). Also, the examples provided by Biggs et al. (2012) on the three principles explaining the resilience of a social-ecological system (i.e., [1] diversity, redundancy, [2] connectivity, and [3] slow variables and feedback) are rather ecological. However, our analysis and Table 3 complement this SES literature by identifying various examples of socially oriented resilience factors under the three principles.

The social factors under the principle of diversity and redundancy include the state and diversity of local knowledge about the livelihood practices providing potential solutions to the encountered challenges (Oskal 2009). Local knowledge of herders includes, for instance, the ability to distinguish between various kinds of snow and weather conditions, to identify different kinds of reindeer, to know where the reindeer are, to know what the best place for reindeer is during the annual cycle, and to have a view on which reindeer should pass down their genes. By the same token, redundancy links to knowledge on the availability of substituting pastures, which can be used if primary pasture areas are unavailable. This is important if predators are moving in certain areas or if snow conditions in some locations make grazing difficult. Redundancy links also to social capital and collective action where practical tasks in reindeer herding can also be done (occasionally) by other herders. Such redundancy is reduced with increasing reindeer farming, where the herding tasks become more individual as everybody takes care of just their own reindeer within pens.

The social factors under the principle of connectivity encompass social capital among reindeer herders (bonding social capital) and between herders and external actors (bridging social capital) (see Pretty 2003). The bonding social capital is increased, for example, by collective herding tasks, which also reify livelihood identity generated by communal “doing” of reindeer herding (see Ingold 2000). On the other hand, bridging social capital may be relevant in land use conflict situations where coalitions with other actors may help gain a more powerful position (Sarkki and Heikkinen 2010). Bridging social capital with representatives of other land users and municipal and land use administrations is also important to achieve better outcomes from collaborative land use negotiations.

Regarding the principle of interactions between slow variables and feedbacks, we consider that slow variables regarding reindeer herding livelihood include reindeer herders’ identity, collective herding tasks, the condition of pastures, and the renewal of livelihood by new generations. Negative feedback that reduces resilience are the impacts of other land uses in pastures that disturb livelihood, and low profitability of reindeer herding, which makes it less attractive to new generations. Positive feedback that enhances resilience includes the existence of annual collective livelihood practices, which enhance a sense of common livelihood identity. Also, feedback from the diversity of available technological options (e.g., GPS collars, snowmobiles, helicopters, all-terrain vehicles) to time costs associated with practical herding tasks enhances resilience by increasing the available time and ability to control bigger herds with less workforce but also increases economic costs. These examples highlight that when assessing livelihood resilience, more attention should be put on social dimensions as the central and explanatory part of livelihood resilience.

Impacts

The impacts on social-ecological systems are often thought about using the concept of threshold, which may be seen as sharp boundaries between two system states operating under different resilience principles (Walker and Meyers 2004). For example, ecological carrying capacity of pastures can be identified by ecological science. Such ecological knowledge is also reflected in practical management actions in Finland. Such a “top-down” approach can enhance the resilience of herding by identifying the maximum sustainable number of reindeer in given pastures. Recent bio-economic research has moved forward from earlier pasture research and shows that there is a lot of variation in the thresholds of optimal reindeer herding and pasture condition due to several ecological and economic factors (Pekkarinen et al. 2015). Furthermore, instead of blaming only herders for overgrazing, this research points to adverse effects of governmental subsidies: “Government subsidies promote reindeer herders to base management on supplementary feeding leading to lower pasture conditions and to the depletion of lichens” (Pekkarinen et al. 2015:256). However, still an additional more “bottom-up” approach is also needed. An equally relevant approach for reindeer herders would be to conceptualize changing a livelihood as a subject of continuous development and adaptation without any sharp thresholds (Nuttall 2012, Nyamwanza 2012). Thus, instead of searching for abstract thresholds to divide systems into two qualitatively different states, more relevant for reindeer herders would be letting them define

whether the changes are enhancing or hindering the viability of this culturally important livelihood.

The impact on a livelihood can be positive or negative when crossing a certain threshold. For example, in the 1970s when snowmobiles were introduced to Finnish reindeer herding, a threshold was certainly exceeded. In public discussions, motorization of herding is sometimes even viewed as cultural decline leading to loss of traditional knowledge. However, this technological development was adopted voluntarily by herders and was considered as positive by them. On the other hand, the increasing numbers of predators in southern and eastern reindeer herding areas can lead to exceeding a negative threshold imposed externally by conservation policies, and is certainly viewed as a negative development by herders. However, this is actually debated in Finland. Herders have argued that the number of predators is beyond a critical limit, while environmental nongovernmental organizations and, to some extent, the environmental administration have argued that, for example, the number of wolves should be increased to avoid inbreeding (Heikkinen et al. 2011). Thus, thresholds can be seen more as argumentative tools to gain agency in environmental governance (e.g., Homer-Dixon 2008) than value-neutral descriptions of systems that would explore uncertainties behind thresholds to a sufficient extent (Davidson 2013). This highlights the need to consider the “resilience for whom” question thoroughly when working with the impact dimension of the DPSIR framework.

Responses

Representative participation should be the aim of governance Responses but can be problematic (e.g., Reed 2008), as shown by regional Natural Resource Planning (NRP) targeting the use of state-owned forests. There are five NRP areas within the Finnish reindeer herding area, while there are 54 RHCs in total in Finland. As there are only one to two representatives of reindeer herding in each NRP negotiation, most RHCs remain unrepresented in forestry planning. Moreover, herders from different RHCs often have very divergent concerns and problems regarding relationships between herding and forestry (Sarkki 2011). Furthermore, having a genuine impact on land use decisions is a constant question when it comes to forestry (Raitio 2008) and mining (Heikkinen et al. 2013).

A proposal sometimes brought forward by herders would be to establish a decision forum focused on the holistic situation of reindeer herding. Such a decision body could recognize and also cope with cumulative pressures. This would be similar to comanagement decision forums nested in existing polycentric governance networks (Sarkki et al. 2015). However, it is not an easy task to develop a forum that would have genuine impact beyond mere discussions. For example, regarding predator management, herders may participate in discussions in regional large carnivore consultative committees in Scandinavia that, however, have failed to have an influence on concrete decision-making due to lack of accountability to existing governance instruments (Sandström et al. 2009).

What we propose here is based on ideas of multilevel governance systems with vertical and horizontal connections between various decision nodes (Andanova and Mitchell 2010). The established forum could be managed by a “middleman” who notifies herders of topical land use developments. The middleman would

acknowledge the related concerns of herders and invite the other land users to the negotiation table. The problem in land use negotiations is often that concerns of reindeer herders are juxtaposed with the interests of other land uses, which leads to lock-in value conflict (e.g., Kyllönen et al. 2006). However, a way out of such a general lock-in situation could be going into depths regarding site-specific solutions, which would allow small victories for each party, and thus increase the acceptability of also small losses (Sarkki and Heikkinen 2015). The outcomes of these ad hoc negotiations would then be taken into negotiations over existing land use governance instruments, such as regional forestry planning, land use zoning, protected area management planning, and environmental impact assessment processes regulating mining developments. The existing land use governance instruments would be formally responsible for taking into account the outcomes of the site-specific negotiations facilitated by the middleman. In this way, the proposed negotiation forum would (1) be close to reindeer herders and allow for easy access by herders, (2) be formally linked to existing land use governance instruments, (3) provide a combination of informal and formal platform, allowing space for free deliberations with a strong link to existing land use governance instruments, and (4) have a holistic overview of the land use situation in reindeer herding areas.

The middleman institution and related negotiations could be organized by the Finnish Reindeer Herders Association, which works under the Ministry of Agriculture and Forestry (MAF). However, MAF also restricts herding by setting up the total allowable number of reindeer within RHCs. As a result, herders have sometimes felt that MAF does not represent their interests (Hukkinen 2008:34). Hence, by supporting the middleman arrangements that are close to herders and represent their interests, MAF could develop a role in herding that is more strongly supported and accepted by herders.

Some notes can also be made on Responses initiated by herders themselves. All herders do not have equal opportunities to undertake adaptive Responses to cope with changing contexts. In fact, even new internal positions among herders may evolve due to varying availability for adaptive measures. First, in the current situation, herders engaged with the growing tourism industry are often in a better position than those retaining just their traditional herding practices. Second, those with meat processing facilities get a better price for meat but have less time to work in forests. Third, those who are farming reindeer within pens during critical times are not dependent on nonfragmented peaceful, natural pastures, but extra food for reindeer is expensive, and collective practices with other herders do decrease. Thus, instead of considering adaptive Responses as magic bullets, it would be relevant to consider what kinds of new positions among herders are posed by varying adaptive Responses.

CONCLUSION

A holistic picture of livelihood resilience can be achieved by applying the DPSIR approach through the three step procedure demonstrated in this paper. A holistic view of livelihood can help elucidate the arguments to avoid false blaming of reindeer herders for unsustainable practices, and to recognize that Pressures but also Responses may change herders' social relations, have impacts on collective herding practices, and affect culture and identity.

Furthermore, internal heterogeneity among herders necessitates empirical studies and an approach that goes deeper into livelihood reality than a focus on the general resilience of SESs.

Livelihood resilience can be defined as “the ability of a livelihood system to renew and maintain its viability in the face of external and internal pressures, and the capability to positively adapt by reorganizing its functions and by having influence on governance of the other livelihoods working within the assessed SES.” As defined here, a livelihood resilience approach (1) focuses on a specific livelihood embedded in wider and changing contexts instead of focusing on the general SES, (2) focuses rather on the continuous and normative renewal of livelihood than on sharp systemic thresholds, and (3) aims to answer questions of specified resilience with the help of the DPSIR approach.

It can be concluded that cumulative Pressures are a key challenge for reindeer herding today. Even if the separate Pressures may be manageable, it is harder to manage cumulative impacts because they consist of many land uses. Such a situation is also experienced by other pastoralists and livelihoods that use rather large geographical areas (Forbes et al. 2009, Pape and Löffler 2012). An important characteristic of cumulative Pressures is that they are invisible to other actors except reindeer herders, who experience their Impacts in practice. One proposal to manage cumulative Pressures would be to establish a negotiation forum, facilitated by a middleman, between herders and existing land use governance instruments, as outlined above. As a consequence, enhancing the livelihood resilience of reindeer herding should not only depend on herders' adaptive actions, but state administration and other governance actors should also help set the stage for positive change and voluntary renewal in changing situations.

Responses to this article can be read online at:

<http://www.ecologyandsociety.org/issues/responses.php/8819>

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