Name of the case study	Finnmark – Traditional reindeer herding and development - Norway [Loss of resilience]							
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	Herding has been a traditional livelihood in different communities across the Arctic linking their cultural practices and well-being to key ecological dynamics that could potentially change in the near future. Herding in Norway has been encroached both in area and on its traditional practices by political and social pressures, which makes this case exceptional from a social/economic/institutional point of view. This case contributes to understanding the resilience of traditional livelihoods to both biophysical forces driven by climate change, and by social forcing driven by energy and infrastructure development, and the cultural clash/conflict between a First Nations communities and modern Norway.							
Templated completed by: *Main contributor	Juan Rocha*, Stockholm Resilience Centre Kate Williman, Stockholm Resilience Centre Elinor Holén, Stockholm Resilience Centre Matilda Lenell, Stockholm Resilience Centre Roweena Patel, Stockholm Resilience Centre				**Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (1) Tyler, N.J.C., J.M. Turi, M.A. Sundset, K. Strøm Bull, M.N. Sara, E. Reinert, N. Oskal, C. Nellemann, J.J. McCarthy, S.D. Mathisesen, M.L. Martello, O.H. Magga, G.K. Hovelsrud, I. Hanssen-Bauer, N.I. Eira, I.M.G. Eira, and R.W. Corell. 2007. Sami reindeer pastoralism under climate change: Applying a generalized framework for vulnerability studies to a sub-arctic social–ecological system. Global Environmental Change 17:191–206.				
Reviewed by (name and affiliation)								
Category	**Resilience/ Adaptability**		**Loss of resilience**		**Transformation**			
			X					
Case study details:	**Country**	**Place**	**Scale – space**	**Scale – time**	**Sector(s)**	**Other (e.g. disturbance)**		
	Norway	Finnmark	49,000 km2	1950-date	Reindeer herding	Encroachment by new sectors (agriculture, energy, infrastructure), institutions		
Drivers (mark with X in appropriate boxes)	**Climate**	**Geopolitical**	**Mineral/ oil extraction & infrastructure**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographic change**	**Other: *agriculture***
	x	X	x					X

	Biophysical: Reindeer husbandry is expected to be affected by climate change by increasing variability of precipitation, hence extreme events on snowfall, and higher temperatures on early summer. While the first will negatively impact herding, the second could play an advantageous role by lengthening the grazing season.	**Social:** With the melting of Arctic sea ice, development projects in the energy sector, fishing industry and tourism, are expected to impact the area where reindeer herding takes place. Such overlapping can reconfigure the space in perception of place, use and physical infrastructure that threatens the traditional way of herding.
1. Basic description of coupled social-ecological system in focus **(**What are the key components and stake holders) If possible draw a systems diagram or conceptual map of the case – this can be a series of diagrams to capture different periods in the case and the drivers/ actors/ events that characterize the period.	a) What types of ecosystem(s) and other major biophysical features are present? This case is delimited by the herding activity, which takes place on the Arctic steppe to tundra ecosystems. b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics? Given that the system definition centres on the husbandry activity, the limits of the system will be given then by the migratory routes of the herders.	c) Who are the key groups of people in this case? Reindeer herders both local (Báiki) and regional (Siidas) organizations; oil and gas companies, tourism industry, forestry industry, reindeer meat industry, Sámi council and other international organizations (Association of World Reindeer Herders, Nordic Welfare system). To be precise, Tyler et al. report that 2000 registered reindeer owners by 2004 and approximately 165,000 – 230,000 reindeer, which is about 75% of reindeer in Norway, in an area of 136,000km^2, roughly 40% of mainland territory (1). d) What kinds of livelihoods are important in the system? Reindeer husbandry, energy production (industry), forestry. e) What institutions are key to this case? Reindeer herders have their own institutional arrangements on how to manage the resource which has been sometimes in conflict with regional and national policies (i.e. wildlife protection, obligatory schooling, national borders, etc.). f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries? The social boundaries of the herding practice extend beyond the physical area of reindeer territories. National level policies have been very influential on the herding practices particularly on

		dictating laws limiting herd size, castration, migration, or commercialization. Lobbying regional organizations of herders and industry (forestry, energy, tourism are also key players.

2. Timeline Draw a timeline of *key* events/ developments to the case. Define the time period (decades – centuries) over which change is considered, Provide a brief description of event/ actors, and ecological impacts Is it possible to identify periods of change from one type of system to another, transformations? Identify disturbances or events that challenged, built, or reduced resilience or adaptive capacity in the system. Consider both biophysical and social dimensions. Mark particularly significant events with *.	1851: Norwegian parliament establish the Lapp fund to change language and culture 1852: Sámi people forbidden to herd between countries (Norway, Sweden and Finland) 1889: 7 years of mandatory schooling, including Sámi people. 1902: Lands Act – people that didn't speak Norwegian were not allowed to buy land, forced assimilation and Norweigianization 1939: World war II bombings 1959: Assimilation policies rejected – new goal was to strengthen Sámi culture, economy and social welfare. 1960s: Introduction of new technologies such as snowmobiles 1968: Oil drilling starts in the area 1978: Reindeer Husbandry Act: only people with Sámi heritage have the right to herd reindeer, only sons are allow to inherit the herd. 1980s: Norwegian parliament regulates number of reindeers 1990: Constitution includes paragraph strengthening Sámi rights Sanitary regulations introduced where majority of control is lost over slaughtering and markets. Production and income halves. 2007: Herding Act 2010: Norwegian Animal Welfare Act: forbids herders to castrate reindeer without veterinarian.

3. Disturbances What are the key disturbances in the system (present and past)	a) Have there been major biophysical disturbances that are relevant for the case? Extreme cold and high variability of precipitation has been recorded across the 20th century.	b) Have there been major social disturbances that are relevant for the case? - Norwegian Animal Welfare Act forbids herders to castrate males - Fixed meat prices introduced in 1990 - Norwegian parliament restricts number of reindeer - Reindeer Herding Act: rules about inheritance and rights of herding - Oil drilling - Chernobyl affected sanitary conditions for reindeer and had an impact on meat market
4. Drivers of change Clarify what impacts these drivers have on the SES and if these are direct or indirect	a) What are the key biophysical drivers of change? Higher precipitation variability will increase snowfall, and increasing mean temperature will produce earlier summer snow melt. Both are direct drivers. It has been reported that large-scale atmospheric phenomena, such as North Atlantic Oscillation and Arctic Oscillations, have an effect on growth, body size, survival and fecundity of ungulates through their effects on grazing conditions (1).	b) What are the key social drivers of change? Policies for development of energy industry, forestry, infrastructure. All are indirect social drivers since it is not clear to what extent, through which mechanism, and where they are strong enough to play a role.
5. Sources of adaptive capacity: What factors allow(ed) the system to adapt to disturbances in the past and present? Give a brief assessment of recent or on-going changes (+/-/0 = increasing/ reducing/ not affecting adaptive capacity)	a) Within the ecosystem? (-) Castration of male reindeer reduces the adaptive capacity of the herd given that males are stronger animals that help breaking the ice, they also help maintain genetic diversity (2), and by having a low male numbers the herd could produce allele effects. (-) Loss of grass land area due to land use change reduces the adaptive capacity of herders. It reduces the potential grassing areas and connecting corridors needed to navigate strong winters and other extreme events.	b) Within society (e.g. people, social capital, management, institutions, infrastructure): (+) Traditional knowledge of herders is embodied in their language and institutions of husbandry. For instance, good herds by Sámi standards require phenotypic diversity, and balance between males and females (1). (+) Political representation of Sámi people increases their power to negotiate and advocate for a husbandry friendly agenda. (+) Norwegian government fund and research organizations for husbandry issues.

The next two sections break down the information in Section I. While it is not necessary to fill these sections, if you have additional information pertinent to specific rows below feel free to enter the material.		
II.1-8 SES, resilience and adaptive capacity		
	Biophysical	**Social**
II.1. Where do we find change and resilience in the face of change?	a) Within nature: Change is found in increasing temperatures, which might favour shrub encroachment and reduce grazing area (habitat loss) for reindeer. On the other hand, grazing controls shrub establishment to certain extent. Resilience is found in: herd diversity, sexual distribution, and access to a variety of grazing grounds when harsh times arise (especially cold winters).	b) Within society: Change: herders now have to attend schools, respect national borders and law regarding market regulations (price) and wildlife (castration, quotas). Resilience: acknowledgement of access rights, diversification of strategies across *Siidas*, or regions.
II.2. What are the system's key components?	a) Key Ecological components (e.g. lakes, coastal zones, caribou) Reindeer, vegetation communities and their interactions with the climate system, and human communities.	b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.? Reindeer herders both local (Báiki) and regional (Siidas) organizations; oil and gas companies, tourism industry, forestry industry, reindeer meat industry, Sámi council and other international organizations (Association of World Reindeer Herders, Nordic Welfare system). To be precise, Tyler et al. reports 2000 registered reindeer owners by 2004 and approximately Sámi owned 165,000 reindeer, which is about 75% of reindeer in Norway (1).
II.3. What are the key linkages? E.g. ecosystem services, resource extraction. These linkages should exist. If there are not mutual links between	a) From nature to society (e.g. ecosystem services) - Primary production - Game - climate regulation (external?) - knowledge and educational values - traditional livelihoods.	b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution) - Husbandry - Mining - Tourism

social and ecological components the case is not a social-ecological system.		
II.4. What are key interactions?	a) What are the key ecological interactions within the case? Competition between pasture and shrubs is mediated by environmental factors, such as precipitation and temperature. Also grazing plays a fundamental role on keeping open grassy landscapes. However, heavy precipitation in winter creates thicker snow layer that makes harder for reindeer to access the buried vegetation. Due to resource scarcity (reindeer food) the herd and the community of herders migrate annually across the landscape. Such nomadic adaptation is crucial for the maintenance of both the reindeer and human livelihoods. b) What are the most important biophysical tele-connections to distant systems? Perhaps the most important teleconnection on the biophysical realm is the effect on temperature coming from increased, and increasing, greenhouse gasses everywhere.	c) What collaborations, conflicts, or other key linkages exist between actors? Potential conflicts include overlapping interests between herders, mining companies and the state. On one hand, with higher demands for energy, both state and mining companies need to find a way to supply such resources. The state often provides incentives for exploration and mining development (especially oil). Once projects are in place, it conflicts with the semi-nomadic strategies that herders need to maintain for their livelihoods. d) Between local actors and distant actors? Distant actors in this case would be final resource users (energy or meat) who through market mechanisms and policy-making can affect reindeer production.
II.5. Culture	a) How is the relationship between society and nature viewed? There is an interdependence between the reindeer population, the livelihood itself and a feedback through grazing that tends to maintain the grassland, benefiting both the herd and herders. b) What meanings are attributed to nature and to interactions with nature? Not clear from literature review.	c) What are key cultural features of relevance for the case? Sámi are an indigenous population from northern Europe who depend on reindeer herding. Their traditional knowledge, practices and collective memory are important components of their adaptive capacity. d) What are key cultural practices and beliefs related to nature? They organize in collective herding partnerships called *siidas*. Traditionally the have been using castrating practices in order to keep a proportion of the herd for traction (hard work, breaking ice, digging snow, etc.) while keeping females low, which is also

		known to increasing the net energy of the herd (1). High mobility and constantly changing migration strategy depend on weather conditions have also been in practice, which is agreed on within the *siida*. They don't believe that climate change is a problem, they have confronted similar variability in the past and adapted to it (1).
II.6. Disturbance What are important types of stress & shock	a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc). Heavy precipitation in wintertime will produce a higher layer of snow, making difficult for reindeer to access food.	b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc) Important shocks that have occurred in the past include the establishment of laws that change the lifestyle of the herders. For instance, the establishment of mandatory schooling limited the semi-nomadic lifestyle (1899), the regulation of herd size (1980's), fixing prices (1990's), and regulations on castration (2010).
II.7. What are key slow variables Changes that occur over decadal or longer time scales	a) What types of ecological processes (e.g. loss of permafrost, shifts in species composition) are driving important long-term changes in ecological structures and processes? Mean annual temperature and bush density are two slow variables that can determine the abundance of reindeer. Temperature affects the vegetation growing season but also the melting of ice, if it is too early then it is difficult to cross rivers once ice has melted. Precipitation is also a key variable. Heavy snow accumulation limits access to vegetation in winter.	b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours? Space encroachment for the migration has been influenced by the development of other activities on the landscape such as tourism, roads, railways, dams, electricity lines, settlements, and agriculture. It has been reported that approximately 25% of reindeer range in the Barrens region has been lost due to overlapping with infrastructure development, and in coastal Finnmark it goes up to 35% in some areas. (1).
II.8. Relationships with ecological regime shifts	a) Are ecological regime shifts driving further ecological change or pressure? Yes, it has been documented that the shifts between steppe / tundra / forest can be mediated by herbivory (2), temperature and precipitation (3). b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)?	c) Can social stresses or major changes be attributed to ecological regime shifts? Not at the moment. Most social stresses have been product of conflict of interest with other actors, including the government, about the use of the landscape and how it should be used. d) Are there specific social practices that might be contributing to ecological regime shifts Yes. The potential collapse or diminishment of herding driven by

	Yes, most of climate change related regime shifts are thought to reinforce climate warming in the Arctic.	social stresses can reduce the grazing feedback and increase the likelihood of shrub encroachment and the transition towards forested landscapes. More distant practices, such as global energy consumption patterns, are driving climate change, which further reinforces the variability of Arctic climate and potential for regime shifts in the Arctic.
II.8 Regime shifts	**If a regime shift exists and is important to this case describe it below.** Please indicate whether the regime dynamics are well-established, contested, or speculative.	
II.8.a. Detailed description of alternate regime shifts A case study can contain more than one type of regime shift	Briefly describe the structure of each regime. What does each regime look like? What are differences in ecosystem structure and function? (e.g. permafrost loss, vegetation change)? Potential regime shifts in northern Norway include the shift from steppe to tundra and tundra to forest (2,3). Both regime shifts are fairly well-established. Steppes are grass-dominated systems usually in drier environments, which have higher primary production and nutrient cycling. Tundra is dominated by moss and has lower primary production and nutrient cycling. Forests, on the other hand, are dominated by tree and shrub species such as spruce, pine, larch and tamarack. How do the properties and behaviours of regimes differ? (e.g. collapse of subsistence food sources, fundamental change in types of livelihoods, change in governance institutions, new actors with significant political power who transform decision making) From the ecological perspective, a shift towards bushy vegetation and early succession of forest will further reduce the grazing area for reindeers. Warmer climates could also promote permafrost thawing with implication for global carbon storage. From the social perspective that could represent a major impact on Sámi traditional livelihoods and therefore their culture.	
II.8.b. Feedback mechanisms within the system that maintain each regime	Ecological feedback mechanisms - Grazing - Nutrient cycling feedback - Competition between vegetation types - Soil moisture - Shrub microbial activity - Albedo	Social feedback mechanisms - Redistribution of herds in Siidas - Castration mechanism (national) - Prices control (national) - Herd number control (national) - Landscape reading according to current and previous winter: determining which pastures are accessible and which not

	- Soil drainage - Shrub permafrost mechanism	depending temperature and snow cover - Migration feedback: determining when to move. - Market feedbacks: demand of meet - Alternative provisions: pellets, subsidies for reindeer lost due to predation.
II.8.c. What key changes drive regime shifts? Describe how these changes alter the state of the system or feedback processes.	a) Drivers of ecological regime shifts (either social or ecological). Herbivory and herding, hunting, temperature increase, climate change, greenhouse gas emissions. b) How do these changes alter biophysical feedback processes? Herbivory mediates competition between grasslands and shrublands, while climate change increases temperature, extreme events and precipitation regionally.	c) Drivers of social regime shifts (either social or ecological). Legal frameworks (castration, prices, regulation on herd size and inheritance), energy and infrastructure development, competing land uses. d) How do these changes alter the social feedback processes? The legal frameworks reduce adaptive capacity of herders while development sectors encroach on the area available for herding. In coastal Finnmark up to 35% or reduction has been reported (1).
II.8.d. Ecosystem services substantially impacted by regime shift	a) Changes in ecological processes that produce ecosystem services Primary productivity, biomass available for grazing, and nutrients cycling is affected with the regime shift. In addition, the ecological structures that have allowed for Sámi culture to prosper and adapt to its environment could disappear (becoming a forest instead of grasslands).	b) Changes in demand for ecosystem services (market and non-market) Preferences about meet consumption and quality standards might affect profitability and the practice of herding. On the other hand, there is increasing demand of energy, development of infrastructure and coastal tourism. c) Changes in the institutional context of ecosystem services e.g. changes in access and changes in how ecosystem services are valued as expressed by rules and regulations. Rules about border limits with Sweden, about favouring the provision of energy or tourism, about wildlife protection (of wolfs, wolverine and other predators) conflict with food production from reindeer, and maintenance of cultural values for Sámi.
II.8.e. What is (+/-) impacted by changes in	a) Impacts from regime shift on ecological components	b) Impacts from regime shift on social actors

ecosystem services directly or indirectly	(-) Shifts in land cover have potential impacts on albedo feedback, climate regulation and carbon sequestration, which reinforces itself and potentially other regime shifts in the Arctic.	(+) The shift might increase services related with forestry (-) The shift will decrease the adaptive capacity of Sámi herders by further encroachment of their activities, threatening their livelihoods.
II.8.f. Potential cascading effects	Describe, if any, the likelihood of potential ecological cascading effects to other SES Although the strength of the coupling is uncertian, this regime shift can increase fresh water runoff to the sea, affecting sea-ice formation and when aggregated at the global level, to some extend the thermohaline circulation.	Describe, if any, the likelihood of potential social cascading effects to other SES Tyler et al reports that in times on crises in Norway, they often import reindeer from Sweden, where regulation about pellets production is softer and cheaper (1).
II.8.g. Where do actors intervene to alter regime shift dynamics and who can do the intervening? This can be listed here or marked with (*) in the table above	Ecological oriented interventions At the local to regional scale, actors can intervene by changing grazing pressure and migration patterns. At the global level, actors need to reduce carbon emissions.	Socially oriented interventions Government intervention that historically have affected the system include: the introduction of mandatory schooling, fixing market prices for reindeer, regulating pellet production, and imports of both animal or reindeer meat when bad herding years produce losses. Subsidies have also been introduced to compensate for losses due to conservation activities for wolfs (1).

REFERENCES/ SOURCES CITED:

(1)	Tyler, N.J.C., J.M. Turi, M.A. Sundset, K. Strøm Bull, M.N. Sara, E. Reinert, N. Oskal, C. Nellemann, J.J. McCarthy, S.D. Mathisesen, M.L. Martello, O.H. Magga, G.K. Hovelsrud, I. Hanssen-Bauer, N.I. Eira, I.M.G. Eira, and R.W. Corell. 2007. Sami reindeer pastoralism under climate change: Applying a generalized framework for vulnerability studies to a sub-arctic social–ecological system. *Global Environmental Change* 17:191–206.
(2)	Olofsson, J., L. Oksanen, T. Callaghan, P.E. Hulme, T. Oksanen, and O. Suominen. 2009. Herbivores inhibit climate-driven shrub expansion on the tundra. *Global Change Biology* 15: 2681–2693.
(3)	Scheffer, M., M. Hirota, M. Holmgren, E.H. van Nes, and F.S. Chapin. 2012. Thresholds for boreal biome transitions. *Proceedings of the National Academy of Sciences* 109(52): 21384–21389.

GLOSSARY OF TERMS IN THE TEMPLATE

Actor	We use this term generally to look for individuals, groups, organisations, and so on that structure actions and/ or are stakeholders.
Adaptive capacity	Is the capacity of actors in the system to manage resilience in order to stay within a desired state during periods of change. This is related to the diversity in the system behind the provision of a function.
Disturbance	This refers to any disturbance to the system, regardless of scale, duration, intensity and frequency. See shock and stress.
Driver	Actor or process that directly or indirectly affects change in a social-ecological system. External means that the system in question (the scale being looked at) is unable to affect the driver in question – there is no feedback from the system to the driver.
Ecosystem services	The goods and services humans derive from ecosystems. These include: provisioning, regulating, cultural ecosystem services respectively.
Feedbacks	A change within a system that occurs in response to a driver, and that loops back to control the system. A feedback can help to maintain stability in a system (negative or balancing feedback), or it can speed up processes and change within the system (positive or enhancing feedback). Feedback processes play a very important role in determining system thresholds and in maintaining system resilience.
Institution	Here we refer to the humanly devised constraints that shape human interactions, such as rules, norms and laws. These can be formal or informal. Note that we are not referring here to institutions as organisations.
Regime shift	For complex systems, a substantial and enduring reorganization of the system, where the internal dynamics and the extent of feedbacks undergo change.
Resilience	This is a property, in this context of social-ecological systems. It relates to the capacity of a system to cope with disturbances and recover in such a way that they maintain their core function and identity. It also relates to the capacity to learn from and adapt to changing conditions, and when necessary, transform.
Shock	A sudden, unexpected disturbance. This kind of disturbance is often punctual, and has important impacts on large parts of the system.
Slow variable	When analysing complex system is often useful separating “fast” and “slow” variables. Fast variables often represent the primary concern of ecosystem users, for instance game or crop production. Slow variables shape the behaviour of fast ones but change slowly with respect to the overall dynamics of the system. Examples of slow variables might include permafrost thawing for a social-ecological system of Arctic hunters where the fast variable is game, or soil organic matter for an agricultural system where the fast variable is crop production.
Stress	This is a disturbance that has long persistence and often low intensity in impact.
Social-ecological system	This is an interwoven system of human societies and ecosystems. This concept emphasises that humans are part of nature and that these components function in interdependent ways. In the template identifying these interactions between the components aims to identify the processes and actors/ components that interact and particularly the feedbacks between the human-related components and the ecosystems/ biophysical components.
Stakeholder	See “actor”
Systems Diagram	This is using a diagram to illustrate the configuration of a system. This is done by defining its structure, function, and feedbacks. For a case there may be more than one diagram if the system changes in character (actors, processes, drivers, disturbances, feedbacks etc.) over time.
Timeline	The goal with the timeline is to capture important events – both punctual and over longer periods of time, identifying the causes of these events and the actors/ processes involved. This should be done chronologically and distinguishing events.