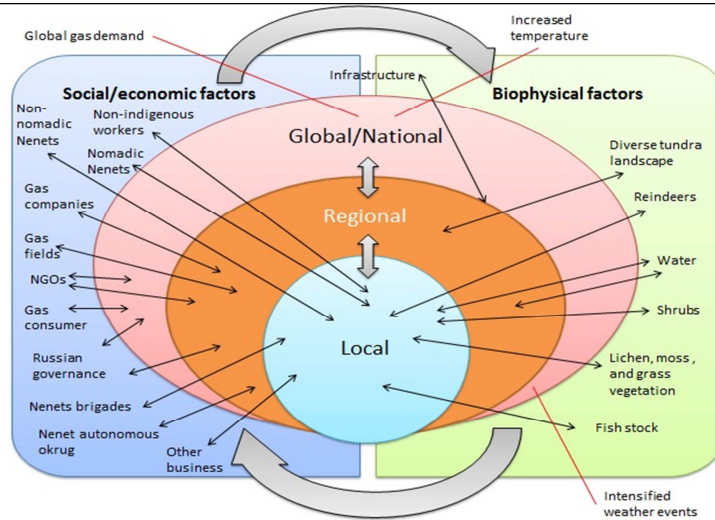


We welcome additions, clarifications and response on the information in the case. If you wish to make your response directly in the template clearly mark your additions in a Word document using “track changes” or highlight your additions in the template. If you provide a references or other details please make clear how this compliments the template.

Please send to Juan Rocha juan.rocha@stockholmresilience.su.se and ARR@sei-international.org.

Name of the case study	Reindeer herding in the Yamal Peninsula in Yamal-Nenets Autonomous Okrug (YNAO)	
Main Contributors	Students from the 2014 Resilience Thinking course at the Stockholm Resilience Centre (Stockholm University): Svetlana Avelova, Anna Degteva, Jonas Gren, Vivi Mellegard, Hanna Ahlström, Linda Lindström, Ashley Perl, and Philipp Siegel, Anna, Svetlana, Viveca Mellegård, Jonas Gren	Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.
Other Contributors	Svein Mathiesen; Miriam Huitric	
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. Additionally, herding in the Yamal Peninsula fared comparatively well to other herding cases in Siberia in terms of being able to maintain their traditional way of life. Currently the largest disturbance to herding is the increase amount of infrastructure related to gas exploration and transportation, to which Nenet herders have adapted.	

	Biophysical	Social
<p>1. Basic description of coupled social-ecological system in focus (What are the key components and stake holders)</p> <p>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.</p>	<p>a) What types of ecosystem(s) and other major biophysical features are present? Yamal Peninsula in western Siberia Tundra – pastures, wetlands Taiga – pastures, wetlands Water/ Ice crossings</p> <p>b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics? Tundra/ Taiga – climatic zone Movement through the boundaries varies annually and depends on: season, herd's welfare, weather conditions, grazing status, mosquito status,</p> <p>A system map of social and biophysical actors and components including the main global drivers of the YNAO's SES and how they are connected on a global/national, regional, and local scale (1)</p>	<p>c) Who are the key groups of people in this case? Nenets – The indigenous people living in the Yamal region, the Yamal Nenets Autonomous Okrug, can be either nomadic herding or non-nomadic. Nenets nomadic herders, around 5,000, have been reindeer herding for up to 2000 years in the southern part of the peninsula and at least 700 years in the Bovanenkovo area; (4) Reindeer herders and their organisations: The herding activities are structured in different enterprises, composed by several <i>brigades</i> which in turn consist of herding families. (4).</p> <p>Local indigenous NGOs: play an important role in promoting their organization's interest e.g. Nenets' rights (3).</p> <p>Local and regional governmental agencies</p> <p>Extractive industries – Recently immigrated workers – especially late 2000's – development of modern communities along the coastline – for extraction and communities (7).</p> <p>d) What kinds of livelihoods are important in the system? Most important ES for herders are provisional services, such as reindeer or fish, during winter and summer migration (5). Cultural services are provided by specific sites that serve rest or spirituality purposes. Reindeer herding. Livelihood is connected to</p>



traditional ecological knowledge (TEK) and local ecological knowledge (LEK) of herding practise and the land.

Gas production/ export – largely recently immigrated workers reliant on income for livelihoods. Dependent on land availability and environmental conditions (7)
 Gas production – main use of land for access and export of hydrocarbons
 Gas transport – pipeline
 Gas/ other goods transport – train
 Gas/ other goods transport – ports

e) What institutions are key to this case?

Nenet regulations: culture, language, TEK, sense of place contribute to institutions around organising herding;
Brigades constitute the local level of governance in the Yamal Nenets (3).

National regulations for:

- herder mobility,
- social organisation (school),
- veterinary regulations,
- land access and use regulations,
- recognition of Nenet rights

Russian authorities own the land, and along with *regional authorities*, have a strong interest in controlling the hydrocarbon resources as means to improve the national economy. Simultaneously, the government wants to preserve indigenous heritage and therefore subsidizes and treats the herding society as a

		<p>part of its agricultural sector (3). National authorities provide for instance subsidies to herding Nenets for slaughtered reindeer to regulate herd size (8).</p> <p>International human rights agreements and indigenous peoples legislation and agreements give the basis for the national legislation (9).</p> <p>f) How are the case’s boundaries socially defined, and how do these social boundaries relate to biophysical boundaries?</p> <p>The social boundaries are defined through the individual Nenets reindeer herding brigades. The social boundaries also extend to those groups who interact with the reindeer brigades (such as the hydrocarbon workers, government representatives, and NGO representatives).</p> <p>Nenet herders brigades travel from the south end of the peninsula in the winter in the taiga area, to the north end in tundra pastures in the summer months. Moving through grazing grounds and grounds for calving females and the males. 1,200 km. Notably, hydrocarbon development has impacted the brigade’s migration routes.</p>
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2. Timeline

Draw a timeline of *key* events/ developments to the case. Points to include:

Make clear the period of time over which the change is being considered.

Provide a brief description of event/ actors, and ecological impacts. Mark particularly significant events with *.

Consider both biophysical and social dimensions.

Additional points that can be considered:

Is it possible to identify periods of change from one type of system to another, transformations?

Identify disturbances or events that

Following 2 diagrams are by (1). An additional timeline is available on request prepared by (2).

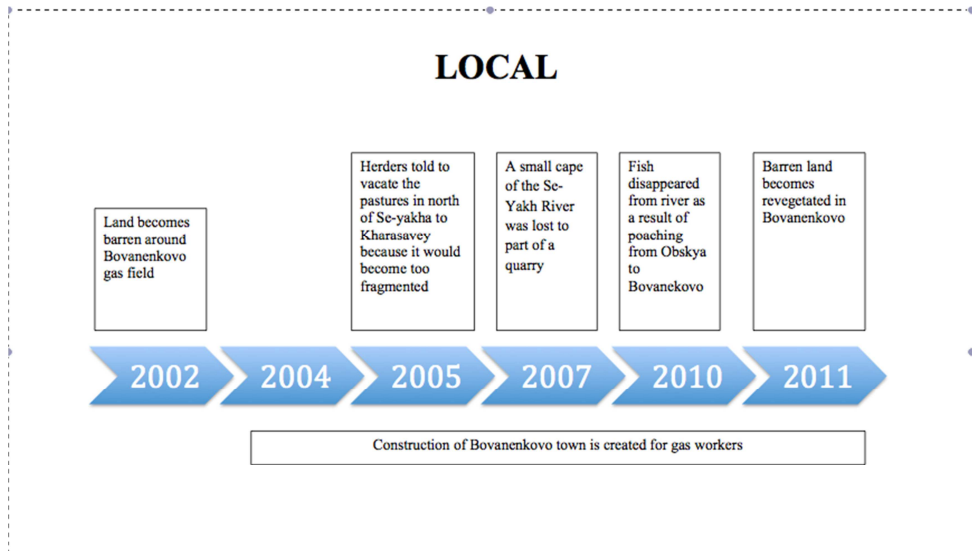


Figure 3a. Key events at a local level of the Yamal Nenets SES

Forbes et al. (2009); Kumpala et al. (2012)

challenged, built, or reduced resilience or adaptive capacity in the system.

REGIONAL

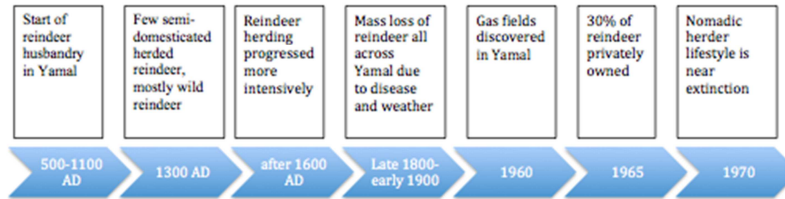
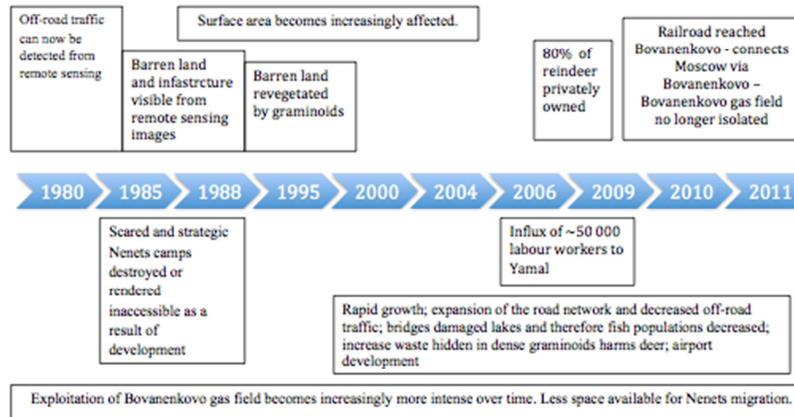


Figure 3b. Key events of the Nenets SES from 500-2011 AD

Forbes et al. (2009); Forbes (1999); Kumpala (2000); Kumpala et al. (2012)

REGIONAL



Forbes et al. (2009); Forbes (1999); Kumpala (2000); Kumpala et al. (2012)

NATIONAL/GLOBAL

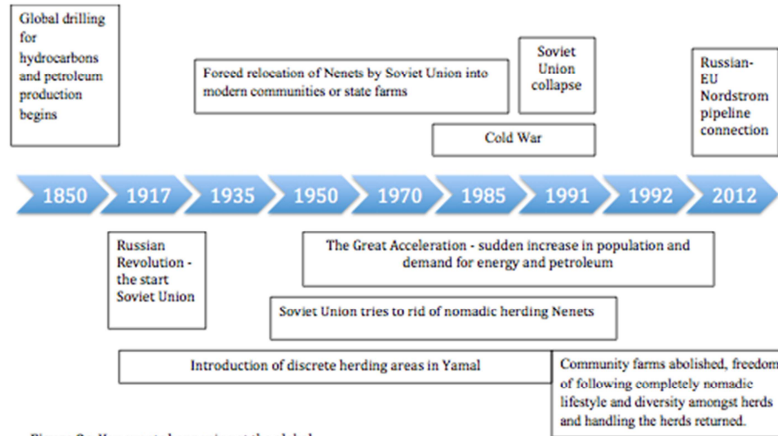


Figure 3c. Key events happening at the global level relevant to the Yamal Nenets SES

Kumpala et al. (2012); Forbes et al. (2009); Forbes (2013); Kumpala (2000)

900 – Reindeer husbandry on the Peninsula

1500 – Road to Ob’ River opens

*1922 – Formation of USSR

1930s –
 establishment of school in Yar-Sale
 Establishment of Yamal National Okrug
 Sedentarization

	<p>1939-45 – WW2</p> <p>1950 – Ob’Bay did not freeze – spent winter on autumn pastures Decree of central committee of farmers’ amalgamation</p> <p>1960s Sovkhozy – strict borders for the brigades From 1960s onwards – increased immigration onto peninsula. Until then mainly inhabited by Nenets</p> <p>1971 – Boanenkovo – gas field exploration 1973 – Law on 2dry education - 1974 – Port Kharasavey</p> <p>1980s – Fur trade collapses Kruzenshternskoe gas field exploration In the 1980s hydrocarbon exploration began in the YNAO, which contains the largest known gas deposits in the world (7). The development of infrastructure and industry has changed the land use and degraded pastures in some parts of the Yamal Peninsula (7). Change of migration routes in northern Yamal Dismiss (?) hunting brigades of Yarsalinsky – increase private herders??</p> <p>1985 - Conflict with gas company – brigadier commits suicide 1985 – Start railway by Transstroy 1987 - Perestroyka 1987 – reduced control of number of reindeer slaughtered *1989 – Gazprom company started Bovanenkovo gas field active 1989 – NGO Yamal to decedents</p> <p>1990s *1991 – USSR collapses 1990-98 economic crisis At the same time, climate change – began to be felt in the 1990s, is affecting tundra vegetation and producing unexpected climatic conditions that pose challenges to the Nenets’ migrations and a resulting loss of reindeer (7).</p>
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Comment [MH1]: Why?

Comment [MH2]: What does this mean?

	<p>1994 – first private gas company 1998 – regional laws on reindeer husbandry 1999, 2000, 2001 – Laws on indigenous peoples 1999 – ice event kills part of herds</p> <p>2000 – gas and oil prices increase – increased number of plants built, and railways 2002 – EU slaughter house 2006 – influx of labour begins 2006 – ice cover of pastures which blocks access 2007 – Northern Sea Route opened for first time 2010 – decrease herb size 2011 – early melt of Ob’Bay 2013 – suspected Brucellosis cases</p>	
<p>3. Disturbances What are the key disturbances in the system (present and past)</p>	<p>a) Have there been major biophysical disturbances that are relevant for the case?</p> <p>Snow/ ice cover events – unexpected and extreme events: permafrost thawing, rain-on-ice events</p> <p>Insect swarms – must find less infested grounds, reduce survival of young.</p> <p>Infrastructure-related events – loss of grounds/ routes – must change and increase routes to go around infrastructure and plants</p> <p>Reindeer – hoof disease caused by litter and waste hidden in shrubs from hydrocarbon industry. Reindeer step on litter, causing wounds and contributing to infections</p> <p>Reindeer – warble fly outbreaks – can be treated</p> <p>Industrial waste – damages reindeer hooves</p>	<p>b) Have there been major social disturbances that are relevant for the case?</p> <p>Restrictions to traditional family units – boarding school</p> <p>Loss of TEK – e.g. herd structures, migration patterns. Issues related to globalization and sedentarization of Nenets are seen as the largest threat to the survival of their traditional knowledge and lifestyle due to the foreign influence, increased modernization of the society (3; 6).</p> <p>After 1990s crisis – loss of income due to loss of subsidies; results in subsistence husbandry.</p> <p>Forced relocation of Nenets by Soviet Union from 1935-1985</p> <p>Development of the hydrocarbon industry starting in the 1980’s</p>

Comment [MH3]: Info on cause?

		<p>Herders forced to relocate from certain parts of the peninsula due to land fragmentation</p> <p>Russian-EU pipeline built in 2012</p>
<p>4. Drivers of change Clarify what impacts these drivers have on the SES and if these are direct or indirect</p>	<p>a) What are the key biophysical drivers of change?</p> <p>Reindeer herd – maintain the herd through calve production, in turn affected by disease, survival, attacks from worker’s dogs...</p> <p>Landcover changes: The vegetation available determines the land’s carrying capacity for reindeer (2013). Gone from: shrub to grass/ lichen/ moss cover – this is regulated by grazing rates of reindeer and clearing of land for infrastructure by gas companies (10; 5; 7). Shrub encroachment in the north (12).</p> <p>Fragmentation of landscape: Changes in vegetation cover – shrub encroachment, reduces grazing – due to increased temperatures and over grazing. Lichen cover – takes 15-20 yeas to re-establish, long time to recover from shrub cover. Loss of grazing lands – lost to infrastructure and plants for resource extraction. Loss of access to grazing lands – cut off by infrastructure and plants</p> <p>Climate change: Temperature changes: Arctic temperatures have increased an average of 2 °C with forecasts suggesting a 7 °C increase over 30 years.</p>	<p>b) What are the key social drivers of change?</p> <p>The main social shock – and subsequent drivers – that the Nenets experienced was the establishment of the USSR (14), which limited freedom or their traditional lifestyle.</p> <p>TEK not valued/ captured by science and non-indigenous managers – loss of activities and knowledge. Loss of TEK – e.g. herd structures, migration patterns. Issues related to globalization and sedentarization of Nenets are seen as the largest threat to the survival of their traditional knowledge and lifestyle due to the foreign influence, increased modernization of the society (3; 6).</p> <p>1990s – fall of the USSR increased ability to live by traditional lifestyle, while economic crisis meant fewer subsidies</p> <p>Demands on stable production of reindeer Subsidies were introduced to regulate herd size but appear to cause have the opposite effect because they are an incentive to keep a big herd and sell more reindeer (8). Ended in 1990s.</p> <p><i>Developers</i> to Yamal-Nenets SES influence soil formation, landscape fragmentation, and other environmental factors through creating infrastructure (7). Development contributes to a warming of the permafrost, which again encourages shrubs to establish (10).</p>

	<p>This has already resulted in longer growing seasons (12), and would impact the migration route and vegetation available to reindeer (3; 8).</p> <p>Warmer summers – Permafrost thawing; insect harassment increases, earlier break-up of ice in spring and later setting of the ice – reducing time to complete migrations. More frequent abrupt weather events; extremely high temperatures, sea level rise, new disease and pests (5; 7).</p> <p>Loss of fish due to poaching (and possibly), which is an important part of Nenets summer diet (1).</p>	<p>Global market for gas (7) The global market price for gas is the main indirect driver to historic and further exploitation on the Yamal peninsula (15). The higher the price gets due to increased consumer demand, the more profitable gas extraction becomes.</p> <p>Russia has a special interest Yamal’s hydrocarbon resources as means to secure energy for the whole nation until 2030 (16).</p> <p>Loss of access to /between grazing grounds. The Nenets are concerned about the progressive loss of pastures, campsites and sacred sites; and gas workers’ poaching of reindeer and fish (5, 7). Competition for higher terrain from Nenets and industry. For the former it offers good chum sites and shelter from heat and mosquitoes that stress their reindeer. For industry high terrain offers better drainage (4). The outcomes for Nenets of this competition could be: poor grazing and possible herd loss; stressed herds caused by loss of higher ground to escape mosquitoes; and change migration route leads to delay in getting to next grazing area (at higher scale this affects other brigades).</p> <p>Nenets – suffering lung disease</p> <p>New resource exploiters – increased since 1980s and even faster in 2000s – Increased immigrant population, industrial development, (3, 6).</p> <p>Misunderstandings among local communities of non-</p>
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Comment [MH4]: What are the causes?
How serious is this?

		<p>indigenous workers and Nenets is an issue in the region as field workers frequently disrespect and/ or do not understand the Nenets traditions (5; 7).</p>
<p>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)</p>	<p>a) Within the ecosystem?</p> <p>(+) Nenets know that smaller herds increase overall herd heterogeneity. Reduced herd sizes are more resilient because every herd has specific individual characteristics (6). Phenotypic variance amongst reindeer within herds increases resilience because diverse types of reindeers can cope differently with various environmental situations (9).</p> <p>(-) With respect to Nenets usage of YANO, land conversation has degraded the ecosystem that the Nenets rely on.</p> <p>(-) Climate change has reduced the ecosystem's adaptive capacity through creating extreme and unexpected weather events, and changing the season length (1, 2)</p>	<p>b) Within society (e.g. people, social capital, management, institutions, infrastructure):</p> <p>(+) The Nenets' understanding of natural processes and their environment is that everything underlies constant change. Every year is different and there are weather variations as well as human influence. Their mind-frame is highly resilient through their acceptance of change. The Nenets have established a wide array of <u>methods</u> to cope with disturbances which has allowed them to keep their lifestyle in the face of change (8; 6). They are adaptive and flexible when it comes to land changes.</p> <p>(+) At the landscape level, Nenets' knowledge at the micro scale about growth cycles of lichen enable them to travel to the best pastures at the right time of year to ensure the reindeer get the right minerals and nutrients for optimal health (4). This intimate knowledge of the landscape enables them to be flexible when there are obstacles such as physical barriers through land use change and industrialisation and when climate events. In spring 2005 Se-Yakha River thawed two weeks early and the Nenets speeded up the migration to get to cool pastures providing insect relief and nutritious meadows for growth of calves (6).</p> <p>(+) <u>Nenet</u> culture and way of life has survived despite enormous social, political and economic events, including collectivisation between 1928-1933, the collapse of the USSR and the subsequent economic crisis in the 1990s (4, 5)</p>

Comment [MH5]: More concrete examples

Comment [MH6]: What explains this?

		<p>(-) At higher scales the Yamal SES is constrained by governance and legislation about land rights. For example in 1961 the Sovkhozy was established with defined borders for each brigade's migration. The implications across scales is that external drivers such as land use change and pasture degradation due to industrialisation can force Nenets to use migration routes outside their specified territories. This might increase competition between brigades for good pastures. Sudden acceleration and expansion of BIC alongside industrial development at the regional scale would reduce the choices of migration routes available.</p> <p>(-) One of the key factors during the Soviet-era administration to remain resilient was that the government did not restrict private ownership of animals. The intrusion of the Soviet system made the other indigenous groups lose their adaptive capacity through confiscation of private property, and forcefully sedentarizing nomads (6).</p> <p>(+?)The Nenets were the only indigenous group in Siberia that was able to cope with this political change and not lose its autonomy. When the Soviet Union collapsed, Nenets were still self-sufficient because they had maintained private herd ownership (3).</p> <p>Adapting to new development:</p> <p>(+) Nenets have domesticated their reindeer to such an extent that they are able to cross gas installations, which would be considered impossible among the wilder Norwegian reindeer (3).</p>
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		<p>(+/0) There is some cooperation between Nenets and hydrocarbon workers. For instance, Nenets accept mobile phone communication to co-ordinate migration through (BIC), but refuse car transportation through BIC (4); However, it's hard to say if this is helping to degrading Nenets adaptive capacity when it comes to nomadism.</p> <p>(+?) <u>National legislation today allows the Nenets to remain resilient.</u></p>
<p>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.</p>		
II.1-8 SES, resilience and adaptive capacity		
	Biophysical	Social
II.1. Where do we find change and resilience in the face of change?	<p>a) Within nature Genetic diversity in herds – within and between.</p>	<p>b) Within society Reindeer herder NGOs</p> <p>Flexibility – open to and understand change (2)</p> <p>Mobility – resilient herders must migrate constantly (2)</p> <p>Independence – rely on herds for sustenance (food and clothes), and also self-autonomous (making decisions at the herd level) (2)</p>
II.2. What are the system's key components?	<p>a) Key Ecological components (e.g. lakes, coastal zones, caribou) Grazing lands – taiga tundra</p>	<p>b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.?</p>

Comment [MH7]: More details

	Reindeer Waterways	Sedentary Nenets Nomadic Nenet reindeer herders – organised in Brigades. Groups of families migrating together. Do communicate between brigades for migration. Gas extraction-related communities Organised in sector: gas production/extraction; transport: rail, pipeline or ship communities: eg shops, schools (?)...
II.3. What are the key linkages? E.g. ecosystem services, resource extraction. These linkages should exist. If there are not mutual links between social and ecological components the case is not a social-ecological system.	<p>a) From nature to society (e.g. ecosystem services) Dry, high grounds – desired for grazing and animal relief and for infrastructure.</p> <p>Grazing grounds for reindeer – move by season and for female and male grounds – need areas for grazing and shrubs for fuel wood.</p> <p>Provisioning ES – reindeer, salmon, fuel wood. Cultural ES – spiritual grounds, interaction between nature and society.</p> <p>Nenets culture is deeply rooted in the landscape (cultural ecosystem service) (1, 2).</p> <p>Hydrocarbon extraction from the landscape for societal use in Russia and Europe (1, 2)</p>	<p>b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution)</p> <p>Overexploitation of fish in waterways – poaching by hydrocarbon workers (1, 2)</p> <p>Pollution from development – damages reindeer hooves</p> <p>Fragmenting the landscape</p> <p>Overgrazing and shrubification</p>
II.4. What are key interactions?	<p>a) What are the key ecological interactions within the case? Grass/ shrubland Open/covered water ways</p>	<p>c) What collaborations, conflicts, or other key linkages exist between actors? Conflict Lack of feedback to the groups of actors associated with gas mining creates conflict between these and the Nenets.</p>

	<p>b) What are the most important biophysical tele-connections to distant systems? Reindeers moving through Yamal peninsula to just off the peninsula</p> <p>Climate change – increased hydrocarbon development will not only indirectly contribute to climate warming, but will also reduce Albedo (removing vegetation for development creates a warming effect on the Yamal peninsula) (1)</p>	<p>Both Nenets and industry want higher terrain because it is beneficial for reindeer or hydrocarbon extraction, respectively.</p> <p>Industry and infrastructure is fragmenting the landscape – reducing access to grounds needed and increasing migration routes. Not yet a conflict but could become.</p> <p>Immigrants do not understand or respect indigenous way of life.</p> <p>Immigrants over-fishing water ways</p> <p>Collaboration Plants stop transport and activity to allow herders and herds through. National government supports indigenous rights and way of life.</p> <p>d) Between local actors and distant actors? Governance and legislation about land rights. For example in 1961 the Sovkhozy was established with defined borders for each brigade’s migration. Sudden acceleration and expansion of BIC alongside industrial development at the regional scale would reduce the choices of migration routes available Global gas market influences gas companies on Yamal</p>
II.5. Culture	<p>a) How is the relationship between society and nature viewed? Seen as a holistic system</p> <p>b) What meanings are attributed to nature and to</p>	<p>c) What are key cultural features of relevance for the case? Nenets livelihood, way of life and cultural identity is inextricably linked to both their reindeer and the land on which they live and depend.</p>

	interactions with nature?	<p>d) What are key cultural practices and beliefs related to nature? Get meat from reindeer, create clothes from hides.</p> <p>Nomadic way of life relies on migration between summer and winter pastures.</p>
<p>II.6. Disturbance What are important types of stress & shock</p>	<p>a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc). Non-crossable ice Water on ice events Insect infestations</p>	<p>b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc) USSR – limited way of life, size of hers, ownership rights 1990s – subsidies removed 1980s to date – increased competition from extraction and transport of gas. Globalization Development of hydrocarbon industry Potential for governmental changes to influence the Yamal peninsula, and therefore the Nenets population</p>
<p>II.7. What are key slow variables Changes that occur over decadal or longer time scales</p>	<p>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? Reinforcing feedback – large shrubs cannot be grazed by reindeers → more shrubs → warmer soil ↑ nutrients → plant growth (5; 17)</p> <p>Large numbers of reindeers graze shrubs and grass and trample and add nutrients to the soil, so as to enforce the productive grass-dominated state (5,18).</p> <p>A key variable that could show nonlinear behaviour is the</p>	<p>b) What types of slow social processes (e.g. aging, population growth, loss of language) are driving important changes in social institutions and behaviours? Large herd size reinforces a nomadic way of life</p> <p>There are two stable regimes for the Nenets, one nomadic and one sedentary (5;7). There is a strong consensus among Nenets, scientists and Russian society that keeping the Nenets' nomadic lifestyle is the desirable state, since it is part of a long Arctic tradition, is an important source of knowledge about tundra life and forms a rich culture (3). It is not clear whether the shrub or the grass state is desirable.</p>

	<p>vegetation. It is not clear to what extent nor at what speed the observed shrub encroachment is taking place. In a scenario where the number of grazing reindeers decrease, it is possible that large areas of Yamal could shift to the stable shrub vegetation state.</p> <p>Fragmentation of the pastures could have nonlinear effects on RH in Yamal. High connectivity between the parts is important for the resilience of RH, since mobility between seasonal pastures underpins the function of the system through provision of grazing land, insect relief areas and resting places (4).</p> <p>Increased temperatures – warmer summers Faster thawing of permafrost and ice cover</p>	<p>Reindeer depend on a diversity of shrubs, moss, lichen, grass pastures (13). In a future case where most of the shrub land turned to grass, or vice versa, the resilience of nomadic herders would likely decrease.</p>
<p>II.8. Relationships with ecological regime shifts</p>	<p>a) Are ecological regime shifts driving further ecological change or pressure?</p> <p>b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)?</p>	<p>c) Can social stresses or major changes be attributed to ecological regime shifts? Development is contributing to land and vegetation change (1, 2)</p> <p>Development is also contributing directly to local warming and indirectly to climate change (1, 2)</p> <p>d) Are there specific social practices that might be contributing to ecological regime shifts? Development is changing the vegetation – land fragmentation has caused areas to become densely covered in shrubs</p>
<p>II.8 Regime</p>	<p>If a regime shift exists and is important to this case describe it below.</p>	

<p>shifts</p>	<p>Please indicate whether the regime dynamics are well-established, contested, or speculative.</p>	
<p>II.8.a. Detailed description of alternate regime shifts</p> <p>A case study can contain more than one type of regime shift</p>	<p>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)?</p> <p>Potential regime shifts is from steppe to tundra and tundra to shrub-dominated. Steppes are grass-dominated systems usually in drier environments which have higher primary production and nutrient cycling. Tundra are dominated by moss and have lower primary production and nutrient cycling.</p> <p>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)</p> <p>From the ecological perspective, a shift towards bushy vegetation 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 traditional livelihoods and therefore their culture.</p>	
<p>II.8.b. Feedback mechanisms within the system that maintain each regime</p>	<p>Ecological feedback mechanisms</p> <ul style="list-style-type: none"> - Grazing - Nutrient cycling feedback - Competition between vegetation types - Soil moisture - Shrub microbial activity - Albedo - Soil drainage - Shrub permafrost mechanism 	<p>Social feedback mechanisms</p> <ul style="list-style-type: none"> - Castration regulations (national) - Controlled prices (national) - Landscape reading according to current and previous years for pasture condition and accessibility; and snow/ ice cover - Migration feedback: determining when to move. - Market feedbacks: demand of meat is unclear - In the past subsidies were offered for production issues

<p>II.8.c. What key changes drive regime shifts?</p> <p>Describe how these changes alter the state of the system or feedback processes.</p>	<p>a) Drivers of ecological regime shifts (either social or ecological). Warming (slow variable) – affects: freezing and thawing events (fast variables) – changes land cover, access to grounds, Herbivory, herding, and grazing intensity; hunting; temperature increase; climate change; green house gas emissions.</p> <p>b) How do these changes alter biophysical feedback processes? Herbivory mediates the competition between grasslands and shrublands, while climate change increases temperature, extreme events, and precipitation regionally. Warmer temperatures promote shrub encroachment further north.</p>	<p>c) Drivers of social regime shifts (either social or ecological). Energy and infrastructure development, competing land uses.</p> <p>d) How do these changes alter the social feedback processes? The development sectors encroaches the area available for herding, in coastal Finnmark up to 35% or reduction has been reported.</p>
<p>II.8.d. Ecosystem services substantially impacted by regime shift</p>	<p>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 the Nenets culture to prosper and adapt to its environment could disappear.</p>	<p>b) Changes in demand for ecosystem services (market and non-market) Preferences about meat consumption is unclear at present. Increasing demand of energy, development of infrastructure.</p> <p>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.</p>
<p>II.8.e. What is (+/-) impacted by changes in ecosystem services directly or indirectly</p>	<p>a) Impacts from regime shift on ecological components (-) Shifts in land cover have potential impacts on the albedo feedback, climate regulation and carbon sequestration which</p>	<p>b) Impacts from regime shift on social actors (-) the shift will decrease the adaptive capacity of herders by further encroachment of their activities threatening their</p>

	reinforces itself and potentially other regime shifts in the Arctic.	livelihoods
II.8.f. Potential cascading effects	<p>Describe, if any, the likelihood of potential ecological cascading effects to other SES</p> <p>Speculative: Although it is uncertain the strength of the coupling, this regime shift can increase fresh water runoff to the sea, affecting sea-ice formation and when aggregated at the global level, to some extent the thermohaline circulation.</p>	<p>Describe, if any, the likelihood of potential social cascading effects to other SES</p>
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	<p>Ecological oriented interventions</p> <p>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.</p>	<p>Socially oriented interventions</p> <p>Government intervention that historically have affected the system includes the introduction of mandatory schooling. Ensuring that Nenets are able to pass down their TEK to younger generations would be one way to intervene with the social regime shift.</p>
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