



BIODIVERSITY AND LAND USE NARRATIVE SYNTHESIS

CHARTER Deliverable D6.1

Grant Agreement Number: 869471
Project Acronym: CHARTER
Project title: Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity
Starting Date: 01/08/2020
Project Duration: 48 months
Project Officer: Alberto Zocchi
Project Coordinator: Bruce Forbes / LAY
Author: Jussi Eronen and Sirpa Rasmus / UH and LAY
Contributing partners: NINA, UEF, UiT, UmU, UTU, WSL, UHAM, AWI, UEDIN

Co-financed by the Connecting Europe Facility of the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

CHARTER Biodiversity and land use narrative synthesis

Version 1.0

CHARTER Deliverable 6.1

Grant Agreement Number: 869471
Project Acronym: CHARTER
Project title: Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity
Starting Date: 01/08/2020
Project Duration: 48 months
Project Officer: Alberto Zocchi
Project Coordinator: Bruce Forbes / LAY
Author(s): Jussi Eronen and Sirpa Rasmus / UH and LAY and the WP6 team (see contributions in section 5)
Due Submission Date: 31/03/2022 (postponed after discussions with CHARTER PO, original submission date was 31.7.2021)
Actual Submission Date: 31/03/2022

Status	
Draft	
Final	x

Type		
R	Document, report	x
DEM	Demonstrator, pilot, prototype	
DEC	Websites, patent fillings, videos, etc.	
OTHER		

Dissemination level		
PU	Public	x
CO	Confidential, only for members of the consortium (incl. the Commission services)	

CHARTER

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Revision history

Date	Lead author(s)	Comments
15.2.2022	WP6 team	Review summaries by contributors
21.3.2022	WP6 team	1st draft version
25.3.2022	Jussi Eronen and Sirpa Rasmus	2nd draft version, circulated for comments within the WP6 team
31.03.2022	Jussi Eronen and Sirpa Rasmus	Final version 1.0, submitted

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

1. Introduction

CHARTER WP6 concentrates on building pathway narratives and developing policy options to offer understandable and relatable information for stakeholders and decisionmakers. WP6 aims at participatory stakeholder dialogue to identify current and co-produce new knowledge and identify best practices to design a set of land-use and biodiversity policy options. These should support the development of an Arctic strategy in general and climate adaptation and mitigation in particular.

The pathway narratives are based on an extensive literature review, empirical data and findings from WP3 and WP5, and stakeholder dialogue to engage with local and indigenous knowledge and views of experts. The design of the pathway narratives and policy options is informed by the findings produced in WP3, WP5 and stakeholder interactions: Findings from WP3 (Socio-economic impacts of Arctic changes on indigenous populations and local communities) and WP5 (Building a full-system view of the physical and socio-ecological drivers) will offer crucial qualitative and quantitative input for WP6 activities, and therefore WPs 3,5 and 6 will coordinate their actions closely.

In the CHARTER DoA, this deliverable was expected to consist of several sub-tasks and documents. These include:

• Extensive literature review and analysis of biodiversity and land use based on scientific publications and grey literature.
• Publications: 1) White Paper on biodiversity and land use narrative synthesis based on the scientific and 2) grey literature review and Research Paper on the biodiversity and land use narrative synthesis.

The white paper on biodiversity and land-use narratives concentrated mainly on the Finnish and Scandinavian region and was published in autumn 2020 as the first CHARTER Working Paper (Available at: bit.ly/3mQiiCB); it collected together knowledge and views for policy makers, developing the climate and environment related legislation.

The grey literature review is summarized in the following sections of this report. A research paper based on the material and analysis described in this deliverable is being finalized and will be submitted to a peer-reviewed journal in spring/summer 2022.

Due to the COVID-19 pandemic the work for this deliverable proceeded slower than originally envisioned, and the delivery date was postponed to March 2022 in agreement with the European Commission.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Narrative synthesis forms the starting point from which the rest of the WP activities stem from. We have compiled a broad set of published scientific literature, as well as policy documents (from circumpolar/Arctic level to sub-national level, from the CHARTER study region) to form a narrative synthesis of land use and biodiversity that includes land-use practices, their effects on biodiversity, and landscape change. As we have been in close contact with WP1 and WP2 where reviews concentrating on nearly same themes are under way, we have dropped the overlapping themes. In WP6 we concentrate on the land-use-biodiversity-climate change nexus. In the following sections we detail the material and methods used to analyse the available literature, followed by summary of the main findings. The last section of the deliverable provides an overview on individual contributions by the CHARTER team and collaboration partners. Here, below, we first summarise the existing knowledge that we base our further sections on.

1.1 Observed changes in the natural environment and societal context

Observed Arctic biodiversity transitions result from include changes in phenology (timing of leaf emergence, flowering/senescence of plants), growth and resulting changes in vegetation composition, and traits of affected vegetation types (e.g. plant height or leaf and stem characteristics), all of which contribute to the overall functional diversity of ecosystems (Elmendorf et al. 2012; Pearson et al. 2013; Bjorkman et al. 2018). It is this functional diversity that links species traits to the key ecosystem functions, such as carbon storage in Arctic ecosystems (Myers-Smith et al. 2018) and determines interactions between trophic levels. Arctic terrestrial ecosystems have low plant and animal species richness, but in a warming climate, boreal and temperate species are projected to expand their ranges northward, thus potentially increasing overall diversity, at the expense of endemic Arctic species (Normand et al. 2013). Simultaneously, changing cryosphere conditions – including snow season duration, winter rain-on-snow (ROS) events, and permafrost thaw – may affect biodiversity in multiple ways (Niittynen et al. 2018).

The circumpolar Arctic plays a significant role in regulating future global climate. Higher temperatures, melting sea and land ice, together with thawing permafrost are transforming marine and terrestrial ecosystems in the Arctic, faster than elsewhere on the planet. Bare ground is becoming vegetated and plants grow faster and taller than they did a generation ago (Macias-Fauria et al. 2012; Miller & Smith 2012; Bjorkman et al. 2019). In West Siberia and Northern Fennoscandia, indigenous Sámi and Nenets reindeer herders have, respectively, reported in situ changes in height and/or encroachment of woody plants (e.g. Salix and Alnus shrubs, mountain birch saplings) that have led to alterations in their grazing regimes (Forbes & Stammler 2009; Macias-Fauria et al. 2012; Horstkotte et al. 2017). An important consequence result is that surface albedo and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

radiation balance are changing, especially in winter and spring, as snow in tundra areas has far higher albedo than in areas with woody plants protruding above the snow surface (Cohen et al. 2013). Such shifts in Holarctic vegetation cover feed back into at least local (Cohen et al. 2013) and regional Arctic climate change (Loranty et al. 2011; Loranty & Goetz 2012). Thus, changes in vegetation have the capacity to increase tundra soil temperatures and affect permafrost dynamics (Myers-Smith et al. 2011, 2018).

Arctic landscapes and social-ecological systems (SES) are considered highly susceptible to disturbances and consequences of land uses, owing to slow rates of biological processes and natural regeneration of vegetation and frozen soils, as well as the speed of environmental (and socioeconomic) change which may exceed the adaptive capacity of the SES. Resilience of Arctic areas to the intensifying human demands on natural resources in the future is expected to be undermined especially by rapid climate change, which is likely to change the ability of Arctic SES to respond and tolerate additional pressures of land-uses and natural resource utilization. Arctic biodiversity and some traditional land uses can help to mitigate consequences of climate warming such as shrubification and reduced wintertime albedo in the tundra. However, Arctic biodiversity and traditional land uses dependent on local ecosystem services are simultaneously under increasing threat by the effects of warming, extreme weather events, landscape fragmentation and conflicting land uses. Careful management of multiple stressors and conflicting interests as well as co-consideration of multiple spatial scales and governance mechanisms are necessary for a sustainable Arctic strategy (cf. Keskitalo et al. 2016). Joint strategies and scenario development across political borders, and multiple levels of governance, steps towards considering areas in which biodiversity, priority conservation needs and traditional land-uses operate (Nilssen et al. 2019).

Rich natural resources make the Arctic attractive for economic development and can turn some challenges caused by climate change into opportunities - for some. Traditional Arctic land use in the Arctic consists of hunting, fishing, gathering, small-scale forestry, trading and herding activities, all of which remain important components of Arctic northern culture and tradition (Meredith et al. 2019). However, climate change and globalization have together increased interest in the large-scale exploitation of Arctic natural resources (Forbes et al. 2016). Petroleum and minerals are extracted in large areas of the Arctic. These and other forms of surface disturbance, combined with warming increasing air temperatures, lead to thawing warming and degradation of permafrost soils (Hjort et al. 2018; Loranty et a. 2018). In addition, boreal forests bordering the Arctic are important sources of wood and timber and peatlands provide biomass for energy production. Due to climate change, mitigation-driven energy transformation has increased demand for renewable energy such as wind, hydro power and bioenergy. Traditional forms of land use such as reindeer management, but also outdoor recreation and nature-based tourism activities that are dependent on ecosystem services, are threatened due to fragmentation. All this industrial development demand

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

increasinges the built area, such as road and rail infrastructure for transportation, settlements for employees and infrastructure for power transmission lines (Forbes et al. 2015; Povoroznyuk et al. submitted). Although the economic development brings opportunities to some, the distribution of risks and costs of these long-term developments is not necessarily equal among Arctic peoples and residents/stakeholders (Forbes et al. 2015). National and regional goals and benefits of these developments are not necessarily in line with the local ones. Activities requiring large land areas, such as forestry and agriculture, inevitably take land from conservation and serve to fragment otherwise largely intact ecosystems, with negative effects on biodiversity and other ecosystem services (Pääkkö et al. 2019). Difficult policy tradeoffs between climate, energy, land use and conservation policies must be carefully considered to ensure sustainable and equitable development of the Arctic (Forbes et al. 2015). Holistic knowledge on the long-term consequences of Arctic industrial development is needed, to elaborate risks and benefits across scales.

In the following sections we review recent synthesis reports and international, EU and national level policy documents relevant for biodiversity conservation in a changing climate in the European Arctic. We focus on how the climate, land use, and biodiversity perspectives are considered in the material, and emphasize the impacts on, recognition of knowledge of, and co-management with, local communities and livelihoods.

2 Material and methods

Using the collective expert knowledge of the group, we first mapped out the existing literature relevant to our research questions. Then we followed by researching the existing public reports from the governments and different stakeholders. Unlike many other reviews done in CHARTER, we did not conduct full quantitative search or meta-mapping based on Scopus or Web of Knowledge. The reason for this was that the CHARTER WP2 and 4 reviews are already doing this, and information gathered in these are being used as background data for this task. After reading the already existing land-use and biodiversity summary reports and articles, our remaining task in this deliverable was to concentrate on the policy-aspect and the possible implications of poor consideration of linkages between certain relevant themes would have.

Our study is based on a corpus of policy and scientific documents, concentrating on European Arctic. To examine the land-use and biodiversity pressures, we reviewed central synthesis reports, policy documents, and industrial/sectoral strategies that we identified. Material consists of 80 documents published during the past 10 years (until 2021). We analyzed 15 Arctic/International level documents, 13 EU-level documents, 9 documents from Nordic, Barents or Sápmi region, 28 national level documents (7 from

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Finland, 8 from Norway, 7 from Russia, 6 from Sweden) and finally 15 sub-national level documents. See the reference list for details.

We assume that whereas policy documents in general guide the work of practitioners, the implementation of policies is not straightforward but potentially frictional as local modes of knowledge and experts' hands-on skills and practices do not match seamlessly with the policies. As a research method we employed qualitative content analysis. The analysis was conducted in interconnected phases: We first did a mapping and scanning of the policy documents and reports, and then developed a coding system of different levels. We then coded the data and our findings by employing the classification of levels and themes. During the analysis, quotations pertaining to each theme were also compiled. To verify the coding process, four of the authors performed the coding analysis work together (Rasmus, Yletyinen, Eronen, Sun). This stage of analysis helped us to identify whether, and how, the co-occurrence of multiple drivers and their interactions are discussed in the reports. In the following section, the results are presented by answering these questions:

1) How are the following aspects considered in relation to each other: **climate** (change/ mitigation/ impact/ feedbacks) and **biodiversity** (change/ conservation/ impact/ feedbacks) considered in relation to each other?

2) How are the following aspects considered in relation to each other: **climate** (change/ mitigation/ impact/ feedbacks) and **land-use** (change/ governance/ impact/ feedbacks) considered in relation to each other?

3) How are the following aspects considered in relation to each other: **climate** (change/ mitigation/ impact/ feedbacks) and **local communities** (needs/ adaptation/ supporting policies/ participation/ utilizing local knowledge) considered in relation to each other?

4) How are the following aspects considered in relation to each other: **biodiversity** (change/ conservation/ impact/ feedbacks) and **land-use** (change/ governance/ impact/ feedbacks) considered in relation to each other?

5) How are the following aspects considered in relation to each other: **biodiversity** (change/ conservation/ impact/ feedbacks) and **local communities** (needs/ adaptation/ supporting policies/ participation/ utilizing local knowledge) considered in relation to each other?

6) How are the following aspects considered in relation to each other: **land-use** (change/ governance/ impact/ feedbacks) and **local communities** (needs/ adaptation/ supporting policies/ participation/ utilizing local knowledge) considered in relation to each other?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

3 Results – biodiversity and land-use narratives

3.1. How are climate and biodiversity considered in relation to each other?

Climate and biodiversity are often considered together in the **international/Arctic-level** assessment reports. Sometimes it is expressed simply as a key finding: climate change as the most serious threat to Arctic biodiversity, at the same time exacerbating the impact of other drivers (CAFF 2013; IPBES 2019; Aronsson et al. 2021).

AMAP (2017) lists more details. Winter thaws and rain-on-snow events can damage vegetation, and affects grazing conditions of animals such as caribou, reindeer, and musk ox. Food webs are affected by changes in the structure of ecological communities and shifts in the geographic ranges of species. There are increases in wildfires and insect pest outbreaks. Changes in Arctic vegetation can cause ecosystem-climate feedbacks that exacerbate climate change. (AMAP 2021)

Climate change is a serious threat to Arctic wetland ecosystems and biodiversity for example through greater fire occurrences and shifts in hydrological flows (CAFF 2021). IPCC (2019) discusses shifts of climate zones and consequent changes in species ranges, abundances, and seasonal activities. There may be vegetation greening due to extended growing season and browning as a result of water stress are also mentioned by IPCC (Meredith et al. 2019).

Climate change as a threat for biodiversity change is also considered in the document considering Arctic Indigenous Peoples food systems (Arctic Council 2019), economy of the north (Arctic Council 2021a), and in Artic Council strategic documents (Arctic Council 2021b).

Similar linkages between climate and biodiversity are presented in the **EU-level** assessment reports. Climate change is seen as the most far-reaching and significant stressor on Arctic biodiversity. It is estimated that 14 % of habitats and 13 % of species of European interest are under pressure because of climate change. Arctic vegetation zones are likely to shift further, and some species of importance to Arctic people declining. Mountain ecosystems are particularly vulnerable. (EEA 2017) Climate change is expected to trigger increased frequencies and intensities of natural disturbances in forests (EEA 2020). Some northern mire habitats are threatened (EC 2016).

In the EU-level policy documents, climate change and change in biodiversity are often seen as interdependent, "two sided of the same coin" (EC 2021a, von der Leyen 2019). EC (2018) sees healthy ecosystems – which depend on biodiversity – contributing to the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

adaptation and mitigation of climate change through "negative emissions" and carbon sinks. EU Adaptation Strategy (EC 2021c) reminds that climate change is amplifying stresses on ecosystems, and that the EU has endorsed the 2020 Leaders' Pledge for Nature, to tackle jointly the climate and biodiversity crises. Climate linked to biodiversity is an essential topic in the EU Biodiversity strategy (EC 2021d); it sees the biodiversity crisis and the climate crisis as intrinsically linked – and solutions as well. For example, sustainable usage of land and resources for the development of renewable and low-carbon fuels can help with climate mitigation and the protection of biodiversity. (EC 2020a)

EU Farm to Fork strategy (EC 2020c) notices that climate change brings new threats to plant health. EU Forest strategy (EC 2013) lists several "hidden vulnerabilities" which climate change has brought to light: pests, pollution and diseases, forest fire regimes, and extreme weather events. The use of whole trees for energy production should be minimized and all primary and old growth forests be strictly protected (these cover 3% of EU forested land).

Barents region assessment report discusses how climate change affects biodiversity and ecosystem processes, and details how biodiversity contributes to ecosystem resilience to climate change. Interactions between species and biome shifts are discussed (AMAP 2017)

In the **Sápmi** region documents restricted availability of pastures, changes in vegetation and changed conditions for parasites and insect vectors, all caused by climate change, are mentioned (Johnsen et al. 2017), and concerns raised about how to grow or sustain lichen in a growing climate, and how climate change will impact different predators, as well as prey-predator dietary switches. (Saami Council 2019).

In the **Nordic** documents, climate change and biodiversity are not considered together.

Climate change is seen as a driver for biodiversity change in most of the **national level** assessment reports. In Finland, impacts on fell habitats (for example conifer timberline climbing higher, snow patches shrinking, more prevalent frost damage and new pest insects) and mire habitats (and vegetation) are listed (Red List of Habitats Finland 2018) Red List of Habitats Norway (Artsdatabanken 2018) lists 35 habitat types that are threatened by climate change. Changes in snow conditions and extreme events are mentioned causing great effects on plants and animals in the mountain ecosystems (Jakobsson & Pedersen 2020). Sveriges naturtyper (2020) quantifies climate change as a threat in ca. 5 % of reported threats for habitats, and 10 % for species Reindeer lichens have an inadequate conservation status with a negative trend in alpine and boreal habitats. 19 of 34 in boreal forests are mentioned to have critical conservation status. Biodiversity assessment Russia (2015) lists changes in snow and ice regimes, permafrost thaw and cryogenic erosion, movement of species northwards.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

In national Arctic strategies climate change is see as a great threat to biodiversity (Arctic Strategy Finland 2021; Arctic Strategy Sweden 2020, Russian Arctic Strategy 2020). Arctic Policy Norway (Norwegian Ministries 2021) mentions specifically species and ecosystems that are dependent on ice and snow, and processes like melting snow and glaciers, permafrost thawing, changing precipitation patterns, more frequent wildfires

This issue is mentioned in many national level sectoral/industrial strategies, but shortly, with limited number of solutions offered (MCE 2015; Russian Strategy for Conservation to 2030; MPE 2020) For many documents, this is out of the aim and scope. MPE (2019) mentions mitigation measures such as correct handling of vegetation from mires to reduce carbon loss, and Wind power Sweden (2020) states that "global warming poses a huge threat to biodiversity while wind power is one of the most effective ways to prevent it." MAF (2016b) refers frequently to the importance of preserving environmental values of forests as well as pointing out the climate gain of more forestry activity. Climate change is seen as affecting reindeer's condition and risk of losing their calf, and the risk of infectious diseases. (MAF 2016a).

Many of the **sub-national level** assessment reports and strategy documents do not discuss climate change and biodiversity together. Some of them do not consider climate change at all. Red book of Nenets Autonomous Okrug (2020) mentions climate change as a problem for snow owls, through the lemming cycle fading out. In the Strategy for Socio-economic Development in Yamalo-Nenets Okrug to 2035 climate change is mentioned as a risk of extinction of some species, affecting negatively the Arctic biodiversity, degrading the arctic flora, influx of new species bringing new diseases.

Storslagen fjällmiljö (2019) states as a goal habitats and associated species having a good conservation status. Concern is that particular ecosystem services of mountains might disappear in warming climate, and that continuous open mountain landscapes and its biodiversity, including palsa mires are threatened. Traditional forms of land use are acknowledged to prevent shrubification. Also several other sub-national documents mention climate change as a threat to biodiversity (Metsähallitus 2013, Saamelaiskäräjät 2020, Lapin liitto 2021).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

3.2. How are climate and land-use considered in relation to each other?

Joint consideration of climate and land-use is not very thorough in many of the **international/Arctic-level** assessment reports. Communities and infrastructure built on frozen soils are noticed to be significantly affected by thawing permafrost, and Arctic winter road transportation and electrical power systems affected by rain-on-snow events (AMAP 2017; Meredith et al. 2019; AMAP 2021). There are risks connected with damage to infrastructure due to adverse climate change impacts (ACAP 2021a). Direct and indirect drivers of change have accelerated during the past 50 years (IPBES 2019). CAFF (2013) warns that in warmer climate there is a threat of increased pressure (exploitation) in Arctic.

Climate and land use are considered in relation to each other throughout the whole IPCC report "Climate Change and Land" (2019) Report highlights how climate change affects land use and land cover and oppositely how land cover and land use contribute to climate change. Land can be both a source and a sink of GHGs. Climate change exacerbates land degradation, permafrost areas given as one example. Climate change -ecosystem feedbacks are explained: for example, in boreal regions where the tree-line migrates northward and/or the growing season lengthens, winter warming will be enhanced due to decreased snow cover and albedo while warming will be reduced during the growing season because of increased evapotranspiration.

Role of Arctic region is seen as potentially significant in production of low carbon energy through hydrogen production with CCS (Arctic Council 2021a). Also, Arctic Council Strategic Plan (2021b) mentions promoting clean energy solutions and technology.

In the **EU-level** assessment reports, climate and land-use are often considered together. EEA (2017) mentions that climate change exacerbates the impact of other human stressors; transitions needed in the energy and food systems are linked to land-use. For example, in northern Europe hydroelectricity and wind electricity are estimated to increase. Land-use (agriculture and deforestation) is important contributor to global climate change, and on the other hand, climate change affects the agricultural land management and agricultural production (EEA 2020).

In the EU level policy documents, climate change and land-use get often linked through low carbon energy solutions. EC (2018) states that sustainable bioeconomy has large potential to reduce greenhouse gases emissions, for example by enhancing the capacity of ecosystems to regulate climate. EU Climate Target Plan (EC 2021b) mention the need to grow the carbon sink and the significance of the land-use sector in the transition to a climate-neutral economy. According to von der Leyen (2019), "climate change, biodiversity, food security, deforestation and land degradation go together".

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

EU (2021) mention ways to address the climate change related challenges: for example "pushing for oil, coal and gas to stay in the ground", meaning not allowing any further hydrocarbon reserve development in the Arctic. It is noted that the Arctic has a huge potential for renewables (geothermal, wind, green hydrogen and hydroenergy) and Arctic States are potentially significant suppliers of raw materials. According to this document, EU will promote best practices for mining, waste management and accident response.

Nature-based solutions are seen as essential in the EU Adaptation Strategy (EC 2021c), and their role should be bigger in land-use management and infrastructure planning to provide climate-resilient services. For example, protecting and restoring wetlands and peatlands, and promoting and sustainably managing forests and farmland will help adapt to climate change in a cost-effective way. Sustainable management of forests, grasslands and soils are seen as essential for emission reduction and climate adaptation in EU Biodiversity strategy (EC 2021d). EU Farm to Fork strategy (EC 2020c) acknowledges that agriculture is responsible for approximately 10 % of the EU's GHG emissions; nearly 70% of this come from the animal sector.

Barents region assessment report considers climate and land-use together, discussing how different land uses contribute to climate change adaptation, and that climate change alters demand for some land use regions (e.g. grazing). Further, climate change can lead to changes in the availability of resources (AMAP 2017).

In **Sápmi region** strategic papers it is recognized that climate change is also about what we are going to eat in the future; part of food security for reindeer herding peoples is their equitable access to and possibility to select their own resource (WRH 2017).

In the strategy papers concentrating on **Nordic region** the linkage is vague. But solutions are proposed, like potential of urban regions in climate mitigation (Nordregio 2021a), or climate budget as a governance tool (Nordregio 2021b). Transformation to bioeconomy or circular economy and Nordic collaboration are seen as possible solutions in solving the "shared challenges posed by climate change and growing urban-rural divides" (Nordregio secretariat 2021; Nordregio 2021c).

National level documents discuss the linkages between climate and land-use from various perspectives.

In the national level assessment reports, it is stated that human activities (land use) and climate change have cumulative effects (Biodiversity assessment Russia 2015). Interaction between climate change and grazing is affecting the fell habitats (Red List of Habitats Finland 2018), and habitat types become threatened due to intensive forestry and climate change; below the tree line, land use change seen as the largest threat (Artsdatabanken 2018). Jakobsson & Pedersen (2020) mention that less grazing and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

small-scale farming has had a larger effect than climate change on the relocation of the forest line towards higher altitudes.

Pressure on the environment is understood to come from human activity in combination with climate change in the Arctic Policy Norway (Norwegian Ministries 2021). Russian Arctic Strategy (2020) considers climate change as one of the main challenges for the development of the Arctic, and that land-use needs to adapt to climate change. Arctic Strategy Sweden (2020) and Finland (2021) consider these topics together from the "green transition" point of view: northern Sweden can contribute to "the extraction of several metals and minerals for new environmental and technological innovations" to reduce carbon emissions in energy production. Also, hydro and wind energy are mentioned.

National level sectoral/industrial strategies consider these topics from practical point of view. Finland aims at carbon neutrality by 2035. The electrification of society requires more renewable electricity production. Aim is to further increase the share of wind power in the energy production. (Prime Minister's Office Finland 2021). According to the Wind power Sweden (2020), doubling of wind power can reduce emissions corresponding to almost a quarter of Sweden's emissions. Wind power is seen as an important contributor also in Norway, but it is noted that large continuous natural areas are important for recreation, species, habitat types and nature´s own way of climate mitigation, and these areas could be negatively impacted by wind power (MPE 2019).

Increased consumption of biomass and increased use of wood-based fuels are mentioned as contributors in climate mitigation (AFRY 2020b, Bioenergy 2020). In a low-emission scenario presented in AFRY (2020a), bioenergy substitutes the fossil fuels, and part of fossil oils by bio-oils, and electrification decreases the use of natural gas.

The level of practicality varies in the strategy documents. For example in the Sweden's forest program (2018) it is seen that forestry contributes to "bio-based economy"; and that forestry shall contribute to "climate benefits" and production can be increased with little or no negative effects on the environment, without specifying how. Russian State Policy on Forests to 2030 mentions climate change explicitly only once, in relation to using forests to slow down the climate change.

Finnish Forest Industries (2020) states that increase of forest resources while they are increasingly used requires state steering towards correctly timed forest management actions. Forest area decrease due to land-use changes needs to be stopped and forestation increased. Fast-growing trees could be grown on fields, or on old peat production areas. The use of biomass with carbon capture and storage discussed as one tool to reach the Paris climate mitigation targets (Bioenergy 2020). Increasing forest areas, by planting trees and reducing deforestation can give positive cost-effective climate effects (MAF

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

2016b), as well as restoration of wetlands that do not have productive forests, to reduce carbon emissions, and probation of new drainage of mires for forestry.

MCE (2015) note that the impacts of climate change on biodiversity will accelerate, and it is important to limit other negative environmental impacts, such as harvesting of threatened species. MPE (2020) emphasizes developing renewable energy production and notes that a shift towards more electrification and low-emission society increases the demand for minerals. According to the LULUCF (Land use, land use change and forestry) treaty, these sectors shall not contribute to "reduced carbon sequestration or increased emissions" (Sveriges energi- och klimatplan 2019).

Many of the **sub-national** level assessment reports and strategy documents do not discuss climate change and land-use together. Some of them do not consider climate change at all.

Unstable or changing climate and economic development / technological disturbance are mentioned as main drivers of change of the vulnerable arctic nature in the Red book of Nenets Autonomous Okrug (2020) and in the Strategy for Socio-economic Development in Nenets Okrug to 2030. Strategy for Socio-economic Development in Yamalo-Nenets Okrug to 2035 notes that climate change creates risks on engineering systems, buildings and infrastructure elements. It may reduce the duration of the "winter roads", which reduces the territorial connectivity.

Storslagen fjällmiljö (2019) mentions the unknown consequences of increased "demand of bioenergy and increased use of forest resources". Likewise, fluctuating metal prices are mentioned as an unknown that could affect "a new boom for the interest in mining in the mountains with increasing conflicts". Also, Lapin liitto (2021) mentions needs for renewable energy, and climate-friendly local food production. According to Saamelaiskäräjät (2020) the land use governance does not consider climate change mitigation adequately.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

3.3. How are climate and local communities considered in relation to each other?

International/Arctic-level assessment reports discuss various climate change related risks and hazards to local communities: ice, snow and permafrost changes restrict access to remote communities, make it harder to obtain wild sources of food, may lead to contamination of freshwater resources, and make traditional food preservation techniques risky (AMAP 2017). On the other hand, increases in precipitation could make the Arctic a potential future source of freshwater and hydropower and climate change may facilitate access to oil, minerals, and other resources. IPCC (Meredith et al. 2019) mentions also positive feedbacks to harvesting which changing ice conditions and raising water temperatures may have, but on the other hand, mental and emotional health issues related to changes in climate. Extreme events, such as floods, landslides, snowfall, rainstorms and wildfires, are risk to local communities (AMAP 2021).

IPBES (2019) reminds that at least a quarter of the global land area is traditionally owned, managed, used or occupied by indigenous peoples and nature here is generally declining less rapidly than in other lands, but is nevertheless declining, as is the knowledge of how to manage it. IPCC (2019) states that climate change adaptation is dependent on involvement of local stakeholders, and the use of local knowledge is mentioned as important for climate change mitigation.

In the Arctic Council documents these linkages are not thoroughly discussed, but climate change is seen as a threat to indigenous and local communities (Arctic Council 2019) and traditional knowledge of local/indigenous communities are seen as important in climate change adaptation. In Artic Council strategic planning, "work to enhance adaptation and resilience of Arctic communities as the Arctic region warms" is mentioned as one strategic action. According to Arctic Council (2021a), other changes and turbulence still overshadow the climate effects in economies in a macro level.

Climate and local communities are often considered together in the **EU-level** assessment reports. EEA (2017; 2020) considers risks, damages, economic costs and health hazards related to warming and more frequent extreme climate events, especially experienced by, but also potential opportunities in northern Europe, including "increased crop variety and yields, enhanced forest growth, higher potential for electricity from hydropower, lower energy consumption for heating and possibly more summer tourism". It is mentioned that "changing socio-economic landscape interacts with climate change impacts and can erode cultural traditions". Indigenous peoples and traditional livelihoods as well as vulnerable population groups (the elderly, children, those in poor health) are specifically mentioned.

Challenges for local communities are listed in some of the EU-level policy documents von der Leyen (2019) acknowledges that changes in climate and technology are

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

transforming the societies, which has left a feeling of unease and anxiety in many communities. Supporting the regions and rural areas through EU Green Deal is emphasized. EU (2021) aims at supporting the sustainable development of the Arctic regions "to the benefit of its inhabitants and future generations, focusing on the needs of Indigenous Peoples, women and the young", in the face of consequences of climate change like thawing permafrost and risks to human, animal and plant health. Buildings and transportation are acknowledged to have significant roles in climate mitigation efforts (EU Climate Target Plan, EC 2021b). EU Adaptation Strategy (EC 2021c) mentions risks to food security, economy, social equalities and cultural heritage, and lists several objectives towards boosting adaptive capacity, strengthening resilience and reducing vulnerability to climate change of communities.

Climate and local communities are considered together in the **Barents region** assessment report when new opportunities for improving accessibility are discussed, and also when extreme weather conditions as a risk to livelihoods, economic activity and human security (through increased conflicts, e.g. due to competitive interests for land) are discussed. (AMAP 2017)

The linkages between climate and local communities are shown through several examples in strategic papers from **Sápmi** or from the **Nordic region**. More frequent extreme weather events and other changes are noted to have implications for the knowledge needs of reindeer herders and their societies (WRH 2017; Johnsen et al. 2017). Saami Council (2019) is concerned about multinational businesses, such as green energy developments, that look to Saami communities for new opportunities. Nordregio (2021a; 2021c) mentions increasing local resilience to climate change through urban area activities. It is mentioned that GHG emission reductions would be best implemented through local efforts and these will also will benefit local communities through creating economic gains (Nordregio 2021b).

National level documents seldom consider climate and local communities together. Red List of Habitats Finland (2018) mentions utilizing reindeer herders' local knowledge about climatic impacts.

In most of the national Arctic strategies, the topic is discussed more thoroughly. Russian Arctic Strategy (2020) states that climate change is a general threat for the development of the Arctic, including the well-being and the activities of local communities. The vulnerability of indigenous peoples, impacts on living conditions of local communities, and the importance of indigenous, traditional and local knowledge and participation of these people in decisions affecting them are listed in the Arctic Strategy Finland (2021), Norway (Norwegian Ministries 2021) and Sweden (2020).

This linkage is not shown strongly in the national level sectoral/industrial strategies.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

MCE (2015) states that local and regional authorities should take responsibility for climate change related activities, and that climate adaptation is an increasingly important task for the municipalities, such as flood prevention, water cleaning and protection against erosion. Sveriges energi- och klimatplan (2019) mentions that national authorities have responsibility for "development plans", taking cultural heritage, Sámi livelihoods and Sámi culture into account.

Bioenergy (2020) reminds about the need for socially just transformation: citizens expect that well-being, economic growth and high-quality employment are all possible also when aiming at climate mitigation targets. MAF (2016b) sees as well that local businesses need support in their development of environmental technology, towards the green shift. It also explains how natural disasters can have great negative ripple effects on local communities and points out needs for better emergency preparedness to mitigate effects of more frequent extreme weather events.

The link between climate and local communities is shown only in some **sub-national level** documents. Metsähallitus (2013) states that warming threatens winter tourism but may give competitive edge in relation to central Europe; it also threatens nature-based livelihoods. Climate change is listed among the risks to the socio-ecological development (Strategy for Socio-economic Development in Murmansk to 2025), or mentioned to limit the possibilities for indigenous people to practice traditional activities such as reindeer herding (Strategy for Socio-economic Development in Yamalo-Nenets Okrug to 2035; Sametinget 2021). Communities practicing traditional livelihoods adapt to climate change impacts with the help of traditional knowledge. (Saamelaiskäräjät 2020).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

3.4 - How are biodiversity and land-use considered in relation to each other?

International/Arctic-level assessment reports see land-use as a serious threat to biodiversity. Land-use change and overexploitation via harvesting, logging, hunting and have large negative impact on terrestrial Arctic ecosystems (IPBES 2019)**.** Species loss in relation to agriculture and forestry but also due to land-use linked to renewable energy production (hydropower, windpower) is mentioned by IPCC (2019 / Climate Change and Land). Some Arctic wetlands are degraded by human land use, and expansion of forestry, agriculture, hydropower, and extraction of peat, fossil fuels or minerals threat wetland functioning (CAFF 2021).

On the other hand, Arctic Council (2017) sees that sustainable land-use and protection of Arctic biodiversity are linked with human well-being and social and economic development. Aronsson et al. (2021) acknowledges that Arctic Indigenous Peoples have been interacting with Arctic biodiversity for millennia - long-term harvesting and herding can have enduring effects on biodiversity patterns, such as increasing habitat heterogeneity and promoting distinct assemblages of native flora. Sustainable harvesting both depends on and supports biodiversity.

When considering Arctic Indigenous Peoples food systems, biodiversity is mentioned as a basis of traditional nature-based livelihoods, and it is stated that measures of biodiversity should address the values, interests and rights involved in the use of land (Arctic Council 2019) Arctic Council (2021a) notes that while the economy in many Arctic regions may be built on mineral extraction, rich wildlife still provides substantial values. In the Artic Council Strategic Plan (2021b), responsible use of the natural resources is mentioned as strategic action, together with the strategic goal "Healthy and Resilient Arctic Ecosystems".

Land-use is seen as a threat to biodiversity also in the **EU-level** assessment reports (EEA 2017, 2021). Reasons for the biodiversity decline are listed: agricultural intensification, unsustainable farming practices, intensive forest management, land abandonment and urban sprawl. Landscape fragmentation continues to increase, damaging habitats and biodiversity (EEA 2020). Changing vegetation patterns and ecosystems are triggering shifts in forests and farmland, leading to adaptation needs for farmers and land managers (EU Adaptation Strategy, EC 2021c). EU Farm to Fork strategy (EC 2020c) lists agriculture-related risks to biodiversity: the use of chemical pesticides, and excess of nutrients in water bodies and wetlands. According to von der Leyen (2019), "climate change, biodiversity, food security, deforestation and land degradation go together."

EU-level policy documents aim at stopping this development. EC (2018) states that sustainable bioeconomy contributes to the land degradation neutrality by 2030 and to restoring at least 15% of degraded ecosystems by 2020. Some mentioned keys to success

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

are the modernisation of European primary production systems and the protection of the environment. EU supports the goal of protecting 30% of land by 2030, and reducing the environmental impact of processes for exploitation and processing (EC 2021a). Biomass for energy use in the EU should be produced sustainably. To limit impact on biodiversity, the use of whole trees and food and feed crops for energy production should be minimised. Unsustainable intensification of forest harvesting for bioenergy purposes should be avoided (EU Climate Target Plan, EC 2021b).

Forest management has significant impact on biodiversity, and some practices can preserve and restore biodiversity. According to the EU Forest Strategy (EC 2013), wood of high ecological value should not be used. EU energy system mentions energy efficiency as a part of solution: it reduces the land and material resource use and biodiversity losses.

Land-use is linked to protecting valuable species and habitats, and diversification of agricultural areas in the EU Biodiversity strategy (EC 2021d). Commitments mentioned include creating ecological corridors to allow for species migration and to maintain and enhance healthy ecosystems, defining, mapping, monitoring and protecting all of the EU's remaining primary and old-growth forests, and providing more space for nature (10% of agricultural area should be transformed into high diversity landscape features by 2030).

The **Barents region** assessment region give some examples about the links between biodiversity and land-use: invasive species (access to new areas via human activities such as increased tourism) and reindeer pastures and impacts on them from changing lichen abudances or moth larvae outbreaks (AMAP 2017)

Strategic papers from **Sápmi** state that reindeer herding peoples have managed their own areas and its biodiversity as a cultural landscape since time immemorial (WRH 2017), and discuss how to restore biodiversity and landscape after deforestration and how reindeer management actually contributes to biodiversity (Saami Council 2019). In the **Nordic** documents these linkages are not considered.

In the **national level** assessment reports, land use is mentioned to cause great loss of biological diversity in terrestrial ecosystems (Jakobsson & Pedersen 2020). Semi-natural habitats, such as hayfields are threatened because of ceased management practice; proper management is needed to maintain their species richness and ecological functions. Forestry and ditching (for forestry or agricultural purposes) as well as construction and infrastructure development cause habitat losses (Artsdatabanken 2018). Also Sveriges naturtyper (2020) mentions especially agriculture and forestry. Species that depend on grasslands and certain old growth forest habitats are particularly endangered. The common EU-policies on agriculture have halted the deterioration of maintenance of

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

remaining pastures, threatened by overgrowing. Forestry has changed earlier disturbance regimes, such as forest fires, or traditional forest uses (grazing) and thus affected the quality of forest habitats. Red List of Habitats Finland (2018) mentions the impacts of reindeer grazing on fell habitat types.

In Russia, industrial development is mentioned to lead to habitat loss in Arctic tundra and forest tundra. Habitat fragmentation due to linear infrastructure makes the situation worse (Biodiversity assessment Russia 2015). Expansion of oil and gas industry is predicted to lead to further fragmentation of tundra and disturbance of wetlands.

According to the national Arctic Strategies, land use and human activities should not pose danger to biodiversity (e.g. Arctic Strategy Finland 2021). The present-day pressure is acknowledged; establishment of protected areas to safeguard the most valuable habitats and ecosystems are mentioned as one solution (e.g. Arctic Policy Norway 2021). Arctic Strategy Sweden (2020) stresses that "difficult balances may have to be struck between using natural resources and protecting the environment". A low level of investment in biodiversity conservation and environmental protection as well overharvesting are listed as problems for the development of the Arctic in the Russian Arctic Strategy (2020).

The same discussion continues in national-level sectoral/industrial strategies. MCE (2015) mentions that land-use and "reallocation of area for infrastructure development" are the main contributing factors on reducing terrestrial biodiversity in Norway. Agriculture and forestry, fishing, mining and energy production are listed in the Russian Strategy for Conservation to 2030.

In the national energy strategies, need for biodiversity protection is noted. AFRY (2020b) is concerned about the availability of biomass, "tightening sustainability criteria for biomass". It also mentions that potential for new hydropower capacity is limited as the remaining locations are protected. It should be ensured that "plant and animal species can survive under natural conditions and viable populations" (Sveriges energi- och klimatplan 2019). Russian Energy Strategy to 2035 suggests developing the legal framework determining requirements for biodiversity conservation in the hydro-electric projects. The documents about windpower acknowledge the impacts on the environment with varying degree. MPE (2019) notices that wind power is area-consuming, disturbs wildlife and causes habitat fragmentation. Mountain areas with wild reindeer are potentially in conflict with the development. Prime Minister's Office Finland (2021) does not discuss this a lot, but notes that areas with nature conservation or landscape values limit the wind power construction. Wind power Sweden (2020) states that wind power is one of the most effective ways to mitigate climate change, which is a threat to biodiversity, and rejection of wind farms for protecting individual birds is seen as illogical.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

A range of legislations (e.g. the Norwegian PEFC Forest Standard) ensures that increased activity in forestry also maintains biodiversity (MAF 2016b). Forests are mentioned as Sweden's most diverse habitat type, meaning that multiple-use of forests needs to contribute to the protection of this diversity (Sweden's forest program 2018) Also Skogvårdslagstiftningen (2020) requires that forestry should be practiced in a way that benefits the "economic output while biodiversity shall be preserved". Russian State Policy on Forests to 2030 emphasizes the interaction between forest management and the conservation of forest diversity. Bioenergy (2020) discusses the sustainability criteria for biomass in Finland. If using imported biomass, the challenge is how to show that the biomass fulfills the sustainability criteria. Conflict between reindeer husbandry and growing predator populations is discussed in MAF (2016a), and reindeer fences are mentioned to cause fragmentation of habitats and injuries to wild animals.

Sub-national level assessment reports discuss the biodiversity and land-use often together. Biodiversity and habitat losses are mentioned to be caused by industrial development, expansion of infrastructure and growing cities (Red book of Yamalo-Nenetskiy avtonomnyi Okrug; Red book of the Komi Republic 2019). Unregulated recreational activity and reindeer grazing are also considered as threats (Red book of Nenets Autonomous Okrug 2020). Red book of Murmansk Region (2014) mentions also forest cutting and fires.

Subnational level policy papers and sectoral/industrial strategies continue this discussion. Strategy for Socio-economic Development in Komi to 2035 emphasizes the preservation and development of protected natural areas, and the role of FSC certificated forest industry. Prevention of the negative impact of economic activities on the natural environment is mentioned in the Strategy for Socio-economic Development in Murmansk to 2025 and in the Strategy for Socio-economic Development in Nenets Okrug to 2030. The extraction of hydrocarbon resources has negative consequences, roads and off-road trails disturb the vegetation and there is pollution. Also Strategy for Socio-economic Development in Yamalo-Nenets Okrug to 2035 is concerned about the northward expansion of extractive industries and the excessive increase of reindeer numbers.

Saamelaiskäräjät (2017, 2021) states that traditional livelihoods contain knowledge related to biodiversity and are key to preserve northern biodiversity. Sametinget (2021) emphasizes that Sámi land use depends on intact biodiversity. Traditional Sámi land use (including reindeer husbandry) is seen as a "precondition to preserve the cultural landscape and diversity of vegetation communities". Goal explained in the Storslagen fjällmiljö (2019) is that open mountains are preserved for reindeer husbandry, and landscape remains grazing-shaped. The document sees predators (i.e. part of biodiversity) as a problem to reindeer husbandry. Metsähallitus (2013) notes that nature-based livelihoods are connected to preservation of biodiversity, but so are also the nature conservation areas.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

3.5. How are biodiversity and local communities considered in relation to each other?

Biodiversity and local communities are often briefly considered together in the **international/Arctic-level** assessment reports. Reindeer herding is discussed (AMAP 2017) and, more generally, polar resource management for sustaining biodiversity (Meredith et al. 2019). It is noted that nature is generally declining less rapidly in indigenous peoples' land than in other lands, but is nevertheless declining. (IPBES 2019), and historical land-use has maintained biodiversity in the Arctic (CAFF 2013) It is also mentioned that sustainable harvesting both depends on and supports biodiversity and that for biodiversity monitoring, all possible sources including remote sensing, Indigenous Knowledge, local knowledge, citizen science and long-term monitoring need to be utilized (Aronsson et al. 2021). CAFF (2021) emphasizes the importance of wetlands to many Indigenous Peoples' lives - they provide and sustain food security, including grazing for traditional reindeer herding - and the knowledge and stewardship of these Peoples' for successful management of Arctic wetlands.

Environmental protection is considered crucial for the well-being, resilience and adaptability of individuals, communities and societies (Arctic Council 2017). IPCC (2019) discusses the land management, especially in regard to agriculture, and how local communities can contribute to changing agriculture towards more sustainable practices. When considering Arctic Indigenous Peoples food systems, biodiversity is seen as a core building block of food production (Arctic Council 2019)

Arctic Council (2021a) state that the health and wellbeing of local communities, especially of those with subsistence livelihoods (e.g. reindeer herders), heavily depend upon biodiversity. Strategic actions suggested by the Arctic Council (2021b) include "encouraging cooperation in monitoring the state of the Arctic biodiversity and ecosystems, as well as impacts of environmental stressors on environmental and human health … utilizing traditional knowledge and local knowledge… and promoting action on issues that are critical to maintaining the health of Arctic ecosystems, as well as Arctic inhabitants."

In the **EU level** assessment reports biodiversity and local communities are seldom considered together. The same implies to many policy documents. von der Leyen (2019) mentions the value of biodiversity together with "the diversity of landscape, culture and heritage" and EU Adaptation Strategy (EC 2021c) states solutions that are needed to help farmers and land managers tackle climate change related problems when vegetation patterns and ecosystems change and trigger major shifts in forests and farmland. EU Biodiversity strategy (EC 2021d) mentions participation from farmers, citizens and local stakeholders as part of EU biodiversity goals: "as guardians of our land, farmers play a vital role in preserving biodiversity. At the same time, certain agricultural practices are a

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

key driver of biodiversity decline." EU Farm to Fork strategy (EC 2020c) mentions healthy food together with healthy planet.

Linkages between biodiversity and local communities are not often discussed in the **Nordic** documents about sustainable development, wellbeing and health or in the Nordregio strategy papers. **Barents region** assessment report (AMAP 2017) acknowledges the complex linkages between local people/cultures and biodiversity, e.g. language loss and biodiversity are coupled, and identifies the impacts of diverse human pressures on biodiversity.

Strategic papers from **Sápm**i discuss these linkages in length. WRH (2017) states that reindeer herding peoples have managed their own areas and its biodiversity as a cultural landscape since time immemorial. Saami Council (2019) links protecting ecosystems to reindeer pasture quality and predators to impacts on herding communities.

Biodiversity and local communities are seldom discussed together in **national level** assessment reports. Sveriges naturtyper (2020) mentions that mountain habitats are influenced by "extensive and low-intensive" land-use; grazing by reindeer and other domestic animals. Northern or Arctic forests are seen as important for traditional acivities like reindeer herding and hunting (Ministry of Natural Resources and Ecology Russia 2020).

In the national Arctic strategies, it is mentioned that the traditional Sámi livelihoods are highly dependent on nature (Arctic Strategy Finland 2021), there is need to protect the "areas of high natural and cultural values in Arctic environment" (Arctic Strategy Sweden 2020), or the linkage between biodiversity and local communities is not mentioned at all.

Policy and sectoral/industrial strategies at the national level most often leave this linkage out of discussion; most often, it is not within the scope of the document. Russian Strategy for Conservation to 2030 states that the role of the civil society in conservation of rare species should be increased and traditional knowledge should be used for conservation aims. Norwegian MAF (2016a) mentions that the use of grazing areas should not degrade the grazing quality or biodiversity, and the law equates ecologically, economically, and cultural sustainability; MCE (2015) highlight that environmental assessments on nature and society should be transparent so that all impacted stakeholders may be heard.

At **sub-national level**, linkages between biodiversity and local communities are considered more, compared to national level.

In the assessment reports problems like excessive hunting and poaching as threat for some species and reindeer herding for wild reindeer are discussed. Overgrazing by

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

domestic reindeer is mentioned as a threat for certain birds, plants and lichen (Red book of Yamalo-Nenetskiy avtonomnyi Okrug, Red book of the Komi Republic 2019, Red book of Nenets Autonomous Okrug 2020) Recreation as a factor of trampling and habitat degradation is mentioned (Red book of Murmansk Region 2014).

The discussion is present also in the sub-national policy documents and sectoral and industrial strategies.

Saamelaiskäräjät (2017) reminds that the Convention on Biological Diversity obligates to protection of indigenous traditional knowledge related to biodiversity.
Sametinget (2021) describes biodiversity and local communities as mutually dependent and Saamelaiskäräjät (2020) connects traditional knowledge to biodiversity. Storslagen fjällmiljö 2019 discusses reindeer husbandry and co-governance of the world heritage site Laponia. Traditional Sami livelihoods and culture are seen as connected to preservation of biodiversity also by Metsähallitus (2013) in Finland, and collaboration between natural parks and surrounding communities mentioned by Lapin liitto (2021).

Strategies for Socio-economic Development in Murmansk to 2025 and Nenets Okrug to 2030 mention developing "environmental culture" by involving the inhabitants of the region in the implementation of environmental social projects that contribute to an increase in the level of environmentally responsible behavior and awareness about biodiversity. Strategy for Socio-economic Development in Yamalo-Nenets Okrug to 2035 mentions also public control against unauthorized waste dumps and reduction of poaching.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

3.6. How are land-use and local communities considered in relation to each other?

Land use and local communities are one of the main focuses in the IPCC 2019 report (Climate Change and Land). The importance of multi-level and cross-sectoral governance and land management decisions from farm level to national scale for effective sustainable management practices is emphasized. Report lists several land management options, such as improved management of grazing lands and forests, which do not require land use change and are applicable at different scales, from farm to regional". Relevant for CHARTER study region is the finding that may "livestock related options can enhance the adaptive capacity of rural communities, in particular, of smallholders and pastoralists. Significant synergies exist between adaptation and mitigation, for example through sustainable land management approaches."

Otherwise, linkages between land-use and local communities (local knowledge, livelihoods) receive little attention in the **international/Arctic-level** assessment reports or policy documents.

AMAP (2021) mentions industrialization that creates barriers to migration routes of reindeer, affecting herding as a livelihood. CAFF (2013) reminds that disturbance and habitat degradation diminishes the opportunities for Arctic residents to enjoy the benefits of ecosystem services and IPBES (2019) that 72 per cent of indicators developed by indigenous peoples and local communities show ongoing deterioration of elements of nature important to them. According to Arctic Council (2017), infrastructure should be developed while taking into account the present needs of local communities.

Equitable access to and possibility to select their own (natural) resources are seen as important, when discussing the food security for Arctic Indigenous Peoples (Arctic Council 2019). The ECONOR document mentions partnerships empowering Inuit to exercise self-determination by managing their own communities and environment. (Arctic Council 2021a) The linkages found in the Artic Council (2021b) strategic goals are vague, but when discussing "Sustainable Economic Development", multiple goals like low-emission societies, aligning economic development with traditional ways of living and promoting responsible and integrated approaches to resource development in the Arctic are mentioned.

Forests and food systems are often discussed when land-use and local communities are considered together in the **EU-level** assessment reports. EEA (2017) mentions ways to use livestock systems to improve and enhance ecosystem services, safeguarding rural communities at the same time. EEA (2020) states that cumulative pressures from land use change, natural resource extraction, pollution, climate change and invasive alien species causes severe harm on human health and well-being.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

EU level policy documents often recognize this linkage. EC (2018) reminds about the role of the bioeconomy in the SDG aim to "live well, within the limits of our planet". von der Leyen (2019) emphasized the importance of the "diversity of landscape, culture and heritage" in Europe.

EU (2021) notes that it exerts a significant impact on the Arctic through its demand for resources and Arctic products, and has responsibility for Arctic sustainable development and for the livelihood of inhabitants, including Indigenous Peoples. The significance of transport routes through northern Fennoscandia "to transport freight originating in the Arctic regions on land and potentially via the Northern Sea Route" is mentioned (EC 2021a). Climate risks and adaptation needs of farmers and land managers due to changing vegetation patterns and ecosystems, and consequent shifts in forests and farmland, are mentioned (EU Adaptation Strategy, EC 2021c). EU Biodiversity strategy (EC 2021d) states that protecting and restoring nature requires action by citizens as well, and restoration investments can provide economic boosts and support local socioeconomic activities such as tourism and recreation. EU Forest Strategy (EC 2013) acknowledges that forest offer not only wood, but also "a variety of equally important additional products and services, from food to ecotourism, which support the economies and the social fabric in rural areas." EU Farm to Fork strategy (EC 2020c) also recognizes the role of rural communities and citizens in the transition to sustainable food systems.

Thorough discussion about the linkages between land-use and local communities are found in the regional documents. Conflicting interests regarding the land use rights and their effects on the livelihoods of indigenous peoples is a recurring theme in the assessment report from the **Barents region** (AMAP 2017); e.g. growing demand to acquire land for activities such as wind farms, mining, as well as Arctic resources, occurring alongside the traditional needs of reindeer herding, farming and forestry.

Strategic papers from **Sápmi** continue this: co-management, inclusion of traditional Indigenous knowledge, and reindeer herders' participation are considered essential in successful and equitable resource management and management of protected areas (WRH 2017), and discussion is needed about circular economy from a Sámi standpoint, and about how to ensure sustainability in business, both with in the more traditional enterprises and the more innovative ones (Saami Council 2019).

Nordic documents discuss for example the multiple land use activities in the Sami reindeer herding communities from many perspectives: employment potentials, carbon sequestration, sustainable forestry versus reindeer herding, and impacts of infrastructure development on reindeer husbandry (Johnsen et al 2017).

In the Nordregio strategy papers support for local implementation and regional and local authorities, and benefits of cross-sectoral approach in implementing SDGs are mentioned

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

(Nordregio 2021a), as well as addressing individual citizens regarding more sustainable production methods (Nordregio 2021b). Transformations lead to adaptation needs for citizens, organizations, and regions; potential is seen in the co-management approach (Nordregio secretariat 2021) and in the knowledge co-production, active integration of indigenous involvement in decision-making processes, and place-based policies tailored to local circumstances (Nordregio 2021c).

National level assessment reports seldom consider the land-use and local communities (local knowledge, livelihoods) linkages. Reindeer pastures and impacts of fragmentation are mentioned (Red List of Habitats Finland 2018, Jakobsson & Pedersen 2020, Sveriges naturtyper 2020). The Russian Biodiversity assessment (2015) mention overgrazing and excessive densities of ungulates that can lead to erosion and reduce the provisional services of pastures.

In national Arctic strategies these linkages are also considered quite vaguely. Connection between the wellbeing of local communities and livelihoods and well-functioning ecosystems is noted, as well as land use impacts on the achievement of the SDGs, and the role nature has in the Arctic food security, human health and wellbeing (Arctic Strategy Finland 2021). Promoting conservation and sustainable land use to the benefit of both individuals and local communities is mentioned (Arctic Policy Norway 2021). It is noted that increased economic activity can contribute to livelihoods in local communities, but there are also risks on the living conditions of the local population, including indigenous peoples (Arctic Strategy Sweden 2020). This Swedish document clearly states that "well-functioning and long-term sustainable reindeer husbandry requires access to suitable calving grounds, functioning migration routes and connected seasonal grazing areas", but it is not specified how this can be combined with the development of other forms of land use.

Several, but not all, national level sectoral/industrial strategies discuss these linkages. MCE (2015) highlights that local and regional authorities should take responsibility for sustainable management of nature, and that traditional knowledge should be emphasized in cases that involves nature. Also AFRY (2020b) and Wind power Sweden (2020) note that communities make decisions related to land use.

Documents on wind power discuss local communities a lot, especially the documents from Norway and Sweden. Areas suitable for wind parks have been identified in Finland; conflicts between other land-users have been experienced. (Prime Minister's Office Finland 2021). Wind parks are planned further away from densely habited areas. Consolidation of land-uses was nevertheless seen as a challenge for the wind power increase. Wind power Sweden (2020) mentions that "today 80 % of wind power development takes place in northern Sweden"; this has effects on reindeer husbandry, and according to this document, national interest has shifted from the wind power for the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

benefit of reindeer husbandry. This relates to the important issue of indigenous peoples' rights. Finding ways to coexist was seen as important. MPE (2020) focuses on inclusion of local businesses and utilization of relevant competence (also local knowledge) in land-use planning. MPE (2019) emphasizes the strengthened local participation in the development of new wind power plants. The Sami Parliament, reindeer husbandry and any other affected Sami interests shall be consulted in matters that affect Sami areas.

[Side note: The Supreme Court of Norway recently passed a sentence over a wind power plant constructed within a reindeer herding area at Fosen in Trøndelag, concluding that it was illegally constructed, because reindeer herding objections had been ignored by the developers. This case will have major consequences for future wind power plant planning in reindeer herding areas, meaning 40 % of Norway's land area, and ca. 80 % of all sites considered suitable for wind power plants]

In the forestry and bioenergy strategies the topic is often discussed. Finnish Forest Industries (2020) emphasize the role of forest industry in the economy and wellbeing, and states that wood processing needs forest owners who are motivated to take care of the forest health, in long term, and grow the forest resources. Just transition is mentioned, because utilizing peat for energy is decreasing rapidly and some are losing their livelihood (even though bioenergy will create jobs) (Bioenergy (2020). Sweden's forest program (2018) mentions the importance of cultural values of forests as well, including reindeer husbandry and nature tourism, and social values e.g experiences, health and recreation. Skogvårdslagstiftningen (2020) reminds that reindeer husbandry shall be respected in forestry activities. Russian State Policy on Forests to 2030 is based among others on the recognitions of the right of the citizen to use natural resources and live in a favorable natural environment; sustainable socio-economic development of forestry regions. This document sees the unclear legal situation as a main problem between industrial forestry and traditional use of natural resources.

MAF (2016a) sees the connection between land-use and local communities as a central topic, mentioning that reindeer husbandry represents a good resource utilization in marginal mountain areas and contributes to industrial diversity and maintenance of local businesses in peripheral districts of Norway. Russian Reindeer Strategy to 2030 sees reindeer herding as the basis of the livelihood of many indigenous people of the North, and discusses topics like overgrazing, impacts of industrial development, and a lack of clear regulations of land-use and pasture use. Conflicts between forestry and reindeer herding in Komi region are mentioned.

Land-use and local communities (local knowledge, livelihoods) are not that much considered together in the **sub-national** level assessment reports. Land-use change resulting from industrial development and increasing human activity in general is considered the main threat of biodiversity in the Red book of Yamalo-Nenetskiy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

avtonomnyi Okrug, and activities of local indigenous people, like hunting and reindeer herding, are considered an additional threat. Red book of the Komi Republic (2019) mentions land use change and local activities such as hunting as threats for different species. ACAP (2021b) has more positive note and discusses the waste disposal sites and clean-up projects in Kola region, and the role of local communities in the success of these activities.

In sub-national policy papers and sectoral/industrial strategies traditional livelihoods are given attention. Strategy for Socio-economic Development in Komi to 2035 mentions conservation of reindeer herding, building a strategy for the interaction of mining companies with the indigenous population, and establishing relationships between reindeer herders and companies of the fuel-energy sector. Representatives of indigenous peoples should be involved in resolving issues of state and local government in the field of protecting rights, the original habitat, natural resources and their traditional use, and traditional way of life (Strategy for Socio-economic Development in Murmansk to 2025). Strategy for Socio-economic Development in Nenets Okrug to 2030 discusses reindeer herding as a land-use; there is concern for potential degradation of reindeer pastures on the one hand, and suggestions for intensification and productivity increase on the other hand. Incentives to reduce reindeer numbers, increase productivity and meat quality are suggested in the Strategy for Socio-economic Development in Yamalo-Nenets Okrug to 2035.

Saamelaiskäräjät (2017) link traditional livelihoods and Sámi communities. The threat of "destroyed grazing grounds" for reindeer husbandry by other land users is mentioned by Storslagen fjällmiljö (2019). Large-scale extraction of natural resources and landscape fragmentation is mentioned to have negative impacts on Sámi livelihoods by Sametinget (2021) and Saamelaiskäräjät (2020), and the lack of Sámi influence on land use decisions is stressed. Traditional knowledge is not given enough weight in land-use governance, according to these documents.

Land-use strategies from northern Finland on the other hand acknowledge the participation of local communities in the planning of the forestry operations (Metsähallitus 2013), and rights of indigenous peoples to participate and lead development of their living area (Lapin liitto 2021). Estimation of land-use in Sápmi reindeer herding area is promoted, to secure herding conditions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

4 Concluding remarks

Interestingly, most of the linkages studied were considered at the global level, less at the regional level, and again rather comprehensively when looking at the national or sub-national levels. Very often local communities, as well as biodiversity, are seen as something affected by other drivers, not as active actors or drivers of change. The method we applied is a simple one, but very illustrative and able to bring out existing and missing linkages at various governance levels, and emphasis of political papers and livelihood strategies.

Local Arctic communities have long used exploited tundra ecosystems as rangelands and their relationship with the animals as sentient beings, and nature in general, has been central to their worldview and well-being (Anderson 2000; Natcher et al. 2007; Crate et al. 2017). In turn, herbivory has modified significant portions of the tundra biome, particularly in NW Eurasia (Forbes et al. 2006; Olofsson et al. 2009; Horstkotte et al. 2017; Olofsson & Post 2018). These local communities are now under pressure to adapt to a rapidly changing climate, along with globalization and urbanization and their desire to preserve ways of life across the generations. Yet how these multiple changes will unfold, and what non-linearities or possible tipping points there are (both social and biophysical) in the underlying systems is not yet clear. Similarly, questions like how communities can adapt to multiple drivers/non-linearities, and how those pathways might shape the Arctic environment as a whole, need more attention.

Reindeer herders point to flexibility of their herding practices in space and time is repeatedly identified as key to reducing vulnerability in relation to climate change (Rees et al. 2008; Horstkotte et al. 2014) but there is still little knowledge regarding how land-use flexibility and climate change link to reindeer nutrition and productivity. Under conditions of rapid anthropogenic global change, maintaining viable SESs for the future requires new approaches (Falardeau et al. 2019). Specific Arctic adaptation strategies are needed both to mitigate and to adapt to challenges brought by changes in the cryosphere (JOIN 2016). The question is not only about biodiversity conservation and optimal management of reindeer herds, but also about developing more sustainable ways for infrastructure development, which tundra pastoralists must navigate (Forbes et al. 2006, 2009). Developing effective strategies under this new paradigm will also require deeper understanding of how SES dynamics have developed through time and how they influence the present actions and perceptions of risk in local communities.

There is a strong need for a joint Fennoscandian assessment of Arctic biodiversity and conservation actions that encompasses the entire area and directly link these to SES. To be most impactful, such assessments should increasingly incorporate a systemic view: they should consider complex feedbacks and interactions between species and between

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

the above-ground and below-ground biogeophysical systems, and the complex feedbacks and interactions they have with humans as SES. This review is a first step towards development of such an assessment. Interesting further steps will be analyzing the "full nexus" (three to four aspects considered together), knowledge gaps listed and policy recommendations given in the documents.

5 Contributions

The following team members have contributed to this deliverable:

Writing: Jussi Eronen (UH), Sirpa Rasmus (LAY and UH), Mia Landauer (LAY), Maria Tuomi (UiT, UH collaborator), Johanna Yletyinen (University of Jyväskylä, UH and LAY collaborator), Jarle Bjerke (NINA), Hans Tømmervik (NINA), Christian Rixen (WSL), Dorothee Ehrich (UiT), Tim Horstkotte (UmU), Timo Kumpula (UEF), Bruce Forbes (LAY), Otto Habeck (UHAM), Heidrun Matthes (AWI), Isla Myers-Smith (UEDIN), Sari Stark (LAY)

Analyses: Sirpa Rasmus (LAY and UH), Johanna Yletyinen (LAY and UH collaborator, JyU), Jussi Eronen (UH) and Ningning Sun (LAY intern)

Literature review and collection of material: Mia Landauer (LAY), Maria Tuomi (UiT, UH collaborator), Leena Leppänen (LAY), Christian Rixen (WSL), Sonja Kivinen (UEF), Teresa Komu (LAY), Johanna Yletyinen (JyU, UH and LAY collaborator), Sirpa Rasmus (LAY and UH), Jussi Eronen (UH), Ningning Sun (LAY intern), Jarle Bjerke (NINA), Marit Arneberg (NINA), Tim Horstkotte (UmU), Dorothee Ehrich (UiT), Svetlana Divina (UiT collaborator)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

6 References

Synthesis reports, policy documents, industrial/sectoral strategies used in the analyses

International/Arctic level (15 documents)

ACAP (Arctic Contaminants Action Program). 2016. ACAP Strategy to Address Contamination of the Arctic Environment and its People.

ACAP 2021a, Black Carbon and Methane from the Oil and Gas Sector: Report with Recommendations. 10 pp.

AMAP, 2017. Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. Arctic Monitoring and Assessment Programme (AMAP).

AMAP Assessment 2018: Biological Effects of Contaminants on Arctic Wildlife and Fish (terrestrial section). Arctic Monitoring and Assessment Programme (AMAP).

AMAP, 2021. Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-makers. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. 16 pp

Arctic Council. 2017. Sustainable Development Working Group. The Human Face of the Arctic. Strategic Framework 2017.

Arctic Council. 2019. EALLU Arctic Indigenous Peoples Food Systems: Youth, Knowledge & Change 2015-2019.

Arctic Council. 2021a. The Economy of the North – ECONOR 2020

Arctic Council. 2021b. Arctic Council Strategic Plan 2021-2030.

Aronsson, M., et al. 2021. State of the Arctic Terrestrial Biodiversity Report (START). Conservation of Arctic Flora and Fauna International Secretariat, Akureyri, Iceland. ISBN 978-9935-431-94-3.

CAFF. 2013. Arctic Biodiversity Assessment: Report for Policy Makers. https://www.caff.is/assessment-series/229-arctic-biodiversity-assessment-2013-report-for-policy-makers-english

CAFF. 2021. Resilience & Management of Arctic Wetlands (RAW)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Resilience and Management of Arctic Wetlands (RAW) - key findings and recommendations. https://oaarchive.arctic-council.org/handle/11374/2631

IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz et al. (eds.). IPBES secretariat, Bonn, Germany. 56 pages.

IPCC (2019). Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
Meredith, M. et al. (2019). Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner et al. (eds.)].

EU level (13 documents)

EEA 2017. Climate change, impacts and vulnerability in Europe 2016: An indicator-based report. EEA Report No 1.

EEA 2020. The European environment — state and outlook.
https://www.eea.europa.eu/soer/2020

European Commission (2013). A new EU Forest Strategy: for forests and the forest-based sector. Communication from the Commission to the European Parliament and the Council, the Economic and Social Committee and the Committee of the Regions.
https://www.eea.europa.eu/policy-documents/the-eu-forest-strategy-com

European Commission (2016). European Red List of Habitats. Part 2. Terrestrial and freshwater habitats. Luxembourg: Publications Office of the European Union.

European Commission, Directorate-General for Research and Innovation (2018). A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment : updated bioeconomy strategy, Publications Office, 2018, https://data.europa.eu/doi/10.2777/478385

European Commission (2020a). Powering a climate-neutral economy: An EU Strategy for Energy System Integration. Communication to the European Parliament, the Council, The European economic and social committee and the Committee of the regions. COM/2020/299 final.
https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2020:299:FIN

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

European Commission (2020b). EU Proposal for a new Sustainable Batteries Regulation.

European Commission (2020c). EU Farm to Fork strategy. https://ec.europa.eu/food/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf

European Commission (2021a). A stronger EU engagement for a peaceful, sustainable and prosperous Arctic. Joint communication to the European Parliament, the Council, The European economic and social committee and the Committee of the regions. https://www.eeas.europa.eu/sites/default/files/2_en_act_part1_v7.pdf

European Commission (2021b) Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people. Communication to the European Parliament, the Council, The European economic and social committee and the Committee of the regions. COM/2020/562 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562

European Commission (2021c). Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change. Communication to the European Parliament, the Council, The European economic and social committee and the Committee of the regions. COM/2021/82 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

European Commission, Directorate-General for Environment (2021d). EU biodiversity strategy for 2030: bringing nature back into our lives. https://data.europa.eu/doi/10.2779/048

von der Leyen (2019). My agenda for Europe. Political guidelines for the EC 2019-2024.

Nordic and Barents and Sápmi level (9 documents)

AMAP, 2017. Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area. Arctic Monitoring and Assessment Programme.

Johnsen, I., Berlina, A., Mikkola, N. & Smed Olsen, L. (eds.). 2017. Reindeer husbandry in Sapmi - How can we support a prosperous future for reindeer herding through research? Nordregio working paper 2017:8.

Nordic Council of Ministers 2020. State of the Nordic Region 2020. Wellbeing, health and digitalisation edition

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Nordregio 2021a. Localizing the Sustainable Development Goals in Europe: Perspectives for the North.

Nordregio. 2021b. Agenda 2030. How to reach the goals and measure success at the local level. Nordregio Reoprt 2021/8.

Nordregio 2021c. Nordregio Strategy 2021-2024.

Nordregio secretariat. 2021. The Nordic Cooperation Programme for Regional Development and Planning 2017-2020.

Saami Council 2019, The Sámi Arctic Strategy
https://www.saamicouncil.net/documentarchive/the-smi-arctic-strategy-samisk-strategi-for-arktiske-saker-smi-rktala-igumuat

WRH. 2017. Jåhkåmåhkke Declaration.
https://reindeerherding.org/images/wrh/declarations/pdf/2017-Jahkamahkke-Declaration.pdf.

National level (28 documents; 7 from Finland, 8 from Norway, 7 from Russia, 6 from Sweden - synthesis reports, policy documents, industrial/sectoral strategies; some reference details missing)

AFRY (2020a). Roadmap for the forestry sector in a low-carbon world. Metsäteollisuus.

AFRY (2020b). Finnish Energy. Low-carbon roadmap

Artsdatabanken (2018). Norwegian Red List for Habitat types 2018. URL: https://www.artsdatabanken.no/rodlistefornaturtyper

Bioenergy (2020). The contributon by the bionenergy sector to low-carbon future in Finland

ENERGY STRATEGY Russian Federation for the period up to 2035

Fifth national assessment about biodiversity conservation in the Russian Federation. Ministry of natural resources and ecology of the Russian Federation, 2015

Finland's Strategy for Arctic Policy (2021). Publications of the Finnish government 2021:55

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Finnish Forest Industries. (2020). Green and energetic economy. The climate roadmap of the forest sector.

Fundamentals of state policy in the field of use, protection and growing of forests in the Russian Federation for the period up to 2030

Jakobsson, S. & Pedersen, B. (Eds.) (2020). The Nature Index for Norway 2020. State and trends for Norwegian biodiversity. NINA Report 1886. Norwegian Institute for Nature Research.

Ministry of Agriculture and Food of Norway (2016a). Reindrift. Meld. St. 32 (2016-2017), 71 pp. Stortinget (Parliament of Norway), Oslo. [White paper on reindeer husbandry]

Ministry of Agriculture and Food of Norway (2016b). Verdier i vekst. Konkurransedyktig skog- og trenæring. Meld. St. 6 (2016-2017), 82 pp. Stortinget (Parliament of Norway), Oslo. [White paper on forestry]

Ministry of Climate and Environment of Norway (2015). Natur for livet. Meld.St. 14 (2015-2016), 155 pp. Stortinget (Parliament of Norway), Oslo. [White paper on the management of biodiversity]

Ministry of Petroleum and Energy of Norway (2019). Vindkraft på land. Meld. St. 28 (2019-2020), 86 pp. Stortinget (Parliament of Norway), Oslo. [White paper on wind power on land]

Ministry of Petroleum and Energy of Norway (2020). Energi til arbeid. Meld. St. 36 (2020-2021), 185 pp. Stortinget (Parliament of Norway), Oslo. [White paper on the value creation of Norwegian energy resources]

Norwegian Ministries (2021). The Norwegian Government's Arctic Policy. People, opportunities and Norwegian interests in the Arctic, [White paper]. URL: https://www.regjeringen.no/globalassets/departementene/ud/vedlegg/nord/arctic_strategy.pdf

Prime Minister's Office. 2021. Tuulivoimarakentamisen edistäminen. Keinoja sujuvaan hankekehitykseen ja eri tavoitteiden yhteensovitukseen [Advancing wind power construction in Finland]. Valtioneuvoston kanslia Helsinki 2021

Red List of Habitats: Finland (2018), Threatened Habitat Types in Finland 2018

Red List of Habitats: Norway (2018), Norsk rødliste for naturtyper

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Skogvårdslagstiftningen 2020 [Law of forest management, Sweden]

State Assessment of the status and conservation of the environment in the Russian Federation in 2019. Published by the Ministry of Natural Resources and Ecology of the Russian Federation, Moskva 2020.

Strategy development of reindeer breeding in the Russian Federation until 2030

Strategy for the conservation of rare and threatened species of animals, plants and fungi in the Russian Federation for the period to 2030

Strategy of development of the arctic zone of the Russian Federation and ensuring of the national security until 2035. Amendment of the President, 2020.

Sveriges arter och naturtyper i EU:s art-och habitatdirektiv (2020)

Sveriges integrerade nationella energi- och klimatplan (2019)

Sweden's national forest program (2018) https://www.skogsstyrelsen.se/en/about-us/national-forest-program/
Sweden's strategy for the Arctic region (2020). Government Offices of Sweden. https://www.government.se/contentassets/85de9103bbbe4373b55eddd7f71608da/swedens-strategy-for-the-arctic-region

Wind power strategy Sweden (2020).
https://swedishwindenergy.com/wp-content/uploads/2021/01/Roadmap-2040-ENG-rev-2020.pdf

Sub-national level (15 documents - synthesis reports, policy documents, industrial/sectoral strategies; some reference details missing)

ACAP 2021b. Kola Waste Project: Cleaning of the Sámi Territory in the Murmansk Region (2018-2020).

Lapin liitto. 2021. Lappi-sopimus. [Land-use strategy, Lapland, Finland] https://www.lapinliitto.fi/aluekehitys/lappi-sopimus/

Metsähallitus 2013. Ylä-Lapin luonnonvarasuunnitelma 2012-2021. [Natural resource management plan, Upper Lapland, Finland] https://julkaisut.metsa.fi/julkaisut/show/1696

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Red book of Murmansk Region. Second edition 2014.

Red book of Nenets Autonomous Okrug. 2020.

Red book of the Komi Republic (2019)

Red book of Yamalo-Nenetskiy avtonomnyi Okrug

Saamelaiskäräjät. 2017. Saamelaisten perinteisten elinkeinojen nykytilanne Suomessa – Biodiversiteettisopimuksen seurantaindikaattorien taustoitus [Saami traditional livelihoods, status, Finland]

Saamelaiskäräjät. 2020. Saamelaisten oikeus-, elinkeino-, kulttuuriperintö- ja ympäristöpoliittinen toimintaohjelma 2020-2023. [Saami justice, livelihood, culture and environmental policies program, Finland]

Sametinget. 2021. The Sámi Environmental Program Eallinbiras. Sweden.

Socio-economic development strategy Yamalo-Nenets Autonomous Okrug for the period up to 2035

Storslagen fjällmiljö. 2019. Swedish Environmental Goal "Magnificent Mountains".

Strategy for socio-economic development of the Murmansk region for the period until 2025

Strategy for socio-economic development of the Nenets Autonomous Okrug until 2030

Strategy for socio-economic development republic of Komi for the period until 2035

Other references

Anderson, D. (2000). Identity and ecology in Arctic Siberia: the Number One reindeer brigade. Oxford: Oxford University Press.

Bjorkman, A. D., et al. (2019). Status and trends in Arctic vegetation: Evidence from experimental warming and long-term monitoring. Ambio, 1-15.

Bjorkman, A. D., et al. (2018). Plant functional trait change across a warming tundra biome. Nature, 562(7725), 57.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Cohen, J., et al. (2013). Effect of reindeer grazing on snowmelt, albedo and energy balance based on satellite data analyses. Remote Sensing of Environment, 135, 107-117.

Crate, S., et al. (2017). Permafrost livelihoods: A transdisciplinary review and analysis of thermokarst-based systems of indigenous land use. Anthropocene, 18, 89-104.

Elmendorf, S. C., et al (2012). Plot-scale evidence of tundra vegetation change and links to recent summer warming. Nature Climate Change, 2(6), 453.

Forbes, B. C., & Stammler, F. (2009). Arctic climate change discourse: the contrasting politics of research agendas in the West and Russia. Polar Research, 28(1), 28-42.

Forbes, B. C., et al. (Eds.). (2006). Reindeer management in northernmost Europe: linking practical and scientific knowledge in social-ecological systems (Vol. 184). Springer Science & Business Media.

Forbes, B. C., et al. (2009). High resilience in the Yamal-Nenets social–ecological system, West Siberian Arctic, Russia. Proceedings of the National Academy of Sciences, 106(52),

Forbes, B. C., et al. (2016). Sea ice, rain-on-snow and tundra reindeer nomadism in Arctic Russia. Biology letters, 12(11), 20160466.

Falardeau, M., et al. (2019). A novel approach for co-producing positive scenarios that explore agency: case study from the Canadian Arctic. Sustainability Science, 14(1), 205-220.

Hjort et al. (2018). Degrading permafrost puts Arctic infrastructure at risk by mid-century. Nature Communications 2018, 9:5147 | DOI: 10.1038/s41467-018-07557-4

Horstkotte, T., Sandström, C., & Moen, J. (2014). Exploring the multiple use of boreal landscapes in northern Sweden: The importance of social-ecological diversity for mobility and flexibility. Human Ecology, 42(5), 671-682.

Horstkotte, T., et al. (2017). Human–animal agency in reindeer management: Sámi herders' perspectives on vegetation dynamics under climate change. Ecosphere, 8(9), e01931.

JOIN (2016) Joint Communication to the European Parliament and the Council: An integrated European Union policy for the Arctic. JOIN (2016) 21 final. 27 April 2016, Brussels. 17 pp.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Keskitalo, E.C.H., T. Horstkotte, S. Kivinen, B.C. Forbes and J. Käyhkö (2016) ''Generality of mis-fit''? The real-life difficulty of matching scales in an interconnected world. Ambio doi:10.1007/s13280-015-0757-2.

Loranty, M. M., & Goetz, S. J. (2012). Shrub expansion and climate feedbacks in Arctic tundra. Environmental Research Letters, 7(1), 011005. doi:10.1088/1748-9326/7/1/011005

Loranty, M.M. et al. (2018) Changing ecosystem influences on soil thermal regimes in northern high-latitude permafrost regions. Biogeosciences 15: 5287–5313, https://doi.org/10.5194/bg-15-5287-2018.

Loranty, M. M., et al. (2011). Tundra vegetation effects on pan-Arctic albedo. Environmental Research Letters, 6(2), 024014.

Macias-Fauria, M., et al. (2012). Eurasian Arctic greening reveals teleconnections and the potential for structurally novel ecosystems. Nature Climate Change, 2(8), 613.

Meredith, M. et al. (2019). Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner et al. (eds.)].

Miller, P. A., & Smith, B. (2012). Modelling tundra vegetation response to recent arctic warming. Ambio, 41(3), 281-291. doi.org/10.1007/s13280-012-0306-1

Myers-Smith, I. H., et al. (2011). Shrub expansion in tundra ecosystems: dynamics, impacts and research priorities. Environmental Research Letters, 6(4), 045509*

Myers-Smith, I. H., & Hik, D. S. (2018). Climate warming as a driver of tundra shrubline advance. Journal of Ecology, 106(2), 547-560.

Myers-Smith, I. H., et al. (2019). Plant traits inform predictions of tundra responses to global change. New Phytologist, 221(4), 1742-1748.

Natcher, D.C. et al. (2007). Arctic Anthropology 44, 113–126. ISSN 0066-6939

Niittynen, P., et al. (2018). Snow cover is a neglected driver of Arctic biodiversity loss. Nature Climate Change, 8(11), 997.*

Nilsson, A., M. Carson, D. Cost, B.C. Forbes, R. Haavisto, Ø. Paasche, S. Sarkki, J.N. Larsen and A. Pelyasov (2019) Promises, challenges, and ways forward for participatory scenario methodologies in the Arctic. Polar Geography doi:10.1080/1088937X.2019.1648583.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869471

Normand, S., et al. (2013). A greener Greenland? Climatic potential and long-term constraints on future expansions of trees and shrubs. Philosophical Transactions of the Royal Society B: Biological Sciences, 368(1624), 20120479.

Olofsson, J., & Post, E. (2018). Effects of large herbivores on tundra vegetation in a changing climate, and implications for rewilding. Philosophical Transactions of the Royal Society B: Biological Sciences, 373(1761), 20170437.

Olofsson, J., et al. (2009). Herbivores inhibit climate-driven shrub expansion on the tundra. Global Change Biology, 15(11), 2681-2693.

Pearson, R. G., et al. (2013). Shifts in Arctic vegetation and associated feedbacks under climate change. Nature Climate Change, 3(7), 673-677.

Povoroznyuk, O. et al. (submitted) Arctic Roads and Railways: Environmental and Social Consequences of Transport Infrastructure in the Circumpolar North. Arctic Science (in review).

Pääkkö, E. et al. (2019). Fell habitats. In: T. Kontula & A. Raunio (eds.) Threatened habitat types in Finland 2018: Red List of Habitats Results and Basis for Assessment. The Finnish Environment 2.2019. Finnish Environment Institute and Ministry of the Environment. Helsinki, pp. 153-185.

Rees, W. G., et al. (2008). Vulnerability of European reindeer husbandry to global change. Climatic Change, 87(1-2), 199.