FutureArcticLives - Future Arctic livelihoods and biodiversity in a changing climate

1. Excellence

1.1 Aims and Objectives

The overall objective of *FutureArcticLives* is to provide biological and economic forecasts and scenario assessments to assess in collaboration with local and indigenous people the impacts of climate and biodiversity change on the welfare and wellbeing of Arctic communities. *FutureArcticLives* will also explore management options under global policies and trends and in contexts of national policies increasingly favouring large-scale operations and other sectors constraining communities' adaptation possibilities. The project is therefore, guided by the overall question - what are the likely future impacts and adaptation possibilities for small-scale primary resource users in Greenland and Arctic Scandinavia in the face of climate and biodiversity change? The project focus on traditional Inuit hunters and small-scale fishers in Greenland, Saami reindeer herders in northern Sweden and Norway and the coastal Saami in Norway, but in the context of broader interests and commercial operations.

The following overall objectives are defined for individual case study areas and for a crosscutting policy study:

Traditional hunting and small-scale fisheries in Greenland: Assess the implications of climate change for biodiversity and the welfare of Greenland's traditional hunters and fishers (includes five specific objectives in WP1). People in smaller settlements along the coast of Greenland depend partly or entirely on hunting and small-scale fishing for food-security, health and income. However, quantitative assessments of the importance of hunting and fishing in Greenland are scarce and particularly the subsistence component is not visible in national income assessments. Historically, people have been able to shift to relying on other species when populations declined or management regulations tightened. However, such adaptive strategies are becoming increasingly constrained by climate-induced changes. Reduced hunting and fishing yields, because of climate change, conservation initiatives or both, may, therefore, severely affect the material wealth and general well-being of hunting households without being detected in national income statistics. Overall objectives therefore include quantifying reliance on wildlife and fish at the household and national economic level and assessing welfare implications in future scenarios of biodiversity change and development in other sectors making maps facilitating optimization of strategic investments in social services. The usefulness of Community Based Monitoring data will be explored to achieve this in a context of limited scientific data on population trends exploring the correlation between user generated data and scientific population surveys, and hence its usefulness as cost-effective indicators of biodiversity trends and input to biological advice on hunting and fisheries quota allocation. Information on species-specific vulnerability will be synthesized and forecasts for selected wildlife and fish populations made as input to regulations. Predictions will be made on likely prey target shifts of hunters and fishers as a result of regulations and climate change identifying species likely to come under increased pressure.

Reindeer herding in Northern Sweden and Norway: Assess the biodiversity and welfare implications of climate change for reindeer herding Saami in Northern Sweden and Norway (includes five specific objectives in WP2). Reindeer herding is of great importance to Saami communities, the only indigenous population of Scandinavia, both economically and, not least, culturally. Historically, herders have handled seasonal changing environmental conditions by moving herds across huge areas between winter- and summer grazing ranges. To cope with sudden vegetation shortages, difficult winter conditions, pests, and losses to carnivores, Saami reindeer herders have often practised herd size accumulation as a risk management tool. Climate models predict more variable future winter conditions in the Scandinavian Arctic. This has the potential to negatively affect reindeer husbandry, and make reindeer herding even more vulnerable to potential external limiting factors such a as forestry and predation by carnivores, negatively affecting the welfare of the Sami. Insights are urgently needed about likely future scenarios and welfare consequences facilitating necessary adaptions, and providing input to regulations governing reindeer husbandry. Objectives, therefore, include determining to what extent cultural and intrinsic values and income from reindeer husbandry are crucial to the modern Norwegian and Swedish reindeer herding households and their coping strategies. Combining data on climate, land use, predation and reindeer productivity with household survey data will enable forecasts on the viability of Saami herder livelihood strategies. Empirical results will be used as input in bioeconomic models to assess costs and benefits to Saami reindeer herders in various climate scenarios. Maps illustrating the welfare effect across Saami communities will be produced to reveal areas likely to be

negatively affected by climate change. Results will provide input to regulating authorities, especially regarding optimal design of economic instruments to reduce the risk of a collapse of reindeer pastoralism.

Traditional coastal fisheries in Northern Norway: Assess the biodiversity and welfare implications of climate change for coastal Saami in Northern Norway (includes four specific objectives in WP3). The Porsanger fjord in Northern Norway has experienced multiple social-ecological changes due to invasion of Greenlandic seal, loss of habitat for spawning fish, invasion of the Red King crab, increasing sea urchin populations and a vessel quota system from which the fjord has not recovered. However, there is limited information about how the coastal indigenous population, the Sea Sami, has adapted to and will attempt to mitigate further climate change in the fjord system. There is an urgent need to co-develop and test flexible harvest control rules and adaptive management strategies. Overall objectives therefore include conducting an ecosystem service assessment of loss and status of nature's contribution to local and indigenous communities, identifying local and indigenous conceptions of ecosystem health and indicators of wellbeing for coastal communities. How to accomplish ecosystem restoration goals in sub-Arctic areas will be assessed and an adaptive management plan for the Porsanger Fjord co-developed with local communities and local municipal and regional authorities in the form of an interactive ArcGIS map database designed in collaboration with ongoing regional coastal zone planning efforts by the County authorities. Such indigenous adaptation and mitigation processes can provide essential insights for coastal planning and management and constitute a model for indigenous adaptations to climate and biodiversity change elsewhere in the Arctic.

Cross-cutting study of the legislative and policy context of nature-based primary industries: Assess the policy synergy and tradeoff implications for adaptation (includes two specific objectives in WP4). The interests of nature-based primary industries such as hunting, small-scale fisheries and reindeer husbandry are often at odds with societal priorities at large. Policies and laws governing these activities operating in a hierarchy of priorities of other sectors and bureaucratic levels as well as international legislation and treaties, may therefore reduce the resilience and inhibit the adaptive capacity of communities. By analysing these relations across widely different sectors in Greenland, Sweden and Norway theoretically and practically generalizable information will be generated to inform policy development. Objectives therefore include analysing the synergies and trade-offs between policies and laws applicable to hunting, fishing and reindeer husbandry and their relation to those on biodiversity, climate and other relevant sectors at relevant levels. In addition, policy and legal barriers to nature-based solutions for mitigating and adapting to climate will be assessed, and the role of "agents of change" at local, regional and national levels evaluated. This will provide the legislative and policy context to objectives described above.

1.2 Relation to the call theme
FutureArcticLives responds to the BiodivERsA 2019-2020 call on "**biodiversity and climate change**" addressing the challenges highlighted in theme 1 "**Consequences of climate change on biodiversity and nature's contributions to people"**. The project does so by assessing the individual and combined effects of climate change on biodiversity and the associated effects on natures contribution to indigenous and rural Arctic communities at national and relevant scales, identifying thresholds beyond which collapse of traditional livelihoods will ensue, in case study countries. *FutrureArcticLives* also address themes 3 "**Potential of nature-based solutions for mitigating and adapting to climate change**" and 4 "**Synergies and trade-offs between policies on biodiversity, climate and other relevant sectors, and the role of agents of change**". This will be achieved by analysing current strategies of nature-based primary sector users (cf. above) and the extent to which these and nature based solutions are inhibited by multiple layers of legislation and policies, drawing out generalizable requirements and synthesising recommendations across the case study countries.

FutureArcticLives generates transnational added value originating from the combination of expertise brought together in the project and by considering multiple cases across Greenland and the Scandinavian Arctic enabling synthesis of future impacts of climate change on biodiversity and livelihoods in a range of different Arctic settings, policy contexts and primary industries. *FutureArcticLives* will generate common and local specific recommendations revealing commonalities as well as differences in how policies can be adjusted to facilitate adaptation to climate change at national and international levels and how local nature based solutions and agents of change can be promoted.

1.3 Concept and approach
Climate change is occurring faster in the Arctic than any other region (IPCC 2014), with tremendous consequences for Arctic biodiversity and the people that depend on it (AMAP 2011; CAFF 2013; AHDR

2014). Indigenous peoples have inhabited the Arctic for thousands of years and estimated still represent about 10 percent of the Arctic population. Recent years have seen an exceptional decline of sea ice volume, area, age and thickness while on land the climate is becoming unpredictable with increasing rain, snow and thawing events during winter (Arctic Council 2016). Climate change is causing rapid large-scale ecological and social changes (ACIA 2005; CAFF 2013; AMAP 2013; AHDR 2014). Observed changes include disappearance or dramatic modification of habitats, ecosystems and populations, shifts in species geographic range and the timing of ecological events and outbreaks of pests and disease (CAFF 2013). Examples include strong negative influence on seals, polar bear and narwhal - the basis for traditional Inuit communities in Greenland and extreme rain-on-snow events are causing increased mortality and range displacement negatively influencing reindeer-herding Saami in Northern Scandinavia. Furthermore, climate-linked moth larvae outbreaks kill large areas of birch forests, shrub lands and berry heath in Sápmi in Northern Norway, affecting reindeer and sheep pastures, moose and ptarmigan populations, and hence heading, hunting and harvesting activities. Climate and biodiversity change can undermine established production patterns of hunting, fishing, gathering and herding by Arctic communities negatively influencing their welfare and wellbeing (ECONOR 2008). Climate change furthermore occurs in a context of far-ranging economic, cultural and political change (ECONOR 2015), including commercial fisheries and other sector activities such as infrastructure and housing development, mining and forestry taking place in the same areas.

Around 10 million people live in the Arctic today, of which 2.4 million live in Greenland, Iceland, Arctic Scandinavia (defined as the northern regions of Norway, Sweden and Finland), and adjacent parts of Russia. All of the above-mentioned countries except Iceland have indigenous peoples living within their Arctic territory. However, although there are over 40 ethnic groups in the total Arctic region this project focus on the Greenland Inuit (Kalaallit) and the Saami in Arctic Scandinavia. The combination of ecological and societal changes facing small-scale rural users and indigenous groups in this region may well surpass their resilience and adaptive capacity and therefore needs urgent assessment to reduce adverse social and ecological outcomes (Arctic Council 2016). The diversity of problems across the Arctic presents a significant challenge for developing cross-sectoral and cross-scale solutions (AMAP 2016). Both physical and economic forecasts and scenario assessments are needed to assess impacts of climate and biodiversity change on Arctic communities and explore adaptive management options under global policies and trends (NRC 2014; ECONOR 2015). Particularly social science research describing the systems that are part of ongoing changes is underrepresented and needed to inform decisions (NRC 2014; Arctic Council 2016). Hence, this project will mainly focus on the social aspects of the social-ecological system guided by the overarching questions: What are the likely future impacts and adaptation possibilities for small-scale primary resource users in Greenland and northern Sweden and Norway in the face of climate and biodiversity change? Focus will be on traditional hunting, small-scale fishing and reindeer husbandry as carried out by rural and indigenous populations in these areas, but in the context of broader interests and commercial operations.

1.4 Linkages to other national and international projects/efforts
From 2014-2019, ARTEK in Greenland, the Technical University of Denmark and Aalborg University, both partners in *FutureArcticLives*, co-funded by the municipality of Avannaata and the Greenlandic Government carried out research on the interrelation of local livelihoods and societal infrastructures. The project developed policy recommendations for new investments and initiatives in settlements (Hendriksen & Hoffmann 2018). *FutureArcticLives* will continue this work (WP1). UoG – a partner in *FutureArcticLives*, was the main resource for the Greenlandic part of the SLiCA-1 project conducting more than 8,000 interviews among Inuit, Saami and indigenous peoples of Chukotka and the Kola Peninsula between 2001 and 2008. SLiCA-1 documented significant economic, nutritional, social, cultural, identity and integrational aspects of subsistence activities among Arctic indigenous peoples. Using qualitative indices SLiCA-1 for example showed that more than half of Greenlandic households' meat and fish consumption was harvested by household members. SLiCA-2 is in planning allowing evaluation of changes through comparison with SLiCA-2. *FutureArcticLives* will complement the efforts of SLiCA by quantitatively assessing future trends. *FutureArcticLives* will also supplement efforts endorsed by the Arctic Council exemplified by the Arctic Human Development (AHDR 1 & 2), Arctic Social Indicators (ASI 1 & 2), and Economies of the North (ECONOR 1, 2, & 3) reports that several partners in *FutureArcticLives* have been involved in. These initiatives have provided essential knowledge about living conditions and the quality of life in the Arctic – not least about hunting, fishing and herding and the role of these traditional harvest activities and how they interact with market economic activities. The first three volumes of ECONOR (from 2006, 2008, and 2015) all contained assessments and analyses of the interdependency of subsistence and market economies in the Arctic. ECONOR 4 is planned to be published in 2021 and will include a follow-up analysis of these aspects and *FutureArcticLives* will provide basis for further developments in that direction (WP1). From 2006-2009,

Norwegian University of Science and Technology (NTNU) (a partner in *FutureArcticLives*) funded by the Norwegian Research Council, carried out research on the economics of Saami reindeer herding in Norway with a particular focus on overgrazing and the role of market- and non-market values of reindeer. Results showed that non-market values are of great importance in some reindeer herding areas and that policies that fail to consider this may fail to promote sustainable reindeer herding (Johannesen and Skonhoft 2011). *FutureArcticLives* will develop this research further by including the impact of climate change on the economy of reindeer herding (WP2). Furthermore, *FutureArcticLives* will conduct new updated surveys, including comparisons between Norwegian and Swedish reindeer herding, and apply improved evaluation methods, which will form a stronger basis for future policy recommendations. *FutureArcticLives* incorporates existing data and network of the *Fávllis* project (funded NRC 2009-2011) in which the Arctic University of Norway UiT) (a partner in *FutureArcticLives*) in collaboration with the coastal Saami center, *Mearrasiida*, established a local ecological knowledge database for Porsanger Fjord. Mearrasiida and the Norwegian Institute for Marine Research (IMR) is currently working to restore marine ecosystems in Porsanger fjord using nature-based solutions, through the Porsangerfjord 2.0 project (IMR Feasability study Strand 2019). The ongoing project *CoastChange* (funded Fram Center 2019-2021) is making a new regional marine strategy plan, and *FutureArcticLives* will contribute to this initiative (WP3).

1.5 Overall methodology

Quantitative aspects of the project (in WP1-3) uses a combination of primary data collection through household questionnaire surveys and choice experiments and detailed register data combined in ways not previously attempted to produce new datasets. The initial part of this analysis will involve descriptive statistics and graphical illustrations describing variation and co-variation between species, localities and over time. In addition, households will be divided into income and user types for the purpose of assessing inequality and comparing groups in terms of vulnerability to climate and biodiversity change. Econometric regression analysis will enable comparative analyzes and test of hypotheses regarding the importance of households' economic, socio-demographic and geographical characteristics as well as the effects of climatic conditions and catch regulation. Bioeconomic models and Monte Carlo simulations will be applied to examine the household and national level implications in future scenarios. Qualitative aspects of the project will explore conceptions of nature and its status and trends based on local and indigenous knowledge and practices as alternatives to the notion of capital dominating the ecosystem service approach (IPBES 2019). Narratives of wellbeing will be recorded using audio-visual approaches taking departure in concepts of "being" and experience-near relations to the natural environment (WP3). Approaches from policy and legal studies and political ecology, drawing on applicable law, including case law, and relevant policy frameworks will be combined for policy analysis (WP4). Theoretically, this rests on an understanding of the social, economic and environmental context as formed by multiple interests and actors taking departure in the policy sciences institutionalist school as well as legal analysis. Focus will be on highlighting both the formal (organizational, legal and policy) and informal (norms and practices) governance system and potential path-dependent features serving as lock-in to the present system (North 1994; Young et al. 1999; Pierson 2000). This perspective thus contextualizes stakeholders within the system in which they make their decisions highlighting that possibilities for actors to work as "agents of change" are shaped by the institutional context, in which specific paths of change may be either promoted or inhibited. Case studies will explore potentially path-dependent as well as more easy-to-shift features of the system.

1.6 Organization of the project

This proposal involves three case-based work packages (WPs) addressing the call's Theme 1 in three different countries to ensure transboundary added value, focusing on three indigenous (sub-) groups relying extensively on natures contribution to people. The fourth WP will address Themes 3 and 4 across the three case studies and relevant countries. A fifth WP will be devoted to managing the project including interacting with the projects steering groups, facilitating data management, dissemination and policy engagement.

Work packages:
WP1. Climate change implications for biodiversity and the welfare of Greenland's traditional hunters and fishers. Lead: University of Copenhagen (UCPH).
Sea ice cover along Greenland's coasts is expected considerably reduced already by the middle of the 21st century affecting bird, mammal and fish populations, with some effects already observed (CAFF 2013). Preceding climate change, some species have been subject to high hunting pressure, leading to introduction of quotas and repeated tightening of hunting regulations. People in smaller settlements along the coast depend partly or entirely on hunting and small-scale fishing (Rasmussen 2005; ECONOR 2008; Hendriksen 2013). When quotas restrict access to some species, the catch of other species increases as seen for birds

and mammals when quotas for small-scale fishing were reduced favouring larger vessels. Such adaptive strategies are increasingly constrained by climate-induced population change. Quantitative assessments of the importance of subsistence hunting and fishing in Greenland are scarce and few studies have examined how climate change will affect households' food security and total income or evaluated their adaptation strategies (AHDR 2014). It is well known that subsistence hunting and fishing are important to the welfare and health of many households in Greenland yet this is not visible in national income assessments (ECONOR 2008; ASI 2010). Reduced hunting and fishing yields, either as a consequence of climate change, conservation initiatives or both, may therefore severely affect the material wealth and general well-being of hunting households without being detected in national income statistics (ECONOR 2008; ASI 2010). Monitoring climate change impacts and species trends is furthermore constrained by the geographical scale and biophysical characteristics of Greenland. However, local user generated observations constitute a rich source of information about stock development as well as climate change. Hunter catch records constitutes one such underutilised source of quantitative information. However, assessment of the accuracy of this data as an indicator of biodiversity trends is needed. See specific objectives in section 3.1.

WP2: Biodiversity and welfare implications of climate change for reindeer herding Saami in Northern Sweden and Norway. Lead: Swedish University of Agricultural Sciences (SLU).
The Saami is the only indigenous population of the Scandinavian Arctic of 50-60.000 people in northern Norway and 30-40.000 in Sweden. Reindeer husbandry is an exclusive right of the Saami and is today a modern business, geared mainly towards meat production by family companies. Reindeer, with some exceptions follow an annual migratory cycle moving between grazing grounds allowing natural replenishment requirering large areas. In both Norway and Sweden, the Reindeer Husbandry Act provides the Saami right to let their reindeer graze on about 40% of the land area. Climate change, forest management, and predation may negatively affect reindeer husbandry and hence, Saami welfare. Climate change is projected to increase plant productivity in the spring, fall, and summer, and may increase reindeer body mass (Tveraa et al. 2013). However, as lichen availability in winter is critical for reindeer survival and determines the maximum possible reindeer herd size (Bostedt, 2005), climate change affecting winter lichen availability could reduce maximum viable herd sizes. Furthermore, spruce trees must be older than 80-100 years to support high tree lichen mass. Forests in northern Scandinavia are typically clear-cut approximately every 80-120 years, imposing a negative unidirectional externality on reindeer husbandry, by reducing winter grazing resources. In addition, there has been bark-beetle outbreaks and large-scale tundra fires, both of which are likely to become more frequent as the climate warms. Herders' ability to adapt depends on the flexibility to undertake seasonal migration, which in turn is affected by loss of grazing areas, predation, and government regulations. In Sweden and Norway, land-use changes have been identified as restricting reindeer winter foraging (Riseth et al., 2016). Hence, as the Arctic climate shifts into a new regime, insights are urgently needed about likely future scenarios and welfare consequences for Saami communities to enable necessary adaptions. See specific objectives in section 3.1.

WP3: Biodiversity and wellbeing implications of climate change for coastal Saami in Northern Norway. Lead: The Arctic University of Norway (UiT).
The Norwegian fisheries governance system recognises limited fishing rights for small-scale fishers in the northern part of Norway designated as a Coastal Saami Fisheries Policy Area, acknowledging the state's obligation to preserve Saami culture. Climate change may affect habitats, growth and distribution of commercial marine species, and as created ecosystem changes along the Norwegian coast (Kortsch et al. 2015). The consequences of biodiversity and ecosystem change for the wellbeing of the coastal Saami and other people in the sub-arctic region, their resilience and/or adapting capacity, are uncertain. Studies have identified tipping-points on the social-ecological timeline of the Porsanger fjord in this region, due to invasion of Greenlandic seal in the late 1980s and the introduction of vessel quota system in 1990, from which the fjord has not recovered (Brattland et al. 2018). The habitat loss, invasion of Red King crab, and radical institutional change in the harvest management system, has changed the ecosystem beyond recognition for local inhabitants. Flexible ecosystem management is needed to maintain and utilise biodiversity in the sub-Arctic but is not provided by current management regimes. Substantial natural fluctuations in the sub-Arctic region, and possible impacts of climate change, calls for management systems where different species can be targeted at different time and by different gears, depending on the state of the ecosystem and market conditions. Thus, the main objective is to deliver input to future adaptive ecosystem-based management for the Porsanger fjord system based on local co-developed indicators and criteria. Furthermore, while most municipals planning activities in Northern Norway follow EU strategies for blue growth, through aquaculture and salmon farming, a coastal Saami organization (Mearrasiida) is working with the Norwegian Institute for

Marine Research (IMR) to restore the marine ecosystem in Porsanger fjord using nature-based solutions such as facilitating regrowth of microalgae and kelp beds. Development of indigenous adaptation and mitigation attempts can provide essential insights for coastal planning and management and constitute a model for indigenous adaptations to climate and biodiversity change elsewhere in the Arctic. See specific objectives in section 3.1.

WP4: Assessing the policy synergy and tradeoff implications for adaptation. Lead: Umeå University (Umeå). Nature-based primary industries, sectors and activities, including hunting, fishing and reindeer husbandry, are embedded within society and are subject to much wider interests (Delany et al. 2012, Hendriksen 2013). Some of these interests are at odds with each other or societal priorities at large (Hendriksen and Jørgensen 2015). Policies and laws governing these activities operate in hierarchy of priorities of other sectors and bureaucratic levels, including EU and international legislation and treaties that may constrain resilience and inhibit adaptation. This WP will, therefore, review the synergies and trade-offs between policies and laws applicable to hunting, fishing and reindeer husbandry with other policy areas, incl. policies related to biodiversity, stock management, climate and other relevant sectors, focusing on the aims expressed in each policy area and the extent to which these can be undertaken given other policy areas (Pettersson and Keskitalo 2013). As an example at the national level, implementation of policies favouring large-scale commercial interests has disadvantaged costal-communities fisheries, and under-prioritisation of community infrastructure development has inhibited exploitation of changing local fish resources (Hendriksen and Hoffmann 2018). By analysing these relations across widely different sectors in Greenland, Sweden and Norway theoretically generalizable information as well as information on the specific cases can be generated to support decision-making. See specific objectives in section 3.1.

WP5: Project management. Lead: University of Copenhagen (UCPH).
This WP will be devoted to managing the project, incl. necessary sub-contracts with Greenlandic partners and ensuring fulfilment of commitments in the grant agreement. This includes interacting with BiodiveERsA's secretariat, ensuring adherence to ethical requirements, and development of a project data management plan, dissemination strategy and exploitation plan for project results through identification of policy interphase pathways to impact. WP5 will also arrange executive committee meetings between WP leaders and an annual meeting of the consortium tracking progress and scientific quality and engaging in the policy process. National steering groups will be selected by each WP leader (overlapping in WP4) to facilitate stakeholder involvement. WP5 will also coordinate preparation of periodic and the final report including financial and progress reports and make updated plans for dissemination and exploitation of results that are dynamic documents that will evolve throughout the project. See specific objectives in section 3.1.

1.7. How gender dimensions are taken into account

While most projects on hunting, fisheries, and herding focus on the role and capacities of males, *FutureArcticLives* recognises the roles, knowledge and capacities of both men and women in livelihoods in Arctic communities. Not least in the current transition between traditional and modern lifeforms, traditional gender roles are under pressure and women play important roles supporting local sustainable development. Gender dimensions will, therefore, be included when relevant - e.g. in policy analysis, interviews and workshops and policy recommendations. The project will furthermore include both male and female participants of different age group categories, as they tend to use different natural resources and have knowledge about different topics. *FutureArcticLives* includes six male and seven female named scientists.

2. Impact

2.1. Expected impact – advancement beyond the state of the art

Through the described actions, *FutureArcticLives* will support the CBD Archi targets and post-2020 global biodiversity agenda. *FutureArcticLives* is also aligned with the objectives of UN's Framework Convention on Climate Change (UNFCCC), and EU's Arctic policy. Insights of *FutureArcticLives* will support implementation of UN's Sustainable Development Goals (SDGs) (goals 13-15 as well as 17) and contribute to efforts to identify and develop Arctic Sustainable Development Goals by the Arctic Council's Working Group on Sustainable Development (SDWG). *FutureArcticLives* will hence provide input to biodiversity conservation, sustainable development and blue growth in the Arctic (WWF 2018). It is for instance expected that working groups of the Arctic Council will be interested in the results, including: 1) the Arctic Monitoring and Assessment Programme (AMAP); 2) Conservation of Arctic Flora and Fauna (CAFF); and the 3) Sustainable Development Working Group (SDWG). The Arctic Economic Council (AED) is also a highly relevant body to develop the project results further. The results on reindeer herding in northern Sweden and

Norway and fisheries management and ecosystem restoration in northern Norway will provide input to regulating authorities, not only on the central level in the respective countries but also on the regional (län/fylke) level, especially regarding optimal design of economic instruments and adaptive management strategies. It is also expected that the project results will be of interest to the Saami Council, the pan-Nordic organization for the Saami people, with Saami member organizations in Finland, Norway, Russia, and Sweden.

2.3. Communication and outreach plans

The objective is to ensure that general information about *FutureArcticLives* and its research outcomes are available and accessible to target audiences in different sectors in appropriate formats to absorb and ensure uptake and implementation of knowledge gained. All partners will contribute to the development of a dissemination strategy (see Task 5.5) and an exploitation plan (see Task 5.6) to ensure a cohesive and concerted effort. The Dissemination Strategy (DS) will ensure that results and co-created knowledge is widely disseminated to the appropriate target audience, at appropriate times and using the most suitable methods. The DS consists of an internal and an external part. Internal dissemination and full disclosure about work progress and results will promote cross-project synthesis by informing partners about work progress, bottlenecks and obtained results, and transferring knowledge for carrying out activities and exploiting results. The external DS aims to enhance transfer of co-created knowledge and exploitation of results for development of management policies and mitigation strategies for maximum project impact. To this end, it is crucial that the outcomes are disseminated, promoted and accepted by governmental, private and academic sectors in relevant domains including natural resources management, social services and climate change, mitigation and adaptation domains. This will be enhanced through the national steering groups (see section 3.2.). A preliminary target audience has been identified incl.: 1) Scientific research communities active in the area of biodiversity, ecosystem services and climate change in the Arctic; 2) Relevant management bodies, incl. the government sector and NGOs; 3) Politicians with a specific interest in indigenous communities, biodiversity and climate change in the three countries; 4) The general public, in the three countries as well as world-wide (particularly other countries with Arctic populations); 5) The local public and indigenous communities, such as Inuit and Saami organizations in Greenland, Norway and Sweden, incl. small communities with a personal interest in ecosystem service provision change; 6) The media, incl. journalists with an interest in Arctic research and ecological, social and economic science output. Specific contact persons will be identified in producing the DS along with detailed pathways to impacts. However, all countries participating in the Arctic Science Ministerial in 2020 are in the target group for the DS. Some stakeholders (i.e. government and private sector, scientists and community members) will be included in the project through the NSG's (see section 3.2). Project partners are furthermore already engaged with these stakeholders through past and ongoing research projects (see section 1.4). As a flagship dissemination channel, the project website will be used for publicizing the project and awareness creation. *FutureArcticLives* aims to publish results open access in high quality peer-reviewed journals. Publications will be reviewed internally prior to submission for quality assurance and to enhance internal information transfer. The press releases and opinion pieces taking departure in each publication will be the basis for development of stories for the mass media. Dissemination material for use towards decision makers and other stakeholders will be prepared by individual partners based on publications. Scientists will be encouraged to attend conferences, exhibitions and seminars and present *FutureArcticLives* and its results both during and after project end. Relevant international events include Arctic Science Summit, International Congress on Arctic Social Sciences (ICASS) and the Barents Forest Forum.

FutureArcticLives will enhance the projects societal impacts by developing of an Exploitation Plan (EP) describing how project outputs will be further developed and used after project end, who will be involved and what rights and obligations are connected to the results. *FutureArcticLives* results will be useful to a range of other projects and programs and for policy development on the national, European and pan-Arctic level. Preliminary expected exploitable results include: 1) Assessment of user observations and knowledge as a cost-effective indicator of ecosystem and biodiversity trends and guidelines for selection of ecosystem indicators of wellbeing and development and implementation of community-based monitoring schemes. 2) Synthesis of species-specific climate vulnerability and forecasts for specific species as input to natural resource management. 3) Predictions of climate-feedbacks identifying species likely to come under increased pressure due to shifts in specific locations facilitating conservation planning. 4) Maps of welfare/well-being impacts in future scenarios of change facilitating optimization of strategic investments in social services. 5) Input to the development of future regulations and adaptive management plans for biodiversity conservation ensuring the long-term interests of society as well as rural and indigenous groups relying on nature's contribution. 6) Identification of policy adjustments and investments necessary to eliminate barriers to

adaptation of nature based solutions and involvement of local agents of change. Key results of *FutureArcticLives* will be compiled and exploitable results presented to policy-makers on national and regional levels including through individual meetings and at strategic events at the Arctic Circle and Arctic Frontier policy sessions and at the Arctic Council secretariat for its Working Groups as well as for Indigenous peoples' organizations. Success will be measured through use of results by stakeholders including policy makers in the focus countries as well as international governance bodies and coordination programs.

3. Implementation

3.1. Work breakdown structure

Work package:	1	Lead beneficiary		UCPH			Start	M1	End:	M36
Title	**Climate change implications for biodiversity and the welfare of Greenland's traditional hunters and fishers**									
Participant number	1	2	3	3a	4	5	6	7	8	9
Participant	UCPH	SLU	DTU	UoG	NTNU	UMU	LTU	AAU	UIT	NINA
Person months	22		2	1½						

Overarching objective: Assess climate change welfare impacts on traditional hunting and small-scale fisheries households and hence the feasibility of traditional livelihood strategies and the sustainability of small settlements along the coast of Greenland delivering input to development of future regulations that best possibly ensure biodiversity conservation and serve the long-term interests of society and specific user groups relying on nature's contribution.

Description of activities:

Task 1.1: Hunter catch records as source of information about wildlife stock development (UCPH, UoG).

Objective: Evaluate hunter catch records as a user-generated source of monitoring data on species population trends to inform management decisions and assist overcoming inherent data constraints.
Activities: 1) Collate time-series data on catch per month of individual species by location from individual hunters and fishers recorded in the Greenlandic hunting license (Piniarneq) and catch database (LULI) available for the period 1994-2019. 2) Compare wildlife population trends based on hunter catch time-series (controlling for effort) to point estimates based on scientific monitoring surveys obtained from Greenland Institute of Natural Resources. 3) Review scientific literature on individual species expected response to climate change. 4) Combine data and insights, including climate data, to generate forecasts about future population trends for each relevant species. Climate data, including temperature, precipitation, wind speed, cloud cover, air pressure, humidity and snow cover will be obtained from the Danish Meteorological Institute (DMI) available for the period 1958-2019. Ice charts for the period 2000-2019 are also available from DMIs homepage and older ice charts can be obtained.

Task 1.2: Evaluate household reliance and national economic contribution of fish and wildlife (UCPH, UoG).

Objective: Determine to what extent cash and subsistence income from individual species contribute to hunting households' total annual income as well as Greenland's national economy.
Activities: 1) Valuate the contribution of hunting and fishing at the household level based on catch (cf. task 1.1) of each species and its market price. Information about prices will be obtained from local trading points on a monthly basis to the extent available. Differentiation between cash and subsistence value will be made based on records from local buying stations for primarily sealskin and fisheries landings obtained from the Greenlandic fisheries license control (GLFK). 2) Obtain information about monthly household income from each source for all individuals registered in the hunting licence register for the period 1994-2019, from the Tax Agency. 3) Determine the cash and subsistence contribution (reliance) of each income source by month and individual as the share in total household income.

Task 1.3: Evaluate determinants of reliance and hunting yield (UCPH, UoG).

Objective: Compare reliance on hunting and hunting yield composition over time and between locations and examine to what extent species substitute each other, how this is influenced by climate, hunting regulations and trade prices and evaluate potential biodiversity implications.
Activities: 1) Obtain information about management measures including closed seasons, quotas and local regulations enacted on a monthly basis for the period 1994-2019 from the Ministry of Fisheries, Hunting and Agriculture (MFHG). 2) Acquire data on subsidies and aid schemes in relation to catch and fisheries as well as pensions, housing assistance and other social benefits received at the household level from MFHG and the Tax Agency. 3) Get local price data per month for fuel and ammunition by location throughout Greenland in the period 1994-2012 from Greenland Statistics. 4) Conduct simple cross-

correlation tests to evaluate relationship between catch and reliance of different species. 4) Construct time-space models to predict catch and reliance on different species based on mentioned explanatory variables.

Task 1.4: Future scenario analysis on household welfare (UCPH, UoG)

Objective: Conduct future scenario analysis and simulations to predict household welfare, societal aggregated economic and biodiversity consequences of reduced access to individual species, due to climate change and proposed hunting regulations.

Activities: 1) The literature review (task 1.1) will provide insight on likely range restrictions, population trends and possible extinctions due to climate change and provide a basis for future scenarios, although additional assumptions will be needed. 2) Expectations regarding development of the tourism, transport and raw material industry (i.e. mining), will form basis for testing scenarios regarding the significance of this source of income for hunters in different areas and with different ages and educations. 3) Simulation approaches will be used to predict welfare consequences in future climate scenarios with altered access to species and scenarios with new income sources.

Task 1.5: Determine whether particular groups of hunters and fishers, such as highly specialised hunters in remote communities, are more exposed to these impacts than others (UCPH, UoG).

Objectives: Determine whether particular groups of hunters and fishers, such as highly specialized hunters in remote communities, are more exposed to these impacts than others.

Activities: 1) Households will be divided in income groups (cf. task 1.4). 2) Similarly, distinction will be made between locations and between occupational and recreational hunters based on hunting license type. 3) Cluster or latent class analysis will be conducted to identify hunter type specializations based on catch and methods. Data from SLiCA can furthermore be used. 4) Compare groups in terms of vulnerability to change measured as the income gap or welfare decline experienced in various future scenarios.

Work package:	2		Lead beneficiary		SLU		Start	M1	End:	M36
Title	**Biodiversity and welfare implications of climate change for reindeer herding Saami in northern Sweden and Norway**									
Participant number	1	2	3	3a	4	5	6	7	8	9
Participant	UCPH	SLU	DTU	UoG	NTNU	UMU	LTU	AAU	UIT	NINA
Person months		11			6					

Overarching objective:

Assess the biodiversity and welfare implications of climate change for reindeer herding Saami and hence the risk of collapse of reindeer pastoralism in Northern Sweden and Norway and facilitate necessary adaptations.

Description of activities:

Task 2.1: Assess the future viability of reindeer herding as the basis for Saami livelihoods (SLU, NTNU).

Objective: Assess the viability of Saami herder livelihood strategies and the risk of a collapse of reindeer pastoralism based on productivity forecasts.

Activities: 1) Review literature on the impact of climate driven vegetation change on reindeer productivity. 2) Review literature on the impact of climate change on losses of reindeer to carnivores. 3) Collect and structure data on reindeer production (reindeer numbers and weights) and losses to carnivores over time, and compare trends across villages and countries. Data is available for the period 2000-2020 at the Saami reindeer herding community level/district level. 4) Obtain and organize climate variables describing environmental conditions and vegetation productivity in reindeer herding areas. These include the North Atlantic Oscillation index, local weather data from the Norwegian Meteorological Institute, the Swedish Meteorological and Hydrological Institute and satellite based observations of vegetation. 4) Combine data and make a model enabling productivity forecasts.

Task 2.2: Assessment of the importance of reindeer herding (SLU, NTNU).

Objective: Determine to what extent cultural and intrinsic values and income derived from reindeer husbandry are important to the modern Norwegian and Swedish reindeer herder household including as an adaptation strategy in the face of climate change.

Activities: 1) Develop a household survey to quantify market and non-market values of reindeer husbandry. 2) Implement the survey in selected reindeer herding areas covering productive and non-productive environments and less and more carnivore dense areas. 3) Compare the role of market and non-market values across areas. 4) Combine survey data with existing data on vegetation and climate, herd size, losses to carnivores, and income for individual herders. Data on income and costs are available

for Norway from the Norwegian Agriculture Agency and for Sweden from the Sami parliament of Sweden (Sametinget). 5) Develop a bioeconomic model capturing the impact of climate change on reindeer productivity and predict the economic impact of climate changes considering also the non-market values. This constitutes a new contribution to the literature and important insights for development of Saami adaption strategies (task 2.3) and policy responses (task 2.4).

Task 2.3: Identify effective adaption strategies depending on geographical area (SLU, NTNU).

Objective: Determine how the Saami adapts to varying impacts of climate change on grazing across geographical areas. The impact of climate changes on vegetation may differ across geographical areas, in both strength and direction. Consequently, the economic impact and optimal adaption strategies may also differ between geographical areas.

Activities: 1) Design and include in the household survey (task 2.2) a choice experiment to reveal the optimal adaption strategy as seen by the individual herder depending on how the herder weigh non-market values and harvest income identifying adaption strategies (e.g., adjusting herd size, introducing supplementary feeding) and how these differs between geographical areas. The design of the choice experiment will match the design of the climate and reindeer productivity analysis, to enable an empirical relationship between the two analyses. 2) Determine the optimal adaption strategy using the bioeconomic model (task 2.2), considering that climate changes impacts on vegetation and reindeer productivity differs across geographical areas.

Task 2.4: Predict welfare consequences of climate change across Saami communities (SLU, NTNU)

Objective: Conduct future scenario analysis and simulations to predict the impact of climate change and the proposed adaption strategies and compare welfare effects across different geographical areas.
Activities: 1) Apply the output of the literature reviews and forecasts (task 2.1), as input to development of future scenarios of Saami reindeer herding in Norway and Sweden. 2) Use the extended bioeconomic model (task 2.3) to make simulations based on these future scenarios and predictions of the welfare consequences. 3) Allow for altering predator densities to account for any differences in welfare consequences between areas with more or less dense carnivore populations.

Work package:	3	Lead beneficiary	UiT			Start	M1	End:	M36
Title	**Biodiversity and wellbeing implications of climate change for coastal Saami in Northern Norway**								
Participant number	1	2	3	3a	4	5	6	7	8	9
Participant	UCPH	SLU	DTU	UoG	NTNU	UMU	LTU	AAU	UiT	NINA
Person months									9	

Overarching objective: Provide input to the development of an adaptive ecosystem-based approach for indigenous and small scale marine resource management in northern Norway

Description of activities:

Task 3.1: Marine ecosystem contributions to coastal Sami culture and livelihoods (UiT)

Objective: Assess the degradation of and current state of marine ecosystem services supporting indigenous and local culture and livelihoods in the Porsanger fjord area.
Activities: 1) Assess marine resource degradation and restoration efforts regarding fish and other ecosystem services by comparing the current state to two baseline period the 1970s (long term) and 2004 (short term). 2) Conduct a literature review and reinterpretation of existing sources for provisioning and cultural ecosystem services assessing the contributions to diversification in local economies, and degree of ecosystem health and wellbeing maintained in relation to the two baseline situations.

Task 3.2: Wellbeing and ecosystem services for coastal Saami livelihoods (UiT).

Objective: Identify local and indigenous conceptions of ecosystem health and indicators of wellbeing for coastal communities.
Activities: 1) Collect personal and collective narratives using mapping and visual ethnography techniques, as well as utilisation of existing databases on local ecological knowledge from previous projects and the review (task 3.1) to identify local perceptions of drivers of change and clarify balances of ecosystem services in the two baseline periods. 2) Scale up audio-visual narratives and map biography using different trajectories of mediation to inform a broader audience about local and indigenous concerns for the environment, and 3) as data for translating experience near knowledge to aggregated indicators for management purposes (task 3.4), through the conceptual framework of ecosystem services.

Task 3.3: Harvest control rules and adaptive local management initiatives in Porsanger (UiT).

Objective: Describe existing Harvest Control Rules (HCR) and identify how these may be adapted to fisheries management in the Porsanger fjord.

Activities: 1) Develop a scenario model to investigate how different management strategies may affect biodiversity and local communities exploiting the managed systems. 2) Explore alternatives to the current quota-based management regime by developing simple and transparent Harvest Control Rules (HCR), where catch rates are given by rules based on indicators developed by involving stakeholders in the discussion of the proper rules, indicators and objectives to be used.

Task 3.4: Policy implications of an adaptive ecosystem-based management approach for indigenous and small-scale marine resource management (UiT).

Objective: Develop a proposed management plan for the Porsanger fjord, with suggestions for how it can be adapted to other areas in the same region.

Activities: 1). Build on Tasks 3.1-3) to present an interactive map-based management plan using ArcGIS and discuss an adaptive ecosystem-based management approach for the Porsanger fjord with relevant decision-makers. 2) Evaluate the policy implications of an adaptive ecosystem-based management approach for marine resource management in coastal Saami areas. 3) Communicate the results and the proposal to relevant management institutions arenas (Norwegian fisheries ministry and Sami Parliament, as well as relevant municipalities and regional authorities).

Work package:	4	Lead beneficiary		UMEÅ		Start	M1	End:	M36
Title	**Assessing policy synergy and tradeoff implications for adaptation**								
Participant number	1	2	3	3a	4	5	6	7	8	9
Participant	UCPH	SLU	DTU	UoG	NTNU	UMU	LTU	AAU	UIT	NINA
Person months			5				2	4	5	2½

Overarching objectives: Study the legislative and policy context to WP1-3 and conduct case studies contextualising some of the results in WP1-3 without necessarily building on those.

Description of activities:

Task 4.1: Analyse legal and policy synergies and trade-offs

Objective: Analyse the synergies and trade-offs between policies and laws applicable to hunting, fishing and reindeer husbandry and their relation to those on biodiversity, climate and other relevant sectors at relevant levels.

Activities: 1) Combine approaches from policy and legal studies and political ecology drawing on applicable law, including case law and relevant policy frameworks to analyse the national, international, EU, and national legal and policy context. 2) Compare the Norwegian Finnmark Act case and the protection it affords local renewable resource users with that in northern Sweden under general Swedish and municipal regulation systems. 3) Analyse relationships between Greenlandic policies and regulations governing fisheries, hunting, tourism, mining, marine transport and infrastructure development at the local and national level. 4) Describe implications, barriers and constraints created by policies and regulations for local communities' ability to exploit the local resource base and/or engage in the other sectors mentioned.

Task 4.2: Possibilities and barriers for adaptation and mitigation for actors at different levels

Objective: Discuss the extent to which policy or legal change and Nature Based Solutions (NBS) for mitigating and adapting to climate change may be undertaken, and the role for "agents of change" at local, regional and national levels.

Activities: 1) Conduct interviews with actors at the local level in case study areas to assess the potential for NBS. Interviews will also address contexts of particular historical, cultural and ethnic dimensions, influencing the ways institutional processes are interpreted and reacted to locally. 2) Conduct interviews at the regional, national and potentially EU level, to evaluate the extent to which actors at the different levels can implement NBS. 3) Describe lessons learned from cases in Greenland, Sweden and Norway. 4) Qualify results and develop policy recommendations by engaging with and presenting to individual stakeholders or through workshops as appropriate depending on location.

Work package:	5	Lead beneficiary		UCPH		Start	M1	End:	M36
Title	**Project management and coordination**								
Participant number	1	2	3	3a	4	5	6	7	8	9
Participant	UCPH	SLU	DTU	UoG	NTNU	UMU	LTU	AAU	UIT	NINA

Person months	5	3			2		3	

Overarching objectives: Ensure achievement of all objectives through sound and effective project management striving to foster strong and vibrant collaboration between partners, timely high quality deliverables and facilitate synthesis of project results disseminated to the appropriate audience for exploitation of results and maximum impact.

Description of activities:

Task 5.1: Coordinate project management and meetings (UCPH)

Objectives: Manage the project in accordance with the grant agreement to ensure timely achievement of milestones, high scientific quality in deliverables and overall objectives through monitoring progress, and coordinating with BiodivERsA's secretariat.

Activities: 1). Prepare the consortium agreement based on the DESCA model and facilitate Grant Agreement (GA) negotiations with beneficiaries and sub-contractors. 2) Administer and distribute BiodivERsA's financial contribution in its allocation between partners and activities, in accordance with the GA and decisions by the General Assembly. 3) Develop the project website. 4) Organize project meetings including a kick-off, mid-term and project end-meeting (i.e. one physical meeting of partners per year) as well as meetings of the executive committee approximately every 3 months (via teleconference or face-to-face). 5) Coordinate preparation of periodic and the final report including financial and progress reports and updated plans for dissemination and exploitation of results.

Task 5.2: Develop an Ethics Requirement Report (Executive Committee)

Objectives: Develop an Ethics Requirement Report (ERP) to ensure that *FurureArcticLives* adhere to research principles for engaging with indigenous groups and local knowledge as well as general ethical principles.

Activities: 1) Review principles developed by IASSA (International Arctic Social Science Association) and others for engaging with indigenous populations. 2) Review relevant ethical guidelines and develop the ERR describing principles for inclusion and exclusion of human subjects and develop the informed consent sheets to be used. 3) Obtain research permission from the appropriate local and national authorities. 4) Submit to ethical review by relevant institutions or national ethical review boards.

Task 5.3: Coordinating National Steering Groups (Executive Committee)

Objective: Select and coordinate with National Steering Groups (NSG's) as scientific advisory boards for each WP (overlapping in WP4) to ensure relevance and facilitate stakeholder involvement.

Activities: 1) Identify and request the participation of relevant institutions representatives. In Greenland, this will include representatives from KNAPK (the occupational hunters and fishers organisation) as well as relevant ministerial departments (e.g. Department of Hunting, Fisheries and Agriculture) among others. In Sweden and Norway, this will include the Saami Council, Mearrasiida, regional level implementing actors (Länsstyrelse) and e.g. the Troms and Finnmark County Governor. 2) Assess and propose possible project reorientation in case of major new developments in the scientific, socio-political, and economic arenas affecting *FutureArcticLives* and its objectives based on input from the NSG's and project partners.

Task 5.4: Develop and implement a Data Management Plan (Executive Committee)

Objective: Produce a Data Management Plan (DMP) describing the life cycle of all collected, processed, and stored datasets and how data will be made available in accordance with the FAIR principles.

Activities: 1) Define and describe partners roles in data management within the project, and where and how to access datasets. 2) Use the projects internal password protected website to store raw data and associated protocols and questionnaires. 3) Use re3data.org to select an appropriate open access repository for processed data to ensure that it is "Accessible". 4) Link from the project website to the selected data repository. 4) Publish metadata descriptions on the project website to make it "Findable". 5) Subject output data to standardization and quality assurance to make it "Interoperable". 6) Develop a Material Transfer Agreement protocol, to be signed by participating partners and external individuals wanting to use the data to make it "Useable".

Task 5.5: Develop a Dissemination Strategy (Executive Committee).

Objective: Enhance practical uptake and implementation of knowledge gained through the project by developing and implementing a Dissemination Strategy (DS).

Activities: 1) Conduct internal dissemination to partners. 2) Develop a matrix specifying the target audience and the specific communication tools used to disseminate tailor-made messages to external audience. 3) Identify specific contact persons (managers, politicians, NGOs, scientists, journalists etc.) along with detailed pathways to impacts. 4) Use the project website for publicizing the project with links to blog posts and publications. 5) Publish results in open access high quality peer-reviewed journals. 6) Produce a biannual newsletter to share project news and updates distributed via partner institutions mailing lists and the project website. 7) Index project dissemination output in an online, open access repository to

ensure widespread accessibility of research findings for uptake and use. 8) Tracking project dissemination by documenting metrics such as social media circulation, publication downloads, altimetry scores, article citations, media mentions, and website views as indicators of audience reach.

Task 5.6: Develop an Exploitation Plan for managing the projects exploitable results and tracking project impacts (Executive Committee).
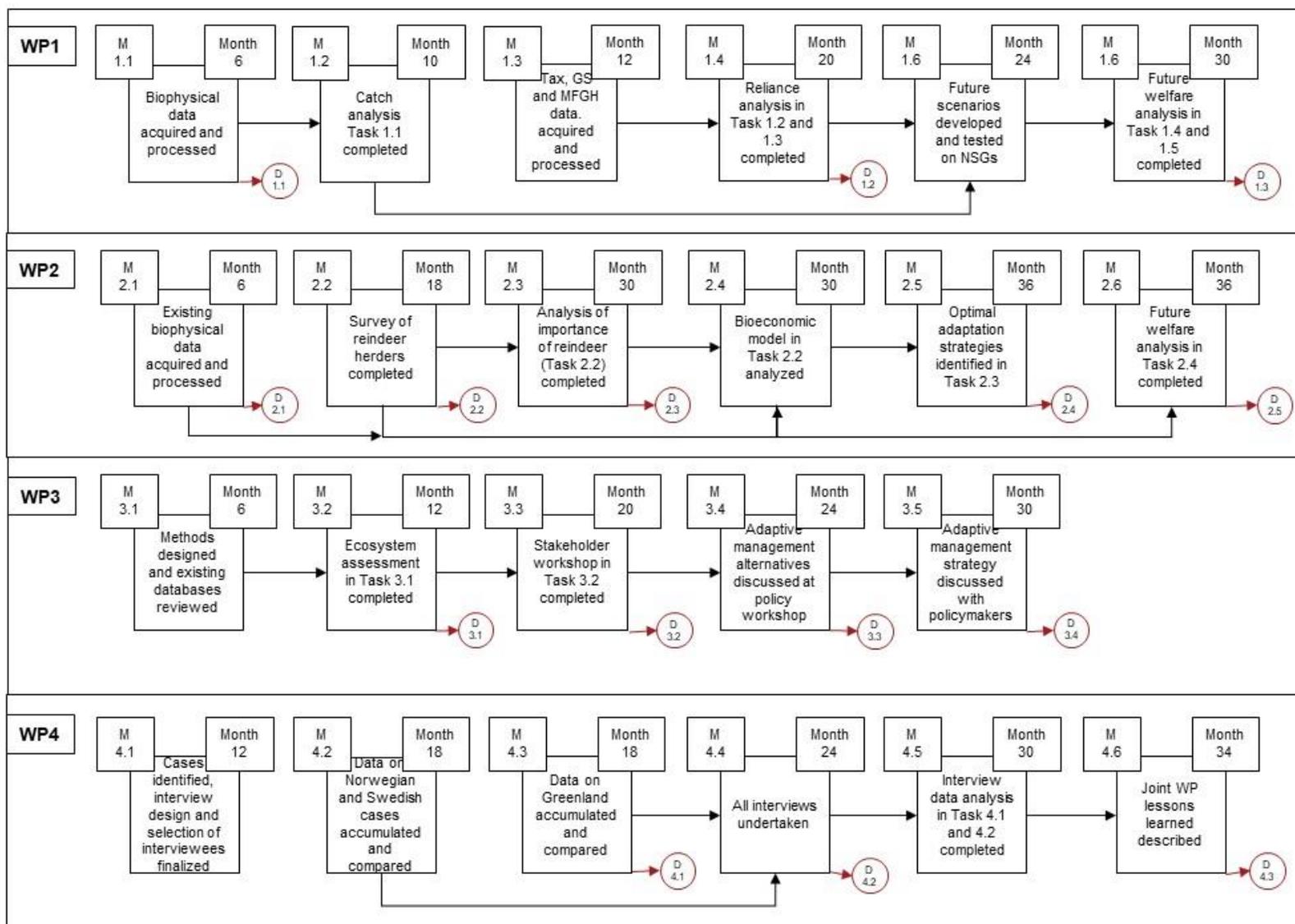
Objective: Develop an Exploitation Plan (EP) to facilitate exploitation of project results for use in further research activities, for generating impacts in terms of societal improvements and to enhance project legacy and sustainability.

Activities: 1) Describe procedures for protecting results and agreeing on publishing of information, access rights for research and commercial use (i.e. ownership); and for identification and collaboration with potential users. 2) Identify policy interphase pathways to impact in each country using input from the NSG's and partners. 3) Use a matrix to describe and track each exploitable results, its status towards finalisation, the identified pathways towards achieving impact and the extent to which that impact has been or is in the process of being realised. 4) Compile key exploitable results and present to policymakers. 5) Produce a final summary of the exploitable results for lay audience.

3.2. Project management and coordination

FutureArcticLives has 10 partners in three countries and has therefore selected a management structure for medium and large projects based on the DESCA 2020 model used in most Horizon 2020 Research and Innovation Action projects. The Project Coordinator (PC) will represent the consortium as the contact point in communication with BiodiveERsA's secretariat supported by a Project Management Team (PMT) consisting of UCPH administrative staff. The PMT will manage the project using established procedures and qualified staff, experienced managing FP7 and Horizon 2020 projects. The PMT will assist preparing the Consortium Agreement (CA) and facilitate Grant Agreement (GA) negotiations. The PMT will administer and distribute the financial contribution between partners, in accordance with the GA and decisions by the General Assembly. The General Assembly, consisting of one representative from each partner, will meet once per year using online platforms to reduce the project carbon-footprint and considering the ongoing pandemic. Major decisions about the strategic orientation of the project, work plan, budget and change in membership as well as conflicts will be settled by vote by the General Assembly. Each of the four science WP's has a WP leader (WPL), who will coordinate activities and together form the Executive Committee (EC) assisting the PC implementing WP5 and the project. National Steering Groups (NSG's) will be selected in each WP (overlapping in WP4) in accordance with CRELE principles – i.e. using a transparent and hence "Credible" process of stakeholder identification based on the objective to include local and indigenous organisations as well as science and management bodies and the private sector (see section 3.1, task 5.3), and by ensuring common agreed "Legitimacy" of members and forms of knowledge. "Relevance" of the process will be enhanced through commonly agreed expectations and invitation to participate in consortium meetings and provide input to the scientific direction and objectives of *FutureArcticLives* as well as the DS and EP. NSG's will also be consulted as relevant by WPL's. The WPL's will coordinate WP activities in accordance with the GA and partners must inform WPL's about all issues affecting project implementation, and the scientific quality of deliverables. The EC will monitor the implementation, progress and achievements of the project in accordance with the GA and project milestones (see Fig. 1) and ensure that the aims of the project are efficiently and effectively met on time linking and synthesising project results across WP's. Hence, the EC will review and ensure the quality of all deliverables made in the consortium and submitted to BiodivERsA. The EC will further evaluate deviations from research plans and in collaboration with responsible partners identify the appropriate course of action, including enactment of risk management strategies (see section 3.3). The EC will also assess and propose possible project reorientation of the consortium in case of major new developments in the scientific, socio-political, and economic arenas affecting *FutureArcticLives* and its objectives based on input from the NSG's. The PMT coordinates the preparation of periodic and the final report based on input from the EC and individual partners. These reports will include financial and progress reports and updated plans for dissemination and exploitation of results. This will be used to monitor the flow of the process and to identify risks and deviations from the plan in order to manage them in a timely manner.

Figure 1. PERT diagram outlining milestones and deliverables in WP1-4.

WP1

| M 1.1 | Month 6 | M 1.2 | Month 10 | M 1.3 | Month 12 | M 1.4 | Month 20 | M 1.6 | Month 24 | M 1.6 | Month 30 |

Biophysical data acquired and processed → Catch analysis Task 1.1 completed → Tax, GS and MFGH data. acquired and processed → Reliance analysis in Task 1.2 and 1.3 completed → Future scenarios developed and tested on NSGs → Future welfare analysis in Task 1.4 and 1.5 completed

D 1.1 — D 1.2 — D 1.3

WP2

| M 2.1 | Month 6 | M 2.2 | Month 18 | M 2.3 | Month 30 | M 2.4 | Month 30 | M 2.5 | Month 36 | M 2.6 | Month 36 |

Existing biophysical data acquired and processed → Survey of reindeer herders completed → Analysis of importance of reindeer (Task 2.2) completed → Bioeconomic model in Task 2.2 analyzed → Optimal adaptation strategies identified in Task 2.3 → Future welfare analysis in Task 2.4 completed

D 2.1 — D 2.2 — D 2.3 — D 2.4 — D 2.5

WP3

| M 3.1 | Month 6 | M 3.2 | Month 12 | M 3.3 | Month 20 | M 3.4 | Month 24 | M 3.5 | Month 30 |

Methods designed and existing databases reviewed → Ecosystem assessment in Task 3.1 completed → Stakeholder workshop in Task 3.2 completed → Adaptive management alternatives discussed at policy workshop → Adaptive management strategy discussed with policymakers

D 3.1 — D 3.2 — D 3.3 — D 3.4

WP4

| M 4.1 | Month 12 | M 4.2 | Month 18 | M 4.3 | Month 18 | M 4.4 | Month 24 | M 4.5 | Month 30 | M 4.6 | Month 34 |

Cases identified, interview design and selection of interviewees finalized → Data on Norwegian and Swedish cases accumulated and compared → Data on Greenland accumulated and compared → All interviews undertaken → Interview data analysis in Task 4.1 and 4.2 completed → Joint WP lessons learned described

D 4.1 — D 4.2 — D 4.3

Deliverables WP1	Month
D1.1: Comparison of catch statistics and scientific monitoring in Greenland	12
D1.2: Comparison and evaluation of the determinants of reliance and hunting yield in Greenland	24
D1.3: Future scenario analysis and comparison of group vulnerability	36

Deliverables WP2	Month
D2.1: Comparison of climate factors and reindeer production trends across Norwegian and Swedish Saami villages	12
D2.2: Forecasts of the effect of climate change on viability of reindeer herding	12
D2.3: Importance of cultural and intrinsic values of reindeer in Saami livelihoods	24
D2.4: Evaluation of Saami reindeer herder adaption strategies	30
D2.5: Simulation of climate welfare consequences for Saami herders	36

Deliverables WP3	Month
D3.1: Assessment of marine ecosystem contributions to coastal Sami culture and livelihoods	18
D3.2: Description and depiction of the concept and content of coastal Saami wellbeing	24
D3.3: Pathways towards ecosystem restoration in the Porsanger fjord	30
D3.4: Guidelines for development and implementation of local harvest control rules in the Porsanger fjord	36

Deliverables WP4	Month
D4.1: Comparison of legal protection for resource users under the Finmark Act in Norway with the situation in Sweden	24
D4.2: Assessment of relationships between policies and regulations at the local and national level in Greenland	24
D4.3: Description of the potential for Nature Based Solutions across cases	36

14

3.3. Risk assessment and management

The EC will continually assess risks and remain highly conscious of potential risks throughout the project Periodic reports and frequent meetings of the EC will enable close oversight of the projects progress and early identification of difficulties. The risks related to *FutureArcticLives* are comparable to similar research projects of this size. WPL's are furthermore experienced professionals anchored in solid institutions that have a long record of accomplishment participating in large research projects. Specific risks and contingency plans are identified in Table 1. The possibility of such events will be handled in the consortium agreement and the management structure.

Table 1. Risk identification, possible consequences and plans for handling risks i.e. contingency plans.

Risk identified	Impact of risk if it occurs	Contingency plan
Necessary data at household level not released by National Statistical Bureaus in consideration of GDPR.	May affect objectives involving modelling.	Work will be done on anonymized data working on the server of National Statistical Bureaus. Alternatively, work can be done on an aggregated level removing all location identifiers. Finally, primary data can be collected instead.
Data quality or quantity too low for modeling.	May result in poor model fit inhibiting ability to make expected predictions.	Develop model of change and research plans identifying necessary and key information needed for modelling and collect all the needed data prior to model application.
Low response rate to household survey in certain areas.	May affect possibilities to quantify market and non-market values resulting from reindeer husbandry.	Do follow-up survey to assess the representativeness of obtained sample.
Ongoing conflicts between stakeholders resulting in the project not being accepted by local communities	May complicate research in some locations and reduce the sample size	The project includes seasoned researchers having previously worked in the communities. Oversampling by selecting additional communities to create a contingency sample.
Large variation between households in ecosystem service dependence	Non-significant results	Purposefully selecting households representing distinct user groups.
Pandemic infection risks	May prevent meetings, fieldwork and face-to-face interviews	Meetings and interviews conducted using various online platforms and software including Skype, Zoom etc.
Estimation of costs inadequate to tasks	May impacts project implementation	Start project by making a scoping document. Co-funding strategies to be adopted by project partners. I.e. several partners are already involved in collateral projects.

3.4. Proposed data management approach

WP5 will produce the projects Data Management Plan (DMP) (see section 3.1, task 5.4). The DMP will cover the life cycle of all data including: 1) Data collection as determined by a research plans developed for each objective by the relevant partner; 2) Initial storage; 3) Development of metadata description; 4) Uploading of data and metadata description to a selected public accessible data repository. The DMP will also define partners roles in data management within the project, and where and how to access datasets. *FutureArcticLives* distinguishes between input data, i.e. pre-existing datasets obtained and used by the partners, and output data, i.e. data collected or datasets compiled within the scope of the project. Input data may not always be storable outside the institution supplying the data. National statistical bureaus may for instance require that any work on the data be conducted on their servers. Output data can be observations recorded in the field or in a lab, but also include the result of an econometric model, spatial data, aggregated data (means, trends, etc. of input data), as well as program code and scripts. Output data will in addition be subjected to standardization and quality assurance by the EC and must be characterised by: 1) A unique system-based identifier; 2) Dataset name and description; 3) Information about ownership (i.e. information about when and whom collected an uploaded the data); 4) Information about access to the data and special conditions for use, including indication of sensitivity of data points (e.g. human interview objects); accompanied by: 5) a thorough description of data collection procedures, location, aim, timespan linking to the relevant research plan; 6) A list of variables describing the units, ranges, and content in each variable. All data generated by *FutureArcticLives* will be made available for use beyond the project and consortium by developing a Material Transfer Agreement protocol.

3.5. Ethics

FurureArcticLives will adhere to research principles for engaging with indigenous groups and local knowledge developed by IASSA (International Arctic Social Science Association). Partners must furthermore carry out their activities in compliance with intellectual property rights and ethic principles, obtaining research permission from the appropriate local authorities and observe confidentiality of data in accordance with the GA and national legal requirements in the three countries as well as the EU code of conduct on research integrity and directive on data protection (directive 95/46/EC). Partners that engage in interviews of persons, as a means of data collection will develop questionnaires, interview guidelines and informed consent sheets as well as protocols describing recruitment processes and inclusion/exclusion criteria for participation that will be subject to approval by national academic ethical review boards prior to commencement of research activities. The project will involve interviews with people selected based on strategic selection criteria to identify and invite for interview individuals with specific organisational positions or undertaking specific activities. However, interviewees will be referred to by organization, organizational type or type of activity only and not by person name to ensure respondent anonymity. Interviewee data will furthermore not be reported or shared beyond the project in any other form than as metadata (i.e. not as recordings or full transcripts). All partners are obliged to read and understand the basic principles of the DMP and the Ethical Requirement Report (see section 3.1, task 5.2) and must follow the rules of data storing and sharing within the project.

4. References

AHDR 2014. Arctic Human Development Report: Regional Processes and Global Linkages – Volume II (2010–2014).

Arctic Council. 2016. Arctic Resilience Report. M. Carson and G. Peterson (eds).

ACIA 2005. Arctic Climate Impact Assessment – Scientific Report. Berner, et al. (eds.).

AMAP 2011. Snow, Water, Ice and Permafrost in the Arctic (SWIPA). Arctic Monitoring and Assessment Program.

AMAP 2013. Arctic Ocean Acidification. Arctic Monitoring and Assessment Program, Oslo, Norway.

AMAP 2016. Adaptation Actions for a Changing Arctic, Oslo, Norway.

ASI 2010. Arctic Social Indicators report. Nordic Council of Ministers.

Bostedt, G. 2005. Pastoralist economic behavior: Empirical results from reindeer herders in Northern Sweden. J. Agric. Econ. 30: 381-396.

Brattland, C. et al. 2018. Social-ecological timelines to explore human adaptation to coastal change. Ambio https://doi.org/10.1007/s13280-018-1129-5.

Bostedt, G. Pastoralist Economic Behavior: Empirical Results from Reindeer Herders in Northern Sweden. Agric. Econ 30(2):38 1-396

CAFF 2013. Arctic Biodiversity Assessment: Status and Trends in Arctic Biodiversity.

ECONOR 2008 and 2015. The Economy of the North. Statistics Norway.

Hendriksen, K., Jørgensen, U. 2015. Hunting and fishing settlements in Upernavik district of Northern Greenland: challenged by climate, centralization and globalization. Polar Geogr 38: 123-145.

Hendriksen, K. and Hoffmann, B. 2018. Drivere og barrierer for erhvervsudvikling i yderdistrikter og mindre bosteder i Grønland – med Qaanaaq og Qeqertarsuaq som cases. DTU og Aalborg Universitet.

Hendriksen, K. 2013. Grønlands bygder – økonomi og udviklingsdynamik. Artisk forskningsjournal 3, Nuuk.

Johannesen, A.B. and Skonhoft, A. 2011. Livestock as insurance and social status: Evidence from reindeer herding in Norway. Environ Resour Econ 48(4): 679–694.

IPBES 2019.Summary for policymakers of the global assessment report on biodiversity and ecosystem services.

IPCC 2014. Climate Change Synthesis Report.

Kortsch, S. et al. 2015. Climate change alters the structure of arctic marine food webs due to poleward shifts of boreal generalists. P Roy Soc B-Biol Sci. 282(1814).

Pettersson, M. and Keskitalo, E.C.H. 2013. Adaptive capacity of legal and policy frameworks for biodiversity protection considering climate change. Land Use Policy 34: 213–222.

Rasmussen, R.O. 2005. Analyse af fangerhvervet i Grønland. NOREGIO. Greenland Home Rule Government.

Riseth, J.Å. et al. 2016. 175 years of adaptation: North Scandinavian Sámi reindeer herding between government policies and winter climate variability (1835–2010). J Forest Econ 24: 186–204.

Tveraa, T. et al. 2013. Population Densities, Vegetation Green-Up, and Plant Productivity: Impacts on Reproductive Success and Juvenile Body Mass in Reindeer. PLoS ONE 8(2):

North, D. C. 1994. Institutional change: A framework of analysis.

NRC 2014. The Arctic in the Anthropocene: Emerging research questions. https://doi.org/10.17226/18726.

Pierson, P. 2000. Increasing returns, path dependence, and the study of politics. A P S R 94(2): 251–267.

WWF 2018. Getting it right in a new ocean: Bringing sustainable blue economy principles to the Arctic.

Young, O.R. et al. 1999. Institutional dimensions of global environmental change. Science Plan. Bonn: IHDP.