The Economics of Ecosystems and Biodiversity (TEEB) for the Arctic: A Scoping Study

Acknowledgements

—— CAFF Designated Area

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Memorandum to the Senior Arctic Officials

17/09/2015

The Economics of Ecosystems and Biodiversity in the Arctic (TEEB) scoping study

For information/action

Background

The Arctic Council has recognized the significance of assessing and understanding the multiple services and values that ecosystems provide. This is evident in several initiatives such as Ecosystem Based Management, the Adaptation Actions for a Changing Arctic, the Arctic Resilience Report, and in particular the Arctic Biodiversity Assessment recommendations that were approved at the Arctic Council Ministerial in Kiruna in 2013.

In response, the Conservation of Arctic Flora and Fauna (CAFF) Working Group initiated an effort to better understand ways that the Arctic Council can address this important topic. The TEEB Arctic scoping study led by Sweden was carried out by the CAFF, United Nations Environment Programme (UNEP) TEEB, World Wide Fund for Nature (WWF), and GRID-Arendal is an important first step. It is submitted by the CAFF Board to the Senior Arctic Officials for approval at their October 2015 meeting.

Organization

- ▶ Steering Group: Sweden, WWF Global Arctic Programme, UNEP Regional Office for Europe, UNEP TEEB, GRID-Arendal, CAFF Secretariat, Project consultant.
- ▶ Project funding and support came from the Nordic Council of Ministers, UNEP, WWF and CAFF
- ▶ Communication group: CAFF Secretariat, WWF, TEEB Office

Next steps:

The TEEB Arctic scoping study provides a basis for beginning a dialogue on the complexities of evaluating ecosystem services within the Arctic. Continuing in this dialogue CAFF is exploring possible next steps. CAFF will provide an update to the Senior Arctic Officials at their March 2016 meeting.

Communications:

- ▶ Project website: www.arcticteeb.net

Actions required:

- ▶ Senior Arctic Officials: Approval of the Economics of Ecosystems and Biodiversity (TEEB) for the Arctic Scoping study

Preface

The TEEB Arctic scoping study was developed by the Conservation of Arctic Flora and Fauna working group (CAFF), with Sweden as the lead country, jointly with the following partners: the UNEP TEEB Office, the UNEP Regional Office for Europe, WWF Global Arctic Programme and GRID-Arendal.

This scoping study is an early-implementation pilot project that follows up on specific recommendations of the Arctic Biodiversity Assessment (ABA). A key objective of the scoping study and the options presented in 'The way forward' (Chapter 7) is implementation of ABA recommendations, in particular recommendation #4 on incorporating biodiversity objectives and provisions into tools specific to development in the Arctic, and recommendation #12 on evaluating services provided by Arctic biodiversity to support decision making.

The project was run and governed through a Steering Group consisting of representatives of the partner organizations. Funding for the project was provided by the Nordic Council of Ministers, UNEP and WWF. The study was conducted mainly in 2014, designed with the aid of a workshop in Reykjavik in May of that year, and informed by 60 responses to an online questionnaire that was active from April to July, 2014. Questionnaire input is included throughout this scoping study report, both in synthesis form and as direct quotes.

The scoping study is predominantly based on the TEEB approach and methodology for a scoping study, as outlined in the TEEB guidance manual for country studies[1]. It differs from this model, however, in two ways: 1) it includes information and discussion related more generally to improving understanding of the full range of Arctic ecosystem services, as well as information and discussion on aspects of governance and of valuing ecosystem services in the context of the circumpolar Arctic and Arctic Council; and 2) it does not conclude with a defined set of specific policies for assessment in a full TEEB study, but rather provides guidance and examples on policy focus areas that could be further refined and assessed using TEEB methodology. These differences are related to the multi-jurisdictional nature of Arctic governance, the diversity of value systems around the Arctic, and to meeting the needs identified by Arctic Council, both through the ABA and through recommendations on implementation of ecosystem-based management in the Arctic.

The scoping study evolved over the course of its development from a focus on design of a full TEEB assessment for the Arctic as a single option, to identification of a suite of opportunities for understanding Arctic ecosystem services and raising their profile in decision making. This suite includes applications of TEEB methodology to assessing policy alternatives as well as other initiatives, including development of tools, methodologies and knowledge. These options complement one another but can be initiated separately and with different working group leads within the Arctic Council work agenda. Each option tackles a specific question or issue and contributes to the overall goal of mainstreaming Arctic biodiversity and ecosystems in decision making.

Resistance to, or caution about, approaches to policy that focus on valuation of ecosystem services arose throughout the scoping study period, often related to concern about putting prices on aspects of Arctic nature that cannot or should not be priced. A related concern is that monetary valuation would result in turning nature into a commodity and that this would exacerbate existing imbalances between development interests and local people, and/or between Indigenous Peoples and others when it comes to decisions involving trade-offs. The capacity of a TEEB approach to fully account for differences in value systems was questioned, in particular by indigenous contributors to the scoping study.

These are important concerns to be brought forward for consideration in all future work in this field. They are not concerns unique to the Arctic, and the TEEB program has recently published a discussion of challenges and responses[2]. Of primary importance is the understanding that value is not the same as price – the TEEB approach is not about imposing economic valuations in situations where they would be misleading or would not contribute to the goal of making the benefits all people derive from ecosystem services visible in decision making. TEEB studies include participatory approaches to determine the appropriate way to assess ecosystem services, including whether monetary valuation is required or not. Moreover, any exercise in valuation will be subjective and will only represent certain views – the key is to be explicit about these views and to be inclusive of different value and knowledge systems. Guidance on valuation of ecosystems and biodiversity has also been developed through the Intergovernmental Platform on Biodiversity and Ecosystem Services.

This report presents the results of the scoping study on ecosystem services and the application of a TEEB approach and methodology in the Arctic. The report includes:
1. Results from compiling and synthesizing information, issues, current practices, methodologies and perspectives on Arctic ecosystem services and their values in relation to decision making,
2. List and discussion of policy areas identified during the scoping study for potential follow up using TEEB methodology,
3. Way forward options, including, but not limited to, application of TEEB methodology to policy focus areas, and consideration of options for practical implementation of TEEB at a range of jurisdictional and spatial scales.

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1   TEEB. 2013. Guidance manual for TEEB country studies. The Economics of Ecosystems and Biodiversity
2   Sukhdev, P., H. Wittmer, and D. Miller. 2014. The Economics of Ecosystems and Biodiversity (TEEB): Challenges and Responses. Nature in the Balance: The Economics of Biodiversity. Oxford..

List of abbreviations

ABA   Arctic Biodiversity Assessment

AMAP   Arctic Monitoring and Assessment Programme

CAFF   Conservation of Arctic Flora and Fauna working group of Arctic Council

CBMP   Circumpolar Biodiversity Monitoring Program

CBD   Convention on Biological Diversity

EBM   Ecosystem-based management

EIA   Environmental Impact Assessment

IPBES   Intergovernmental Platform on Biodiversity and Ecosystem Services

LME   Large Marine Ecosystem

PAME   Protection of the Arctic Marine Environment

SDWG   Sustainable Development Working Group

SEA   Strategic Environmental Assessment

TEEB   The Economics of Ecosystems and Biodiversity

UNCLOS   United Nations Convention on the Law of the Sea

UNEP   United Nations Environment Programme

UNFCCC   United Nations Framework Convention on Climate Change

Man at fishing hole, Greenland. Photo: Lawrence Hislop/UNEP GRID Arendal

Key findings

1. Context and issues

1.1. Featuring ecosystem services in policy development and implementation is needed to help define and balance societal needs and priorities in the rapidly changing Arctic policy landscape.

2. Arctic ecosystem services

2.1. Systematic conclusions on Arctic ecosystem services and their status and trends cannot yet be made based on the data gathered in the scoping study.

2.2. Ecosystem services work should take a holistic approach and operate at the level of ecosystem service bundles.

2.3. Although syntheses, guidelines and analyses of policy options at the pan-Arctic scale can raise the profile of ecosystem services and provide direction, work on ecosystem services is most effective when it builds on analysis at smaller scales.

2.4. Arctic ecosystem services provide benefits to a range of stakeholders at various scales, both directly and indirectly – and the stakeholders who benefit from services and those who affect the availability of the same services are not always the same.

2.5. Reduction of greenhouse gases remains a top priority for conserving ecosystem services.

2.6. Arctic environmental conditions are associated with potential for rapid changes in ecosystem services and high uncertainty – providing a strong incentive to include ecosystem services in policy.

3. Governance

3.1. Incorporation of Arctic ecosystem services into policies and governance practices is a key method for the integration of environmental, economic, and social policies.

3.2. Recognizing Arctic ecosystem services and capturing them in decision-making processes can strengthen the resilience of Arctic social-ecological systems to rapid changes in the region.

3.3. The TEEB approach can make the diverse values that people hold for nature visible by assessing and communicating the role of biodiversity and ecosystem services in the economy and to society.

3.4. Recognizing, demonstrating and capturing the diverse values of ecosystem services in policy instruments for strategic planning and integrated management of natural resources and space can help reconcile biodiversity conservation with development.

3.5. Capturing the benefits and the scarcity of Arctic ecosystem services in economic policies promotes the improvement of economic models and processes.

3.6. Mainstreaming of nature's values by means of ecosystem services requires adjustments to existing policies and instruments as well as the development of new ones.

3.7. The Arctic Council, as a leader in bringing together knowledge across the circumpolar north, has an important role to play for further work on Arctic ecosystem services. These ecosystem services are recognized through the values assigned to them from the perspectives of key Arctic stakeholders and rights holders.

3.8. Taking an interdisciplinary approach that combines economic and socio-cultural analyses to the benefits people receive from Arctic nature faces a number of challenges and concerns. However, it also offers a complementary approach for communicating to decision-makers the importance of nature to people, and a toolkit for evaluating policy options and integrating stewardship into decisions.

4. Valuing Arctic ecosystem services

4.1. The ecosystem services link is crucial when striving for sustainable management of complex social-ecological systems, and valuation in this context can provide powerful information for evaluating alternative management strategies. Cohesive, integrated and commonly accepted frameworks for assessment of the values of Arctic ecosystems are needed.

4.2. Any effective, equitable and sustainable policy must account for a diversity of perspectives and encompass a diversity of value systems.

4.3. There is a persistent risk that social and cultural attributes of ecosystem services are neglected while the monetized economic benefits and ecological causes of ecosystem service change are over-emphasized.

4.4. Health values are often overlooked in ecosystem services analyses.

5. Policy focus

5.1. Policy related to increasing and changing development patterns in the Arctic would benefit from incorporation of consideration of ecosystem services. Participants in this scoping project identified a list of policy areas for further consideration, and two of these were assessed as 'policy examples' through a TEEB approach, at a broad scoping level: expanding shipping and oil and gas development in the marine environment, and industrial development in the North American Arctic.

6. Engagement needs

6.1 Engagement of Arctic Indigenous organizations and a broad range of stakeholders in participatory development of knowledge and policy alternatives is central to a successful TEEB Arctic study. Follow-up work to this scoping study should be structured so that those who wish to contribute can do so through a range of avenues.

6.2 Early policy-maker involvement is crucial for designing effective approaches to policy change. This includes policy-makers at international and national levels, and includes people working on policy not directly related to environmental management, such as trade, business and fiscal policy.

7. Way forward

7.1 This scoping study presents a suite of options for follow-up. The overall objective is to reduce the pressures and threats on Arctic ecosystems by mainstreaming the many and diverse values of biodiversity and ecosystem services into decision making. The options are in two categories:

1. A TEEB Arctic study, or set of studies, based on two to five policy areas
2. A number of additional options, some of which address fundamental issues and challenges to the application of the TEEB approach in the Arctic context

Some options would be done in collaboration with, and enhance, ongoing Arctic Council initiatives. All options would complement the TEEB Arctic study. These options are aimed at increasing the visibility of the values of ecosystem services in policy through improving the knowledge base, raising awareness of the values of ecosystem services, and developing tools, guidance, methodologies and information products.

Greenlandic children. Photo: Carsten Egevang/ARC-PIC.com

Chapter 1. Context and issues

Authors: J. Eamer; M. Kettunen (Section 1.4)

1.1.   What is TEEB?

Because nature is often invisible in the economic choices we make, we have steadily been drawing down our natural capital – without understanding either what it really costs to replace services provided for free by nature, or that man-made alternative solutions are sometimes far too expensive for these services to be replaced or substituted. (Sukhdev et al. 2014)

The purpose of this study is to scope out how the concept of Arctic ecosystem services can be used as a policy framework to make the benefits people receive from nature visible. Making the value of **ecosystem functions**[3] explicit for policy making draws attention to the biodiversity and biophysical processes that provide these functions.

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative coordinated by the United Nations Environment Programme (UNEP). TEEB draws attention to the benefits that people gain from nature (**ecosystem services**), including food from fishing and hunting, maintenance of culture, water, enjoyment of wilderness, nature and wildlife, and provision of raw materials. Equally important but less obvious benefits include climate regulation and flood control. TEEB also brings attention to the costs to society when ecosystems are damaged and when plant and animal populations are lost. TEEB provides an analytical approach, tools and guidance that can help make the range of nature's benefits more visible when politicians, businesses and others make decisions that might affect these benefits or put them at risk.

Looking at nature through the lens of ecosystem services and the benefits that humans derive from these services provides incentives for conserving Earth's resources (**natural capital**). This approach places human needs at the center of biodiversity management, and it is not the only basis for weighing policy options that have consequences for ecosystems and biodiversity.

> **VISION**
>
> *Making nature economically visible*
>
> Biodiversity in all its dimensions – the quality, quantity and diversity of ecosystems, species and genes – needs to be preserved not only for societal, ethical or religious reasons but also for the economic benefits it provides to present and future generations. We should aim to become a society that recognizes, measures, manages and economically rewards responsible stewardship of its natural capital. (TEEB – The Economics of Ecosystems and Biodiversity 2010c)

TEEB aims to bring biodiversity into mainstream decision making – making nature an important part of policy related to business, social and economic development, not just policy directly related to environmental management. **Mainstreaming** the economics of ecosystems and biodiversity is a component of mainstreaming biodiversity across government and society (Sukhdev et al. 2014), an increasingly important target for work carried out through the Convention on Biological Diversity (CBD) and for international conservation investment (CAFF 2013a; Huntley and Redford 2014; Secretariat of the Convention on Biological Diversity 2014), as well as a major new focus for the Arctic Council (CAFF 2013a) (see Section 1.3). Main international initiatives that support this policy thrust by providing guidance and building capacity for bringing ecosystem services concepts into decision making are summarized in Annex 1. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), established in 2012 and described in Annex 1, has recently developed a conceptual framework (Figure A1-1) that explicitly includes multiple knowledge systems and highlights the central role that institutions, governance and decision making play in linking nature, the benefits people derive from nature, and a good quality of life (Díaz et al. 2015a).

1.2.   Scoping study objectives

This report presents the results of a TEEB Arctic scoping study and sets out a plan with options for follow-up, including a comprehensive TEEB Arctic study focused on two to five policy areas. The report incorporates aspects of a feasibility study, scoping out the suitability of a TEEB approach in the context of the Arctic Council. An overview of Arctic issues sets the context, followed by chapters on Arctic ecosystem services, policy and governance in relation to TEEB approaches, and approaches to valuation of ecosystem services. Options for thematic and policy focus areas for a TEEB Arctic study are discussed. The report concludes with an outline of options for the way forward.

Arctic Council-related objective

The scoping study is a follow-up to the Arctic Biodiversity Assessment (ABA), the first major assessment of the state of Arctic biodiversity and ecosystems, launched by Arctic Council in 2013 (CAFF 2013b). A key objective of both this scoping study

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3   Terms **highlighted in blue** are defined and referenced in the glossary.

and a TEEB Arctic study is the implementation of ABA recommendations, in particular recommendation #4 on incorporating biodiversity objectives and provisions into tools specific to development in the Arctic, and recommendation #12 on evaluating services provided by Arctic biodiversity to support decision making (see Section 1.3 'Policy relevance of TEEB in the context of the Arctic Council').

TEEB Arctic scoping study objectives

1. Provide an initial catalogue of the benefits and values that people in the Arctic and beyond associate with the region's biodiversity.
2. Document how a priority range of Arctic ecosystems and biodiversity contribute to human well-being and livelihoods, as well as providing contextual information on how human activities affect these ecosystems, including their functions and ability to sustain the provisioning of essential services.
3. Enable a first view of the state of critical Arctic natural capital and related ecosystem services that can be mapped against opportunities for policy, planning and management, and that can provide a basis for (environmental or financial) accounting within specific sectors.

In addition, objectives for scoping studies from the Guidance Manual for a TEEB Country Study (TEEB – The Economics of Ecosystems and Biodiversity 2013) were adapted to the context of this Arctic scoping study:

1. Identify **region-specific issues** regarding identification and context of benefits people receive from Arctic biodiversity, including questions or methodological adjustments related to appropriateness and legitimacy of the TEEB for the Arctic Scoping Study approach, including for Indigenous peoples.
2. Identify the **scope, thematic focus, purpose, and objectives** of a TEEB Arctic Study, by
   a. providing an understanding of the policy context,
   b. identifying Arctic ecosystem services that are critical for socio-economic development and for the well-being of Arctic and non- Arctic residents,
   c. identifying Arctic ecosystem services that are critical for socio-ecological resilience and adaptive capacity, and
   d. setting out key thematic areas and questions.
3. Provide an overview of the **state of knowledge** on
   a. the status and trends of Arctic natural capital,
   b. the priority ecosystem services and pressures they face, and
   c. major gaps in knowledge and in access to knowledge on Arctic natural capital and ecosystem services.
4. Identify the **relevant stakeholders** for a TEEB Arctic study by
   d. providing an understanding of their main interests, needs and concerns, and
   e. generating a roadmap for their engagement including identifying audience-specific products.
5. Propose a **governance structure** for a TEEB Arctic that ensures legitimacy and credibility to the intended range of audiences.

1.3.   Policy relevance of TEEB in the context of the Arctic Council

TEEB builds on and provides added value to important Arctic Council work. With its experience as a forerunner in bringing together knowledge across the circumpolar north, the Arctic Council is in a good position to take a leadership role with regard to Arctic ecosystem services, including the values attributed to them from the perspective of key Arctic stakeholders and rights holders.

The Arctic Biodiversity Assessment (ABA) (CAFF 2013a) reviewed the science on the status and trends of Arctic biodiversity, informed by Traditional Knowledge and including assessment of selected groups of ecosystem services. The ABA report articulates how the environment is changing and signaled the needs for policy to address secure ecosystems and species that people rely on for life and livelihood (CAFF 2013c). The Arctic Council recommendations on ecosystem-based management (EBM) lay out a framework for a shift in policy focus to incorporate ecosystem considerations into decision making (Arctic Council 2013a). Other Arctic Council initiatives (see Table 1.1 below) include an explicit or implicit focus on ecosystem services. TEEB methodology provides a framework that can help to meet the needs identified through these initiatives, including developing a fuller understanding of Arctic ecosystem services, estimating and demonstrating their diverse values, and undertaking policy analysis to support decision-makers in selecting and adopting policy options that make the values of nature visible in economic choices that affect the Arctic.

Mainstreaming the role of ecosystems and biodiversity into policy making is a priority for the Arctic. It was identified as a cross-cutting theme of the main findings of the ABA and underlies many of the ABA's implementation actions underway and planned for the period 2013-2021 (CAFF 2015). These actions are in response to a number of ABA policy recommendations that were approved by the Arctic Council nations at the Kiruna Ministerial Meeting in May 2013 (Arctic Council 2013b). Two of these recommendations are of particular significance for the TEEB Arctic scoping study and have provided direction in its formulation:

"To mainstream biodiversity by incorporating biodiversity objectives and provisions into all Arctic Council work and into tools specific to development in the Arctic" (rec. #4), and

"To evaluate the range of services provided by Arctic biodiversity in order to determine the costs associated with biodiversity loss and the value of effective conservation to support decision making." (rec. #12).

At the same 2013 meeting of the Arctic Council, the Foreign ministers of the eight Arctic nations approved recommendations from the Council's Expert Group on Ecosystem-Based Management (Arctic Council 2013a), including a recommendation specific to valuing Arctic ecosystem services:

"Assess the value of significant Arctic ecosystem services relevant to the well-being of local communities and regional economies, and those of particular global significance."

These recommendations were made in the context of rapid change in the Arctic (see Section 1.7 'Arctic issue scan') and concerns that, combined with climate change, increased unsustainable development in the Arctic would put ecosystems and species, and subsequent human well-being, at risk. The Arctic Council is also undertaking work on improving capacity to meet these challenges, such as through increasing knowledge and understanding of resilience and social-ecological systems, and through policy-related work on reduction of risk and adaptation to change.

The scoping study also seeks to identify pitfalls and critical views related to the TEEB approach, including perspectives from Arctic Indigenous Peoples. Section 3.8 'Challenges and limitations for the governance of Arctic ecosystem services' includes discussion of issues related to applying a TEEB approach to the Arctic.

Table 1.1 is an overview of Arctic Council work that is strongly related to the concepts and approaches of TEEB. Underlying these initiatives is the Arctic Council framework on EBM, which "*strives to integrate commercial, social, cultural, and ecological values, but the ecosystem aspect is 'first among equals' because ecosystem failure would compromise all other values or goals*" (Arctic Council 2013a).

Table 1.1. A selection of Arctic Council initiatives and their relationship to ecosystem services and their economic values

Initiative	Lead[1]	Date	Relationship to ecosystem services
Arctic Biodiversity Assessment (ABA) (CAFF 2013b) and Action for Arctic Biodiversity: Implementing the recommendations of the ABA, 2013-2021 (CAFF 2015)	CAFF	2013-2021	Comprehensive assessment of biodiversity and ecosystems (status, trends and projections); chapter on provisioning and cultural services including discussion on valuation; policy report recommendations include mainstreaming of biodiversity and cataloguing values of ecosystem services. Implementation of the ABA recommendations is a priority for CAFF and an eight-year implementation plan in response to this directive.
Circumpolar Biodiversity Monitoring Program (CBMP)	CAFF	ongoing	Works to gather, monitor and integrate Arctic biodiversity data across biomes and scales through monitoring plans, status reports, indicator development, and linkages to international initiatives. Operating based on the ecosystem approach and recognizes the benefits people obtain from Arctic biodiversity.
Additional work on indicators, indices and trends assessment	diverse	ongoing	Includes indicators (e.g., CAFF 2008, 2010; Nilsson 2013) and spatially referenced species trend index development (Böhm et al. 2012; Eamer et al. 2012) and ecosystem-specific assessments (e.g., Eamer et al. 2013)
Ecosystem-Based Management in the Arctic (EBM) (Arctic Council 2013a)	Expert Group	2013	Includes framing of ecosystem services in relation to EBM; recognizes values of benefits and costs of degraded ecosystems. Recommendations on documentation, assessment and valuation of ecosystem services in the Arctic to advance EBM.
Framework for a Pan-Arctic Network of Marine Protected Areas (PAME 2015)	PAME	2015	Sets out a common vision for pan-Arctic marine protected area (MPA) network development and management, based on best practices and Arctic Council initiatives. Highlights the integration of MPA networks in EBM and considers sustaining cultural, social and economic values and ecosystem services as goal and objective of MPA networks.

[1] Arctic Council working groups: CAFF=Conservation of Arctic Flora and Fauna; AMAP=Arctic Monitoring and Protection Programme; PAME=Protection of the Marine Environment; SDWG=Sustainable Development Working Group

Initiative	Lead[1]	Date	Relationship to ecosystem services
Adaptation Actions for a Changing Arctic (AACA) (Arctic Council 2014)	AMAP	(2017)	Ecosystem services are an implicit focus of adaptation; potential for building a TEEB approach into adaptation action planning.
Arctic Human Development Report (AHDR) II	SDWG	(2014)	Updated social and economic information provides underpinning for ecosystem service analyses
Arctic Resilience Report (Arctic Council 2013c)	–	(2017)	The project results will assist in understanding changes and risks to ecosystem services, through identifying thresholds and integrated impacts that affect human well-being in the Arctic. Potential for integration of TEEB approaches in the project's evaluation of adaptation strategies.
Arctic Ocean Acidification Assessment (AOAA) (AMAP 2013)	AMAP	2013	Emerging major stressor on marine ecosystems. Evaluates projected economic impacts on provisioning services (especially fisheries and Indigenous Peoples' foods) and on some cultural services.
Arctic Marine Shipping Assessment (AMSA) (Arctic Council 2009) and Plan (AMSP) (in progress)	PAME	2009; (2015)	The assessment identifies and projects impacts from increased shipping and tourism on ecosystems and on some provisioning/cultural services (for Indigenous Peoples).
Identification of Arctic marine areas of heightened ecological and cultural Significance (AMSA IIc) (AMAP et al. 2013)	AMAP, CAFF, SDWG	2013	Areas identified are of importance to supporting services (e.g., areas of high biological productivity) and cultural and provisioning services. Provides place-based information for identification of policy options. Includes heritage sites and traditional use sites (as a subset of available information).
Snow, Water, Ice, Permafrost in the Arctic (SWIPA) (AMAP 2011)	AMAP	2012	Evaluates how changes to the cryosphere affect Arctic ecosystems and peoples, as well as impacts on global climate regulation. Highlights uncertainty and potential for major impacts on livelihoods.
Arctic Ocean Review (AOR) I (PAME 2013a) and II (PAME 2013b)	PAME	2011; 2013	AOR 1: Identifies and summarizes status of human uses. Reviews current global and regional marine governance instruments. AOR II: discusses global value of Arctic Ocean (provisioning and regulating services); considers benefits people derive from Arctic marine ecosystems, including identifying areas of importance and discussing governance in relation to patterns of use. Recommendations focus on EBM and ecosystem services approaches.

[1] Arctic Council working groups: CAFF=Conservation of Arctic Flora and Fauna; AMAP=Arctic Monitoring and Protection Programme; PAME=Protection of the Marine Environment; SDWG=Sustainable Development Working Group

At the global level, the countries involved in this TEEB scoping study through the CAFF working group of Arctic Council are Parties to, and have national policies related to, almost all of the international biodiversity-related multilateral environmental agreements (MEAs). Of particular relevance to identifying opportunities for taking a TEEB approach to policy in the Arctic are decisions under the CBD, notably the Strategic Plan for Biodiversity 2011-2020, including the Aichi 2020 Biodiversity Targets (CBD 2010, 2011; Rode et al. 2012a, 2012b, 2012c). Assessing and taking into account the economic, social and cultural benefits of ecosystems and biodiversity can help to achieve these international and national biodiversity targets, for example:

▶ Integrating biodiversity values into strategies for development and poverty reduction, planning processes and national accounting (Aichi Target 2)
▶ Reforming subsidies harmful to biodiversity and promotion of incentives for conservation and sustainable use of biodiversity (Aichi Target 3)
▶ Increasing the amount and effectively managing land, inland waters and ocean covered by protected areas (Aichi Target 11)

Meeting these global 2020 biodiversity targets will play a key role in achieving the priorities of the global post-2015 development agenda. The UN's new development agenda (September, 2015) includes a set of Sustainable Development Goals (SDGs). Adopting the TEEB approach will contribute to the implementation of these SDGs (United Nations 2015).
The TEEB Arctic Scoping Study builds on recent initiatives in Arctic countries and, in turn, the scoping study provides wider Arctic regional context for such national initiatives. Table 1.2 provides examples of work at the national and regional scale that are relevant to ecosystem services approaches to policy for the Arctic, ranging from providing ecosystem or ecosystem services status and trends information to advancing valuation and policy development.

Box 1.1. TEEB Nordic: Overview and lessons learned for the scoping stage of a TEEB country study

The TEEB Nordic project produced a synthesis of the socio-economic importance of ecosystem services in the Nordic countries. The project also explored the needs and opportunities for future policy action, including possible areas for Nordic cooperation. The overarching aim of TEEB Nordic was to raise awareness on the value of Nordic nature and thereby facilitate policy action in the region.

Outputs of the project were (1) a list of Nordic ecosystem services; (2) identification of indicators for Nordic ecosystem services, focusing on indicators useful to assess and compare ecosystem services at the national level; (3) a synthesis of information on status, trends and value of ecosystem services; (4) identification of knowledge gaps; (5) recommendations for policy action on ecosystem services in the Nordic countries; (6) six stand-alone TEEB case studies authored by a range of Nordic experts; and (7) outreach and communication events, regionally and nationally.

Lessons and insights for other TEEB country studies

▶ Creating a comprehensive (conceptual) framework for ecosystem services and their indicators, including systematic identification of biophysical and socio-economic indicators and understanding the linkages between the two, forms a good starting point for TEEB assessments focused on (scoping) natural assets or adding an economic dimension to existing ecosystem service assessments. Such a systematic framework helps to identify gaps and information needs, further allowing judgement of the reliability of an assessment's outcomes. It also forms a 'road map' for future research and knowledge requirements, and forms a good basis for more detailed (socio-economic) exploration of a number of selected services.
▶ In addition to peer review, active engagement of relevant interested stakeholders can provide multiple benefits to the process, such as raising awareness, increasing buy-in, and bringing additional resources to complement the study. Cooperation with the TEEB UNEP office and/or other TEEB initiatives plays an important role in increasing visibility and helping to share key messages to the wider audience.

Summarized from the Guidance manual for TEEB country studies (TEEB-The Economics of Ecosystems and Biodiversity 2013) (based on Kettunen et al. (2012))

Table 1.2. Examples of government-led Arctic country and regional-scale assessments of ecosystems and ecosystem services

Country or region	Project reports
Nordic countries: TEEB study undertaken through Nordic Council of Ministers	Socio-economic importance of ecosystem services in the Nordic Countries – Synthesis in the context of The Economics of Ecosystems and Biodiversity (TEEB) (Kettunen et al. 2012) See Box 1.1.
Barents Sea: UNEP regional report; bilateral report	Global International Waters Assessment, Barents Sea. GIWA Regional assessment II (UNEP 2004); *Joint Norwegian-Russian environmental status 2008 report on the Barents Sea Ecosystem* (Arneberg et al. 2009)
Europe: methods and case studies report from the European Union Northern Eurasia: initial work on potential TEEB assessment	*A Spatial assessment of ecosystem services in Europe: Methods, case studies and policy analysis* (Maes et al. 2011) *TEEB: Potential and Perspectives of Northern Eurasia. Proceedings of a meeting in Moscow, 2010* (Pavlov et al. 2010)
Canada: national ecosystem assessment, with Arctic and taiga ecozone reports; methodological reports on measuring and assessing ecosystem services	*Canadian biodiversity: Ecosystem status and trends 2010* (Federal Provincial and Territorial Governments of Canada 2010) *Human activity and the environment: Measuring ecosystem goods and services in Canada* (Statistics Canada 2013) *Completing and using ecosystem service assessment for decision-making: A practical interdisciplinary toolkit for managers and analysts* (Federal, Provincial and Territorial Governments of Canada, in press)
Finland: biome-based studies of ecosystem services; TEEB country study	*Freshwater ecosystem services in Finland* (Alahuhta et al. 2013) *Ecosystem services of boreal mires and peatlands* (Aapala et al. 2012) TEEB for Finland study (*Towards Sustainable and Genuinely Green Economy - The value and social significance of ecosystem services in Finland*) in progress
Norway and Sweden: TEEB follow-up reports on values of ecosystem services	Norway: *Natural benefits – on the values of ecosystem services* (NOU 2013) Sweden: *Making the value of ecosystem services visible* (SOU 2013); Inventory of data sources (Statistics Sweden 2013) See 3.5 Some related TEEB initiatives in the region for discussion.
Russia: UNEP regional and Russian national ecosystem assessments	*Global International Waters Assessment (GIWA)*. Russian Arctic (UNEP 2005) *Ecosystem services of terrestrial ecosystems in Russia: Status quo report* (Conservation Centre 2013)
United States: marine integrated ecosystem assessment	*Integrated ecosystem assessment: Alaska Complex* (NOAA) (ongoing) (NOAA n.d.)

1.4. Introduction to ecosystem services

Ecosystem services include both direct and indirect contributions of ecosystems and biodiversity to human well-being (MA 2005a; Raffaelli 2010; TEEB – The Economics of Ecosystems and Biodiversity 2010a). They build on biophysical structures and processes of ecosystems, and, through distinct ecosystem functions, they lead to a range of benefits to humans (Figure 1.1). For example: primary production (a process) underpins the maintenance of viable fish populations (a function) which in turn enables the provisioning of food (a service) (TEEB – The Economics of Ecosystems and Biodiversity 2010a). The provisioning of food in turn can lead to several benefits to **human well-being** (e.g., nutrition and food security) which can be valued in socio-economic terms.

> **Human well-being**: a context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience

This definition of ecosystem services captures the important role nature plays in supporting several aspects of well-being. It also acknowledges that the benefits related to the use of ecosystem services are influenced by anthropogenic factors and are not just determined by the biophysical foundation. For example, the provisioning of food is often significantly enhanced

by human interventions, while the enjoyment of nature is influenced by people's preferences and values. In terms of benefits and values, it is important to note that some values – such as social cohesion and cultural traditions (Figure 1.1) – are essential aspects of many people's connections to ecosystems and biodiversity (and in particular for Indigenous Peoples). However, such values are difficult to capture in the context of a purely economic valuation, such as a study of willingness to pay for ecosystem services. Types of socio-cultural values associated with the two examples in Figure 1.1 are (1) protection from flooding can support social cohesion by not disrupting the spatial locations and patterns of interaction among families, such as through forced relocation; and (2) obtaining products from vegetation supports many aspects of maintaining cultural traditions, such as through harvesting and preparation, during which **Traditional Knowledge** and other cultural knowledge is shared.

Figure 1.1. The pathway from ecosystem structures and processes (the biophysical foundation) to human well-being (socio-economic benefits and values, including economic and socio-cultural values).
(adapted from De Groot (2010), referencing Haines-Young and Potschin (2010) and Maltby (2009))
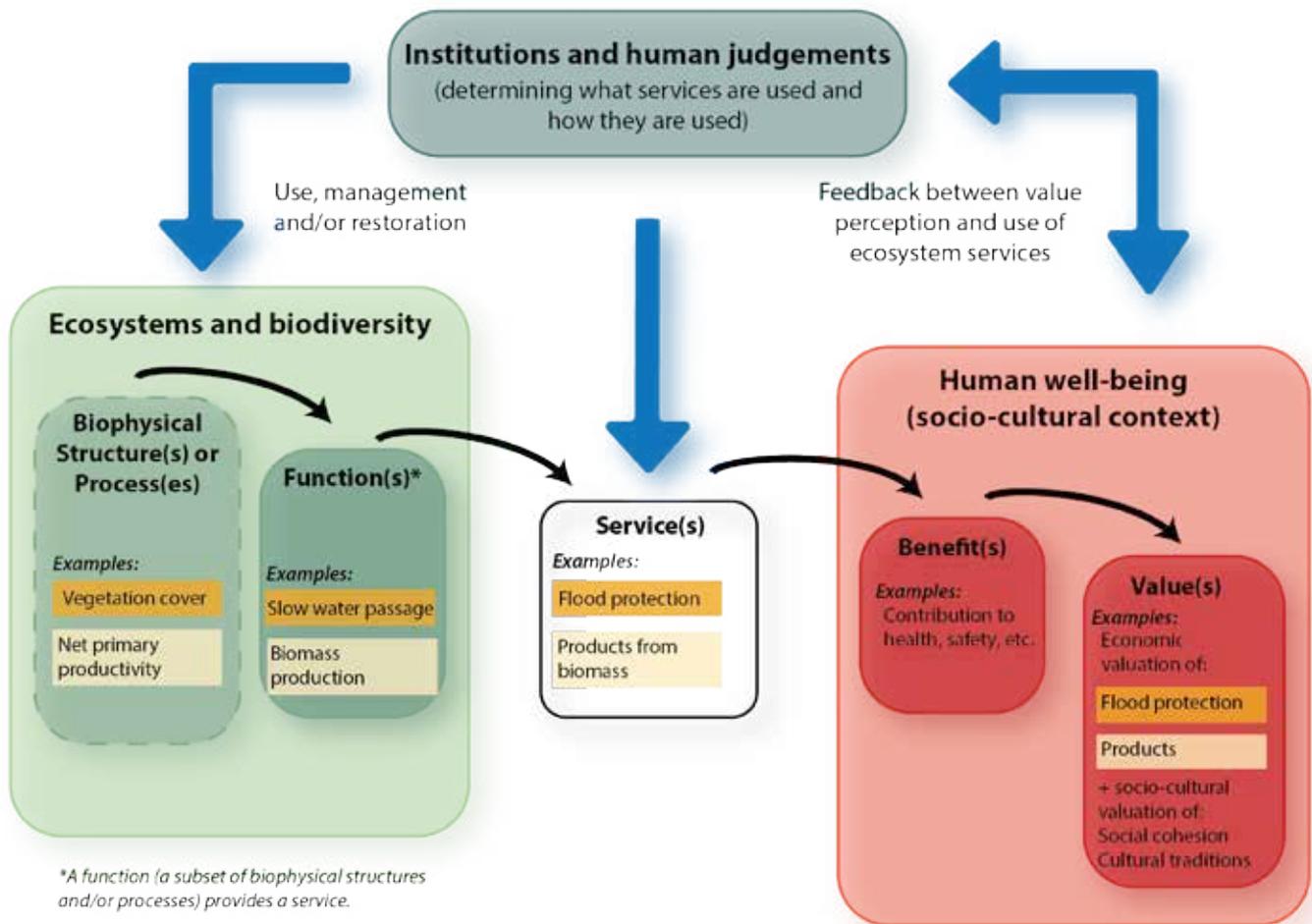
In other words, ecosystem services consist of two elements: the ability of ecosystems and biodiversity to provide services (the biophysical and ecological element), and the benefits of these services to humans (the social, cultural and economic elements) (Kettunen et al. 2012). Given that the human perspective is integral to ecosystem services, ecosystems' resources, processes and functions are generally defined as services and benefits when they are identified as beneficial to humans, either now or in the future.

To help understand and apply the concept of ecosystem services, they are commonly classified into provisioning, regulating and cultural services (MA 2005a; TEEB – The Economics of Ecosystems and Biodiversity 2010a). TEEB's classification also includes the category of habitat services, referencing the importance of ecosystems in providing habitat for species and for protecting genetic diversity (TEEB – The Economics of Ecosystems and Biodiversity 2010a). The importance of ecological processes supporting the other services – and, through this, contributing to human well-being – is often recognized under a separate category of supporting or maintenance services (MA 2005a; Kettunen et al. 2012).

In reality, the different categories of ecosystem services are fundamentally interlinked. For example, the maintenance of soil fertility, provisioning of water and regulation of climatic conditions (regulating services) enable the provisioning of food and raw materials. Cultural services are directly or indirectly linked to an ecosystem's ability to maintain its beneficial

regulatory functions, such as the maintenance of water quality. Cultural services are also linked to the aesthetic features and environmental quality of a particular place, which, in turn, build on (among other things) the abundance of insect-pollinated flowers, regulation of pest and disease outbreaks, and water resources that maintain a characteristic vegetation cover. Consequently, while conceptually it is useful to differentiate among the different ecosystem services to enable their identification and assessment for communication and decision-making purposes, the sustainable management of ecosystem services in practice requires a holistic approach that is based on a comprehensive understanding of ecosystems and biodiversity (an ecosystem-based approach to management).

Ecosystem services are, in effect, defined by people using or enjoying these benefits. Ecosystem services and the benefits provided differ in terms of their distribution: specific ecosystem services and goods benefit specific stakeholders (TEEB – The Economics of Ecosystems and Biodiversity 2011a; Kettunen and ten Brink 2013). The beneficiaries of a given ecosystem service and/or good can be local (e.g., farmers, foresters, fishers, communities, businesses), regional (e.g., consumers of fresh water within a watershed), national (e.g., national food and health sectors) and global (e.g., temperate regions benefiting from Arctic climate regulation, international tourists, consumers of an internationally marketed product). One benefit may also be of value to several stakeholders, further increasing the overall importance of the ecosystem service. Furthermore, while ecosystem services are derived from (or produced by) nature, several stakeholders play a role in ensuring their continued existence and supply (TEEB – The Economics of Ecosystems and Biodiversity 2011a; Kettunen and ten Brink 2013). For example, local communities, landowners and land users help maintain a range of regulating services by adopting sustainable management practices. It is important to identify the beneficiaries, and it is also important to recognize who is responsible for supporting the maintenance of ecosystem services.

Arctic ecosystem services are described and discussed in terms of their classification, interlinkages, beneficiaries, and status and trends in Chapter 2.

1.5.   Introduction to the TEEB approach

This overview of TEEB methodology draws on the Guidance Manual for TEEB Country Studies (*TEEB -- The Economics of Ecosystems and Biodiversity 2013*) and TEEB Challenges and Responses (Sukhdev et al. 2014).

TEEB presents an approach that can help decision-makers recognize, demonstrate and, where appropriate, capture the values of ecosystems and biodiversity through policy (Box 1.2). This approach acknowledges that there are many types of values (including monetary, non-monetary, ethical, spiritual and aesthetic) that people hold for nature, and many different options for better incorporating nature's values into decision making.

Box 1.2. The TEEB tiered approach

Recognizing value. Identifying the wide range of benefits in ecosystems, landscapes, species and other aspects of biodiversity, such as provisioning, regulating, habitat/supporting and cultural services.

Action: Identify and assess the full range of ecosystem services affected by the policy and the implications for different groups in society.

√   In some cases this recognition is sufficient to create norms, policies or legislation for conserving nature. Examples: sacred sites, protected areas, community stewardship of natural resources.

Demonstrating value. Using economic tools and methods to make nature's services economically visible in order, for example, to support decision-makers wishing to assess the full costs and benefits of land-use change.

Action: Estimate and demonstrate the value of ecosystem services, including linkages over time and scale (local versus global, current versus future use)

√   Value could be represented through the expression of stakeholder views, through measures like the number of people who benefit from nature recreation in an area, or through estimates of monetary value.

Capturing value. Incorporating ecosystem and biodiversity benefits into decision making through incentives and price signals.

Action: Seek solutions to overcome the under-valuation of ecosystem services through economic policy instruments.

√   Not just market-based solutions (which are not always appropriate). Examples: regulation, land-use planning, subsidies, fiscal incentives, access or use charges, payments for ecosystem services, eco-labelling and certification.

(TEEB – The Economics of Ecosystems and Biodiversity 2013; Sukhdev et al. 2014)

Box 1.3. The six steps of a TEEB study

STEP 1: Refine the objectives of a TEEB study by specifying and agreeing on the key policy issues with stakeholders.

STEP 2: Identify the most relevant ecosystem services.

STEP 3: Define information needs and select appropriate methods.

STEP 4: Assess and value ecosystem services.

STEP 5: Identify and outline the pros and cons of policy options, including distributional impacts.

STEP 6: Review, refine and report.

(TEEB – The Economics of Ecosystems and Biodiversity 2013)

The objective of a TEEB assessment is to highlight the importance of sustainable use and conservation of nature, rather than reducing it to a commodity. TEEB can provide a bridge between the multi-disciplinary science of biodiversity and the arena of international and national policy, as well as local government and business practices. Ideally, TEEB will act as a catalyst to help accelerate the development of a new economy: one in which the values of nature are fully reflected in public and private decision making.

Policy is the starting point for a TEEB study. Box 1.3 lists the steps that are recommended for a TEEB study and Annex 2 presents a description of the outputs from each step. Consideration of gender and intergenerational differences and social and economic inequality should be embedded in these steps, including in specifying and agreeing on key policy issues with stakeholders (Step 1) and in identifying and outlining the pros and cons of policy options, including distributional impacts (Step 5).

The TEEB methodology includes the use of policy scenario analysis to make the case for policy change. Within each policy context, a TEEB Arctic study would conduct biophysical and economic valuation exercises on the change of ecosystem service provisioning under alternative scenarios compared to 'business as usual'. This will provide policy evidence on the important role of Arctic ecosystems and biodiversity for local and global well-being, with the aim to incorporate these values into decision making. The use of scenarios promotes looking ahead: What are the consequences for ecosystem services and their beneficiaries if we continue along the path we are following (a 'business as usual' policy scenario), and what difference would recognizing, demonstrating and/or capturing the values of nature in policy make (an alternative policy scenario)? The focus is on **marginal change**: how much difference would the alternative policy make; and on **distributional impacts**: who would be the winners and who would be the losers? Box 1.4 describes examples of successful applications of a TEEB approach to major policy decisions.

TEEB studies need input from a wide range of interests and disciplines. The approach is cross-sectorial and participatory, and can only work with active participation of, and consultation with, a broad range of experts and stakeholders. Institutional capacities and governance have to be taken into account to develop viable and realistic policy options. For the Arctic, with its multiple governance jurisdictions, this means that the relevant regions and scales of the policy areas being assessed are very important.

The values of nature

Input, discussion and review of this TEEB Arctic scoping study raised concerns and challenges about the TEEB focus on the values of ecosystem services, and specifically its methodological focus on valuation of these services. The main challenges raised regarding economic valuation are also relevant in other regions of the world and are the subject of a recent TEEB report (Sukhdev et al. 2014). Several of these challenges are discussed more fully in an Arctic context in Chapter 3 'Governance of Arctic ecosystem services' and Chapter 4 'Valuing ecosystem services in the Arctic'.

The TEEB approach is not about imposing economic valuations in situations where they would be misleading or would not contribute to the goal of making the benefits all people derive from ecosystem services visible in decision making. TEEB considers valuation to be a human institution, largely dictated by socio-cultural values, norms and beliefs. As such, different interpretations of 'value' will exist, none of which should

Value: The attribution of significance (importance, worth or usefulness) to an object or concept of any sort by a person or collective.

Valuation: The process of expressing a value for a particular good or service in a certain context (e.g., of decision making) usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology, and so on).

be perceived as either incorrect or invalid. TEEB studies include participatory approaches to determine the appropriate way to assess ecosystem services, including whether monetary valuation is required or not. 'Value' is filtered through different disciplinary lenses as relevant to the type of value or values being assessed and valuation therefore requires broad interdisciplinary involvement.

Challenges and responses
(summarized from Sukhdev et al. 2014):

1. **Values are derived from world views and perceptions of societies**. Any exercise in valuation will be subjective and will only represent certain views. This is recognized in the TEEB approach through being explicit about the context and purpose of valuation and not applying economic valuation where it would be misleading. This highlights the importance of participatory approaches, particularly relevant for the Arctic: "*In complex situations involving multiple ecosystems and services, and/or plurality of ethical or cultural convictions, valuation data may be unreliable or unsuitable. In such cases a differentiated discussion of what choices society has regarding our relationship with nature and what risks these involve is all the more important*" (Sukhdev et al. 2014).

2. **Values often cannot be measured in the same units – or they are reduced to one unit** (usually money) for comparative purposes. This is like equating the loss of a human life with financial compensation. It fails to take into account values that cannot be measured. This serious concern can be addressed by going beyond monetary valuation and placing values in their proper context. Where monetary valuation is used, it is essential to communicate what values and dimensions are or are not covered.

3. **Valuation adds a layer of economic uncertainty on top of the already considerable ecological uncertainty**. A major source of uncertainty is in how we value the future (how we account for the responsibility of the present generation to future generations), which, for monetary valuation, is expressed as a choice of discount rate. The TEEB response to this is to make use of a range of discount rates linked to different ethical standpoints, so that the consequences of these choices are clear. Another response is to advocate for policy options based on precautionary approaches and safe minimum standards in situations of high uncertainty or nonlinear change.

4. **Valuation of nature may lead to it becoming a market commodity and subject to free trade**. The response from the TEEB programme is that concern about commodification of nature is valid. "*We would, however, argue that essential ecosystem services are already being 'traded' in precisely this manner, sometimes for an implicit price of zero*" (Sukhdev et al. 2014). It is important to distinguish between placing a value on ecosystem services and putting a price on ecosystem services. This is discussed further in Section 3.8.4 'Concerns about commodification and marketization of nature'.

Box 1.4. Examples of outcomes from application of TEEB approaches

▶ Plans for draining the Nakivubo Swamps wetland (Kampala, Uganda) were abandoned and the area was gazetted as protected area when it was assessed that maintaining the waste water treatment and nutrient retention capacity of the swamp resulted in benefits assessed to be worth over one million dollars per year, topped up with an additional two million dollars per year in avoided costs of running a sewage treatment facility (TEEB – The Economics of Ecosystems and Biodiversity 2010b).

▶ Managers of the Napa River basin (California) adopted a natural flood management regime when their assessment showed that such a regime would result in benefits in terms of flood prevention, recreation and tourism (TEEB – The Economics of Ecosystems and Biodiversity 2010b).

▶ In the city of Vihti, Finland, an urban wetland was created when the benefits from this were assessed to be a cost-effective way for managing water quality, while at the same time creating recreational and biodiversity benefits (Kettunen et al. 2012).

1.6. Scoping study methods and knowledge base

1.6.1. Project development

The project concepts and terms of reference were reviewed through the CAFF Board, the project partner organizations, and through a workshop held in conjunction with the Arctic Frontiers Conference in Tromsø, Norway, in January, 2014. The project partners comprised the Project Steering Group, which provided direction and assistance to the coordinator and report authors. The Inuit Circumpolar Council and the Aleut International Association also provided input at various stages in the process.

Experts provided input through a workshop in Reykjavik, Iceland, in May 2014 (Eamer et al. 2014) and through an online questionnaire, which consisted primarily of open-ended questions and prompts, tailored to different audiences[4] (Figure 1.2). Input from these two sources was instrumental in the design and implementation of the scoping study and will continue to provide guidance for subsequent TEEB work in the Arctic.

Figure 1.2. Overview of TEEB-Arctic online questionnaire
(J. Eamer)
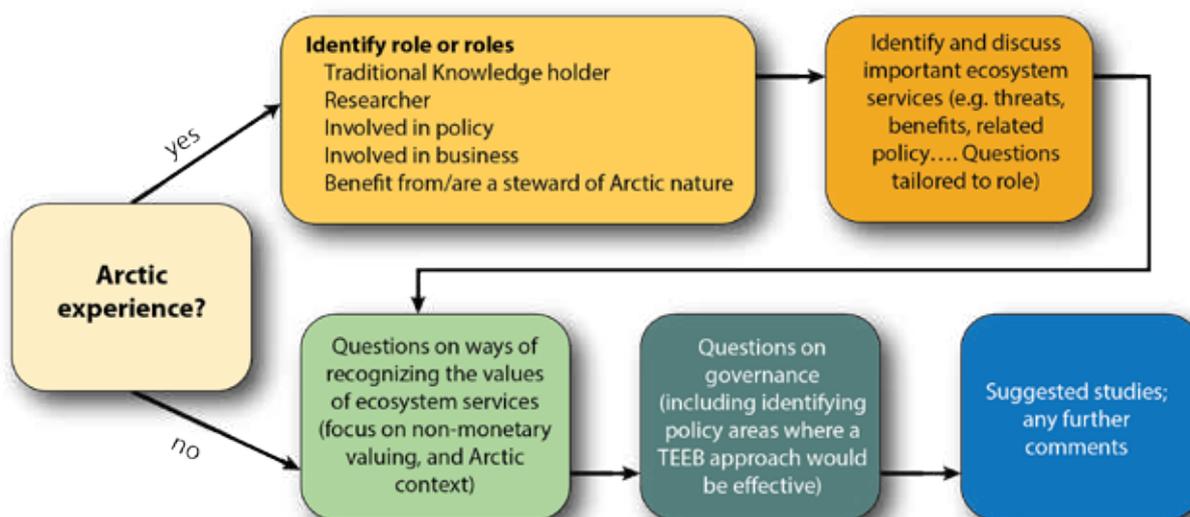
In general the scoping study followed the methods outlined in the TEEB Guidance Manual for Country Studies (TEEB – The Economics of Ecosystems and Biodiversity 2013), adapting methods for the complex, multi-national policy regime of the Arctic, and drawing from other TEEB work, notably the TEEB study for the Nordic countries (Kettunen et al. 2012). Discussions of policy areas were added to help focus the scoping study on policy options that would benefit from a TEEB Arctic assessment.

1.6.2. Communications

A communications team (consisting of CAFF, WWF and UNEP communications specialists) was established to provide information on the scoping study and communications support for events. The scoping study's communications objectives included raising awareness and introducing/reinforcing TEEB concepts and ecosystem values with specific audiences, and engaging audiences and encouraging them to share knowledge and contribute their perspectives on TEEB.

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4   Sixty responses were received, mainly from people living and/or working in the eight Arctic nations. Country and number of respondents: Norway, Denmark, Sweden, Greenland or Iceland (18); Canada (17); US (8); Russia (8); non-Arctic nations (9). People self-identified in one or more of several categories (Figure 1.2). Categories and number of respondents: researcher (31); beneficiary of ecosystem services and/or steward of Arctic ecosystems and biodiversity, which included people working for NGOs and indigenous organizations (25); policy-maker (20); involved with commercial sectors (11); Traditional Knowledge Holder (3); other (6). The questionnaire was advertised publicly on the CAFF website and through requests to identified experts. It was available online in English and Russian.

Main activities and products

1. Project website (www.arcticteeb.net) providing an introduction to the project and a central access point for project documents. It was designed to be easily expanded in further phases of TEEB work in the Arctic (see 'The way forward' section).
2. Presentations and panel discussions at events and conferences[5].

1.6.3. Knowledge base and related initiatives

A large task was to identify relevant knowledge sources. While the available information has not been comprehensively surveyed, the scoping study did take steps to lay the foundations for further development of the knowledge base that would be required for a TEEB study.

There is a wealth of literature that covers aspects of ecosystems, ecosystem services, and the social, economic, policy and governance dimensions of the Arctic. But only a small portion of this literature directly addresses or clearly contributes to recognizing, demonstrating or capturing the values of Arctic ecosystems and their services to humans. In addition, much of the knowledge that is important for implementing TEEB approaches in the Arctic, especially at local scales, is not documented or easily accessible: in particular, traditional and local knowledge of Arctic Indigenous Peoples and local knowledge of other Northerners. This knowledge may be brought into policy making through participatory processes and through documented Traditional Knowledge studies and community-based monitoring programs.

Sources of documented information, guidance, and ideas that can contribute to development of TEEB approaches to policy for the Arctic include (1) academic literature, especially, cross-disciplinary work; (2) reports by Arctic Council, governments, multilateral organizations, NGOs and Indigenous organizations; (3) web-based resources providing tools and methods, such as the Environmental Values Reference Inventory (EVRI 2011), case studies, metadata on valuation studies, and other types of resources.

Scoping study knowledge products

1. Electronic library of relevant published reports and papers. This library will serve as a resource base for future Arctic TEEB activities.
2. Scoping level (incomplete) Arctic ecosystem services inventory used in the preparation of this report (see Chapter 2 'Arctic ecosystem services'). This inventory has potential for further development as a tool for synthesizing information on Arctic ecosystem services and for making this information available to decision-makers (see Chapter 7 'The way forward'). It consists of a structured literature review and summary tables (Figure 1.3). It is a first step in providing supporting information for recognizing the values of Arctic ecosystem services, and for implementing Arctic Council recommendations to catalogue and assess these values (CAFF 2013a; PAME 2013b). The draft inventory is a supplementary document to this scoping study, and will be made available on the TEEB website (www.arcticteeb.net) and the Arctic Biodiversity Data Service website (www.abds.is).

Figure 1.3. Categories for summary tables in the draft Arctic Ecosystem Services Inventory

1.7. Arctic issue scan

1.7.1. Introduction

The Arctic is in a state of flux, with issues emerging that are related to rapid environmental, social and economic change. This section presents a scan of major Arctic issues in relation to ecosystem services and to policy and governance. We return to these issues later in the various chapters – this section is intended to provide an overview and to set the context for this report.

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5   Including CBD side event, October 4-19, 2014, Korea; Arctic Circle, October 31-November 2, 2014, Reykjavik, Iceland; Arctic Biodiversity Congress, December 2-4, 2014, Trondheim, Norway

Figure 1.4 shows the eight Arctic countries and the outline of the circumpolar Arctic, as defined by the CAFF working group of Arctic Council.

Economies are mixed in the Arctic. Both market activities such as oil and gas development and tourism, and non-market subsistence activities, including reindeer herding, hunting and fishing, play a valuable role in community economies. Income is from various mixes of wage employment, traditional pursuits, and government transfers. Cultures also vary. Some Arctic areas have towns and cities dominated by the main cultures to the south. In other areas people are dispersed in small communities, often isolated, and many strongly rooted in traditional and indigenous cultures.

Arctic nature is important to all Arctic residents, but in different ways, and through different world views. This mixed economy and mixed cultural landscape affects the balance of power among Arctic stakeholders. There is growing pressure to find solutions to questions of resource allocation and to address current and potential impacts on socio-economic development and quality of life in the Arctic.

The competition for Arctic resources and use of land and sea goes well beyond the local scale. Much of the public- and private-sector decision making for northern regions occurs far away in southern centers, where Arctic nature is characterized by images of polar bears and vast uninhabited frozen lands and seas. The intimate linkage between Arctic ecosystems and the well-being of Arctic peoples often does not enter into these decisions. But there is increasing global awareness of the services that Arctic ecosystems provide in global climate regulation, and of the impact that decisions around the world on greenhouse gas emissions have on Arctic ecosystems and biodiversity.

Figure 1.4. The Arctic, showing the boundary used by the Conservation of Arctic Flora and Fauna working group (Hugo Ahlenius, UNEP/GRID-Arendal)

1.7.2. Climate change

"Changes in the Arctic will have consequences far beyond this region, including a global rise in sea levels and probably more extreme weather across much of the northern hemisphere. These current and future consequences of climate change require urgent responses. Arctic and non-Arctic countries share responsibility for protecting this region, in particular by limiting their greenhouse gas emissions." (Corell et al. 2013)

Climate change, directly and indirectly, underlies much of the rapid change observed in Arctic ecosystems, biodiversity and ecosystem services, and is linked to current and projected changes in Arctic business development and Arctic economies (Corell et al. 2013; UNEP 2014). The most recent IPCC report places the overall rate of Arctic warming at two to three times the global average (IPCC 2013) and climate change was identified as the most serious threat to Arctic biodiversity in the Arctic Biodiversity Assessment (CAFF 2013a). Biodiversity associated with sea ice is particularly at risk (Eamer et al. 2013). The loss of seasonal sea ice is also rapidly opening new shipping routes, and new potential for oil and gas extraction, mining and mineral extraction, fisheries, tourism and other types of commercial enterprises and non-renewable resource exploitation (Corell et al. 2013).

Change is not just a steady progression as the climate warms and the ice melts: thresholds are passed and sudden, unexpected changes occur (Duarte et al. 2012; Gilg et al. 2012; Lenton 2012). Climate change alters and threatens ecosystem services in the Arctic, for example by changing the ranges or abundance of animals that are important for food – either because their habitat or food supply changes, or because other species move in from the south and displace them (CAFF 2013b).

Climate change in the Arctic also affects ecosystem services beyond the Arctic, for example, by changing Northern Hemisphere weather patterns; contributing to global sea level rise; altering ocean circulation; releasing stored carbon as permafrost thaws, leading to positive feedback loops; and, through posing threats to the global cultural assets of iconic Arctic species, landscapes and icescapes (AMAP 2012; Corell et al. 2013).

Actions on climate change mitigation have been more at the global, national and sub-national scale than through Arctic Council, with the exception of recent initiatives on black carbon (Arctic Council 2013b; ACAP 2014; TFBCM 2014).

Projections
▶ *"The Arctic region will continue to warm more rapidly than the global mean, (very high confidence). The mean warming over land will be larger than over the ocean (very high confidence) and larger than global average warming."* (IPCC 2014a) (Figure 1.5)
▶ *"The subset of models that most closely reproduce the observations project that a nearly sea ice-free Arctic Ocean in September is likely before mid-century (medium confidence)."* (IPCC 2014a)

Understanding the consequences of climate change, and assessing and augmenting capacity to adapt to these changes have been strong focuses of Arctic Council since the Arctic Climate Impact Assessment (ACIA 2004).

The Arctic Council's report Snow, Water, Ice and Permafrost in the Arctic (AMAP 2011) concluded that "*Everyone who lives, works or does business in the Arctic will need to adapt to changes in the cryosphere.*" Follow-up work by Arctic Council aims at advancing policy and action related to adaptation. Part of the challenge is to gauge the ability of Arctic social-ecological systems to respond to change through adaptation or transformation. Ongoing projects on resilience (Arctic Council 2013c) and on adaptation actions (Arctic Council 2014), look at ecosystem services to assess dependencies and benefits between people and the changing Arctic environment.

Figure 1.5. Surface temperature warming at high latitudes is projected to continue to exceed global average change
Predicted surface mean temperature warming by zones, based on the Coupled Model Intercomparison Project (CMIP5) (IPCC 2013).
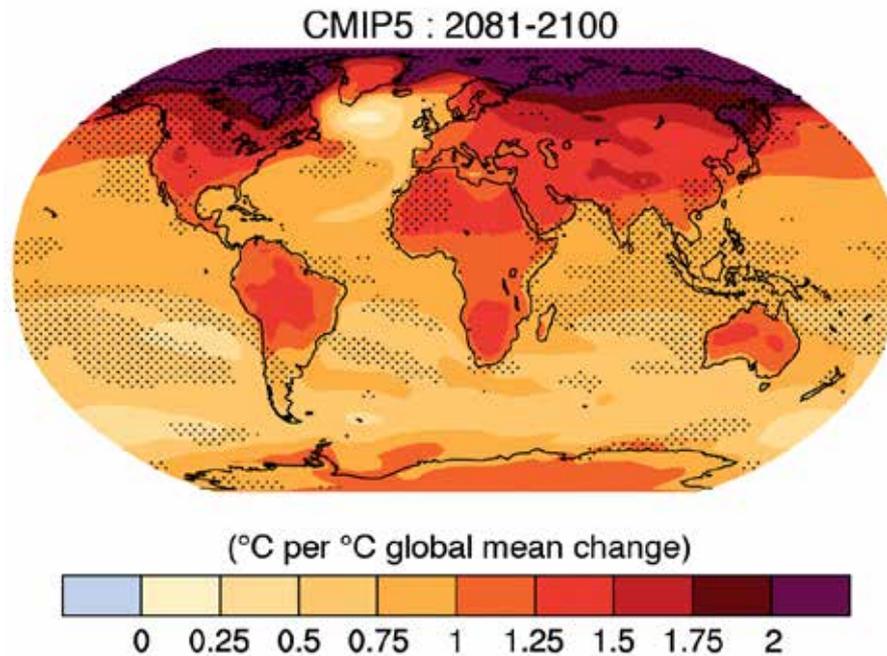
1.7.3. Increases in industrial development and shipping

"Exploitation of natural resources such as minerals and hydrocarbons remains largely a national issue, but it is one in which the global community is taking an interest. With the opening of new shipping routes and the exploration of oil, gas and mineral deposits in the Arctic, non-Arctic countries are eager to gain a foothold in the region." (Corell et al. 2013)

"Commercial ships going through the Arctic are not going through an empty ocean, but may have widespread effects on species and cultures. Recognizing what is at stake can help justify regulatory measures that allow shipping, but also protect nature and communities from disturbance, accidents, etc." (TEEB questionnaire input)

Mining, oil and gas development and shipping are not new to the Arctic. Industry is the backbone of economies in many regions. But the overall picture is changing, due to a combination of many drivers: increased global appetite for raw materials, declining conventional petroleum production, improved technologies, national strategic policy directions (e.g., to develop the North, to enhance sovereignty, to secure domestic energy supplies) and the opening of new marine access due to the climate-change-related retreat of Arctic sea ice.

There remains much uncertainty about what developments are likely to proceed and when – costs and risks to developers are high. This climate of actual and anticipated change, however, brings with it a host of concerns about potentially high risks to ecosystems, biodiversity and ecosystem services from pollution, spills, habitat loss and fragmentation, introduction of invasive species, and increases in disturbance to wildlife and to people who make their living on the land and at sea. Disturbances can be caused, for example, by aircraft, land vehicle and ship activity.

The Arctic Council has completed assessments of shipping (Arctic Council 2009) and oil and gas activities (AMAP 2010a) in the Arctic, as well as guidelines for nations to use in developing standards for offshore oil and gas activities (PAME 2009). Ongoing Arctic Council work includes initiatives to assess and mitigate risks from increased marine activity (Arctic Council 2013b), including development of shipping safety standards and regulations, guidance on oil spill response technologies and best practices for vessel-based Arctic tourism, and agreements on oil pollution prevention (Arctic Council 2013d; TFOPP 2014). Recent initiatives reflect directions to work with industry in developing guidelines and measures to protect the environment and biodiversity, in light of the ramping up of industrial activity in the Arctic (CAFF 2013a).

Points below are based mainly on Andrew (2014) and references therein.

Current situation

▶ Arctic petroleum extraction accounts for 10% of global oil production and 25% of global natural gas production. This is mainly (97%) from onshore fields in Russia and Alaska.

▶ Mining occurs in all Arctic jurisdictions except Iceland and the Faroe Islands, with a bias to large mines, as high costs make smaller operations unprofitable.

▶ Abundant hydroelectricity powers large aluminum smelters in Iceland, and initial studies have been undertaken for smelter development in Greenland (Alcoa 2014; IAAP 2014).

▶ Nearly all current shipping in Arctic waters is destinational (to ports in the Arctic), with the exception of the North Pacific Great Circle Route, which passes through the Aleutian Islands. Transit shipping, which is an alternative to existing shipping routes to the south, is increasing (Figure 1.6).

Figure 1.6. Arctic transit shipping routes
(reproduced from Arctic Council, 2009)
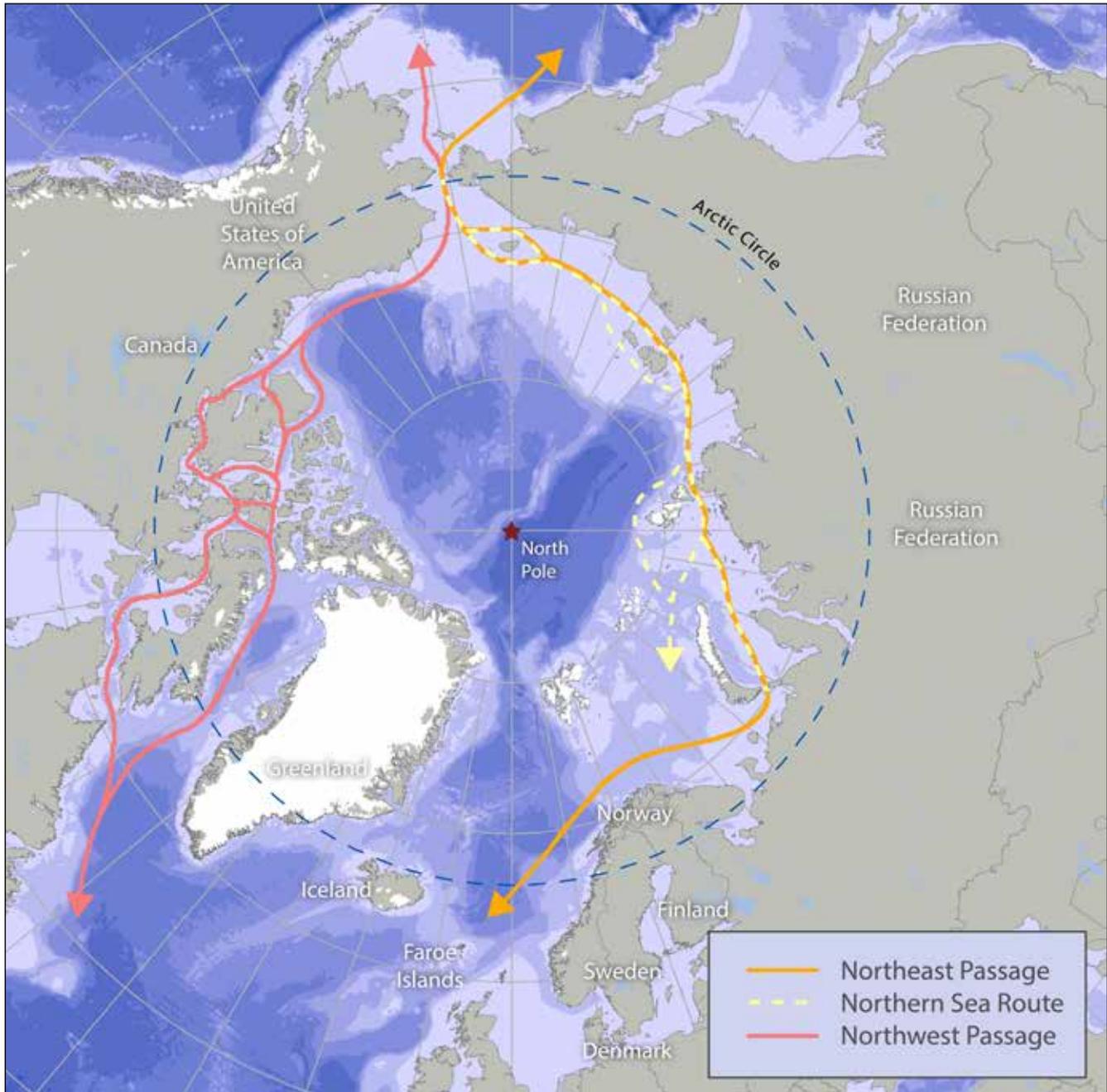
Projections

▶ *"The Arctic is likely to attract substantial investment over the coming decade, potentially reaching $100bn or more."* (Emmerson and Lahn 2012)

▶ The rate and extent of development of petroleum reserves is uncertain, but expected to be sooner for the warmer, ice-free Norwegian Barents Sea than for other Arctic regions. Undiscovered reserves in the Arctic, estimated at 30% of global undiscovered gas and 13% of undiscovered oil, are mostly offshore.

▶ The rate and extent of mining development is also uncertain, but expected to increase due to increasing global demand.

▶ The potential for hydroelectric development to power industrial development is huge across much of the Arctic (Greenland has the world's biggest unexploited capacity), but development faces constraints in terms of capital costs and environmental and social impacts (Koivurova et al. 2009).

▶ The expectation is of increased use of the Northern Sea Route (Eurasian coast). There is more uncertainty about the timing and extent of shipping through the Northwest Passage (North American coast). This is partly due to substantial differences in ice conditions and in existing port infrastructure between the two routes.

1.7.4. Globalization

"Globalization refers to phenomena and systems that are truly worldwide in scale, such as the information and communication systems and technologies of the World Wide Web, or the development of world trade into global free markets and global economy. Similarly, worldwide movements against global markets, as well as general changes such as global climate change and global economics, are also evidence of 'globalization.' Thus, there are several types, or aspects, of globalization, including economic, political, cultural, and socioeconomic globalization and globalization of the environment." (Globalization of the Circumpolar North, Heininen and Southcott 2010).

"Peoples of the Arctic feel a fierce attachment to their homes. Many of them have already had to deal with the legacy of being colonized so that their governance and economic systems have been disrupted. The effects of physical colonization in aggregate have probably been the least severe. But globalization now provides a form of physical colonization, with pollutants from far away settling into the Arctic, and climate change eroding the cryosphere. These impacts eat away at the physical home that provides sustenance both physical and spiritual for Arctic peoples." (TEEB questionnaire input)

Globalization of the Arctic is a significant force on several fronts. The increased global interest in shipping, oil, gas and mineral extraction, and fisheries means that decisions about Arctic commercial activity may be increasingly taken in government offices and boardrooms far removed from those who stand to lose from any consequent damage to ecosystems and biodiversity. The scope and size of many resource development projects in the Arctic means that only large corporations are involved, making resource development inherently global in nature (Heininen 2013). Climate change in the Arctic is largely externally driven, with greenhouse gas emissions tied to economies and market forces world-wide. While many Arctic societies remain strongly rooted in their lands and traditions, most are also strongly influenced by globalization of culture, goods and services. Arctic Indigenous cultures grow and change, like all cultures, remaining grounded in their traditions while taking advantage of new cultures, technology and services. Globalization presents new options to Arctic residents, but also presents challenges to cultural continuity.

The forces of globalization can be major drivers of local-scale Arctic economies: volatile world markets for raw materials often dominate these resource-focused economies, leading to boom-and-bust cycles (Arctic Council 2004); subsistence activities and small-scale industries like trapping and seal hunting are vulnerable to trade bans and protests based on social mores from cities far away. National economic policies promoting globalization and the market economy, such as privatization and cut-backs in social benefits to increase competitiveness, can disproportionately affect some northern regions that have few year-round jobs and high costs of living. Other cultural aspects of globalization can be positive: advances in communication technology and infrastructure can modernize and strengthen cultural ties around the Arctic and open up new educational and career opportunities; the growth of international law and human rights norms can support action towards democracy and human rights (Arctic Council 2004).

1.7.5. Food and water security

"Food security exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (Committee on World Food Security 2014)

"Alaska Inuit food security is synonymous with environmental health. An environment is considered healthy when all parts are fit together. One elder explained that the Arctic environment is like a puzzle, with all pieces having a place and needed to make up the entire puzzle; this includes native languages, retention of Traditional Knowledge, animal health, etc." (Inuit Circumpolar Council Alaska 2014)

"People who do not depend on wildlife for food may not fully understand how fundamental wildlife harvesting is to most Arctic people in terms of food, security, personal health and well-being and cultural continuity. The fact that Arctic people must kill wildlife for food and/or to earn some modest income needs to be well understood by others such that domestic and international policy-makers can do their work with the focus on the true dependents, beneficiaries, stewards and/or rights holders of Arctic nature." (TEEB questionnaire input)

Food security is intertwined with provisioning services, particularly for Arctic Indigenous Peoples. Harvest of wild foods and, in many regions, reindeer husbandry, have historically been the norm for Indigenous Peoples around the Arctic, as well as for many other Arctic residents. Wild foods remain important in quantity and in nutritional value, but Arctic communities also rely on market foods, which are often transported North at considerable cost. Food security is a complex issue, linked to costs, availability and acceptability of different types of foods, and shaped by many policies, such as those that affect food pricing and fuel costs, as well as governance of land and water protection, harvest and food sharing. Changing social and demographic patterns, industrial development, contaminants and climate change affect the provisioning services that contribute to Arctic food security.

Water security has received less attention, but the protection and sustainable management of water resources is a significant issue for many Arctic regions. In parts of the North American Arctic, Greenland and Siberia, the quantity of surface water is being reduced at the landscape level due to lakes and streams drying up as a result of longer, warmer summers – while in other places the supplies of water may be stable or increasing (Callaghan et al. 2011; Bouchard et al. 2013).

Recent and ongoing Arctic Council projects related to food and water security include a report evaluating indicators (Nilsson et al. 2013) and initiatives on resilience and adaptation (Arctic Council 2013, 2014). The Inuit Circumpolar Council Alaska is conducting a study and building a conceptual framework on how to assess food security from an Inuit perspective (Inuit Circumpolar Council Alaska 2014). Food security has been raised by Arctic Indigenous organizations over the past five years as an important issue for the Arctic Council (Saami Council 2013; ICC Canada 2014; C. Behe, pers. comm.)
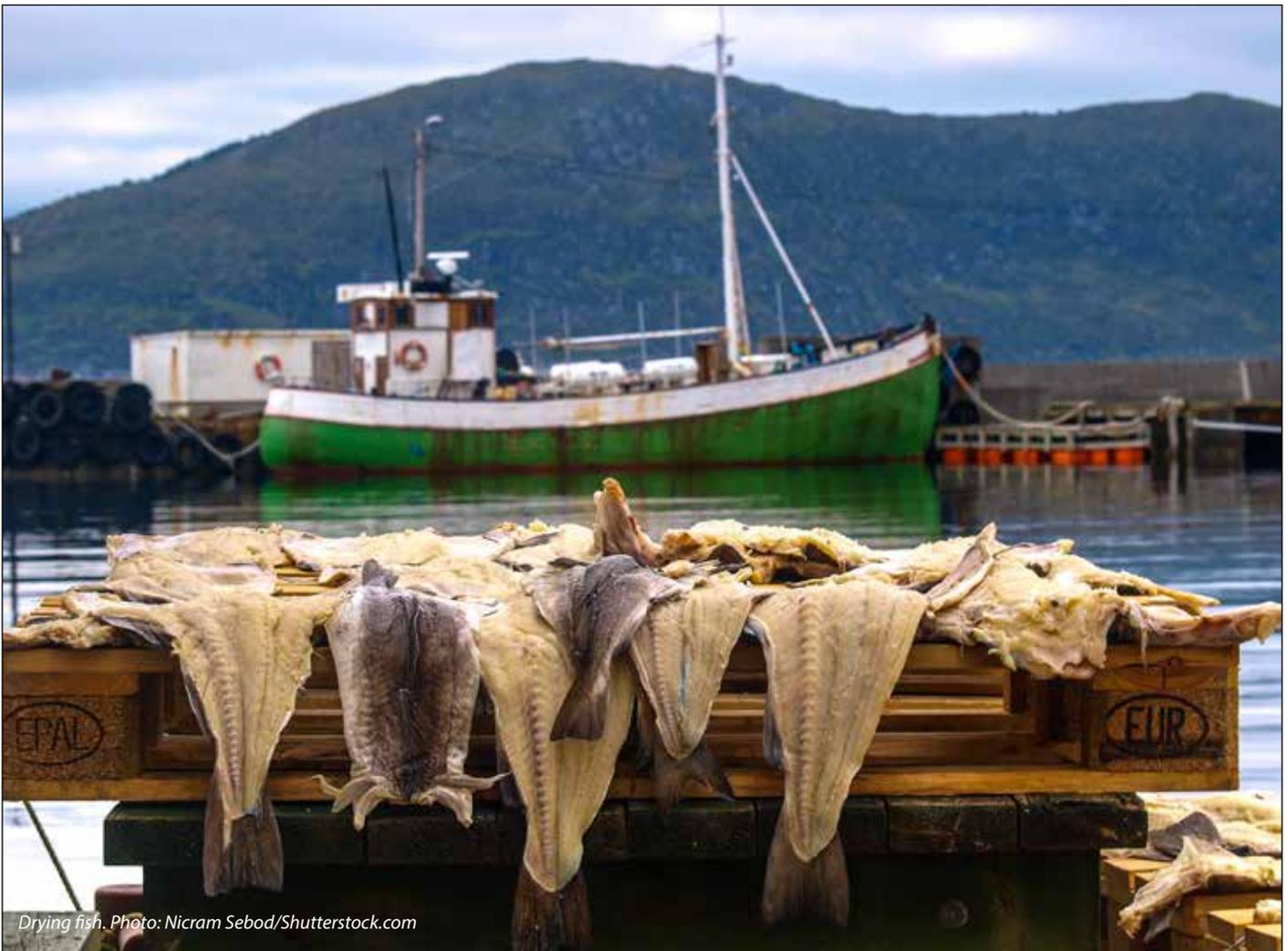
Drying fish. Photo: Nicram Sebod/Shutterstock.com

Tourists with reindeer. Photo: BMJ/Shutterstock.com

1.7.6. Arctic governance

"In a very short time, discussions on Arctic governance have moved from being a topic of scholarly attention and NGO advocacy onto the agendas of states and of the European Union." (Koivurova 2010)

Expansion of interest in Arctic development has also led to discussion and initiatives to improve Arctic governance to meet current and upcoming challenges. While some proposals favour a form of centralized approach, with the Antarctic Treaty often being held up as a model, in general the thrust of this discussion is more towards improving harmonization among different jurisdictions and across governance at different scales (Young 2012). The international waters of the Arctic Ocean, beyond the exclusive economic zones of the coastal states, are of particular interest in terms of ensuring adequate governance to protect these remote regions. International governance mechanisms apply. The Law of the Sea convention (UNCLOS) sets out a legal framework for shipping, and the International Maritime Organization has developed a Polar Code to lay out standards and requirements for the safe operation of ships in ice-filled waters (UNEP 2014). The Arctic Council established a task force during the U.S. Chairmanship (2015-2017) to assess future needs for a regional seas programme or other mechanism as appropriate for increased cooperation in Arctic marine areas (Arctic Council 2015). Regional Seas Programmes are established through UNEP and function through an action plan that is usually underpinned with a strong legal framework (UNEP n.d.).

The Arctic Council was established in 1996 as a forum to promote cooperation, coordination and interaction, mainly on sustainable development and environmental protection. The Council has broadened its scope over the years and recent changes admitted additional non-Arctic observer states while strengthening the Council by establishing a permanent secretariat and taking steps to move more into the realm of policy making (Arctic Council 1996, 2013b). For example, non-Arctic observer states can help facilitate the development of partnerships and policy measures that conserve Arctic-nesting migratory birds throughout their ranges (CAFF 2015).

Chapter 2. Arctic ecosystem services

Authors: M. Macias-Fauria and M. Kettunen

Contributors: S. Fomin and M. Geitz (inventory development); J. Eamer

2.1. Description of Arctic ecosystem services

According to the current definition and understanding, ecosystem services are the direct and indirect contributions of ecosystems to human well-being (de Groot et al. 2010). TEEB follows the Millennium Ecosystem Assessment (MA 2005b) classification of ecosystem services: provisioning services such as **provisioning** of food and water; **regulating** services such as ecosystems' role in flood and disease control; and **cultural** services such as spiritual, recreational, and cultural benefits associated with the natural world. Furthermore, a range of underlying processes (e.g., nutrient cycling) that maintain the conditions for life on Earth – and form the basis for all other ecosystem services – can be distinguished: these are called **supporting** (MA 2005b) or **habitat** (de Groot et al. 2010) **services**, depending on the purpose of the classification. While the Arctic Biodiversity Assessment (CAFF 2013b) includes a chapter on provisioning and cultural services with a focus on six services (namely, 1) reindeer herding; 2) commercial fisheries; 3) commercial and subsistence hunting, gathering and small-scale fishing; 4) recreational and sport hunting; 5) tourism; and 6) the non-market values associated with ecosystems and their services), it did not address regulating and supporting services explicitly, due to insufficient information (CAFF 2013b).

Regardless of the type of ecosystem service being discussed (provisioning, cultural, regulating, or habitat/supporting), no one service can be treated as a separate, unconnected entity. In all cases ecosystem services arise from functioning ecosystems and are thus intertwined. For example, the provisioning of food and water clearly builds on a range of regulating services, such as pollination and regulation of water supply. Similarly, ecosystems' potential to sustain cultural services is inherently interlinked with their functioning, including their ability to mitigate against environmental hazards such as flooding and drought. Furthermore, the different services are experienced and appreciated by the inhabitants of the Arctic and beyond as *bundles of services* (as it can clearly be seen in the responses given in the questionnaire). For example, berry picking and hunting have important dietary functions but in addition they also have strong cultural significance to local people. While appreciating that there are interlinkages among different services, the ecosystem service classification is nevertheless commonly used to 1) demonstrate the various roles of ecological processes; 2) facilitate the organization of the text; and 3) use the terminology used in the ecosystem services literature.

The section starts with a brief description of the diversity of Arctic ecosystems that provide the services that are the scope of this study, followed by an overview of the ecosystem services in the Arctic, their beneficiaries, and the state of knowledge on their status and trends. It does not aim at being comprehensive due to the nature of the scoping study. A comprehensive review of ecosystem services and their status would provide the underpinning for, and complement, a TEEB Arctic assessment.

2.1.1. Ecosystems behind ecosystem services

Classifications are artificial approaches to natural systems, which change most often according to gradients in physical conditions and biological processes. Thus, although the characteristics of the Arctic and its ecosystems are well defined (e.g., extreme seasonality of temperature and light availability, short productive growing season, cold temperatures, presence of ice-related – cryospheric – processes), its boundaries are subjective and depend on the weight the classifier gives to a range of factors. Thus, the Arctic can be defined as all land and ocean north of the Polar Circle (66° 33' 45.6" N), all land north of the latitudinal treeline (approach adopted by the Circumpolar Arctic Vegetation Map working group: CAVM Team 2003), or according to a combination of other factors, including political boundaries, in which case the forest-tundra area south of the treeline is considered Arctic (Figure 2.1) (AMAP et al. 2013; CAFF 2013b). In this section, the CAVM (2003) definition and the Protection of the Arctic Marine Environment PAME (2013c) Large Marine Ecosystems (LME) classification are employed for terrestrial and marine ecosystems, respectively (Figure 2.1).

The overall low productivity (with some remarkable regional marine exceptions) and biodiversity of Arctic ecosystems when compared with lower latitude ecosystems do not imply a lack of diversity of environments and, most importantly, a lack of unique ecosystems that provide services fundamental for the societies of the Arctic and the world. The functioning of Arctic ecosystems is very strongly coupled with physical processes related to the presence of snow and ice. The Quaternary (past 2 million years) climatic fluctuations – glacial cycles – have left an important legacy on the Arctic's biodiversity patterns. Moreover, substrate (in terrestrial) and ocean currents (in marine) also play a very important role in determining the productivity and composition of Arctic ecosystems (CAFF 2013b).

The extended caption below is for the full-page map on the following page.

Figure 2.1. Main features of pan-Arctic ecosystems

Marine ecosystems

Marine ecosystems cover the largest part of the Arctic (the Arctic Ocean covers 10 million km2, but the total extent of marine areas is larger if sub-Arctic seas are included) and are characterized by the presence of sea ice (Michel et al. 2013), which is perennial (known as ice pack, multi-year ice) at the Central Arctic Ocean, and by a very strong seasonality. The Arctic peripheral seas show much greater variability in sea ice presence, from a few months free of sea ice (e.g., in East Siberian Sea) to a nearly complete absence of sea ice (e.g., in Iceland).

Arctic ocean ecosystems are not homogeneous and vary extremely in productivity (by up to two orders of magnitude; Sakshaug 2003) due to ocean currents (the Arctic Ocean is connected with the North Atlantic and Pacific Oceans) and the presence of polynyas and coastal leads (Figure 2.1). Overall, strong ocean stratification (due to large freshwater inputs, low evaporation rates, and presence of sea ice which result in a low-salinity upper ocean layer) and reduced access to light (which is extremely seasonal, more so in the presence of sea ice) imply low nutrient availability in the upper ocean layers. In this respect, the Central Arctic Ocean shows extremely low productivity (< 5 g C/m2; Figure 2.1). However, when and where light and mixing in the water column (i.e. nutrient availability) coincide, blooms of primary productivity occur, reaching the highest values known in oceans globally. This occurs on ice edges and wedges, such as in polynyas, coastal leads (shore leads; Figure 2.1), or at the edge of the retreating melting sea ice in late spring or summer. Since the North Pacific is more nutrient-rich than the North Atlantic, productivity in the Pacific sector of the Arctic is considerably higher than in the Atlantic sector, the highest levels occurring in the northern Bering Sea and southern Chukchi Sea (> 500 g C/m2) (Sakshaug 2003).

Highly productive Arctic maritime areas are at the basis of trophic webs and sustain rich and abundant populations of plankton-feeding seabirds and fish and benthic-feeding mammals such as baleen whales (AMAP et al. 2013), which provide important and, in many cases, fundamental provisioning services to Arctic communities. Dead, not consumed organic matter produced in highly productive areas falls through the water column and provides food for sea-bottom communities growing on the Arctic shelves, as well as sequestering carbon by incorporating it into the ocean sediment.

Polynyas are areas of open seawater in the ice: some remain open throughout winter, while others open in late winter and spring. Shore leads are long areas of open water along the edge of landfast ice; they run parallel to the continents (Figure 2.1) (ACIA 2004; AMAP 2011). Polynyas are areas of earlier and higher primary productivity and serve as wintering areas for birds and marine mammals (whose biggest sea-ice-related threat is the blockage of access to air for breathing), and as stop-over sites for seabirds during spring migration. Shore leads, in addition, are migration corridors for the Arctic whales and walrus (AMAP et al. 2013).

PAME (2013c) proposed a geographical classification of the Arctic and sub-Arctic marine regions into LMEs, to be used in assessments of environmental impact of anthropogenic activities (e.g., shipping, oil and gas extraction), as well as in identifying areas of high ecological value (Figure 2.1) (AMAP et al. 2013). The boundaries of this classification system were agreed upon after a series of expert and Arctic Council ministerial meetings over the period of 2004-2012 (results of which are depicted in Figure 2.1.) (PAME 2013c). The Circumpolar Biodiversity Monitoring Program (CBMP)'s monitoring activities make use of a slightly different classification system: Arctic Marine Areas (Gill et al. 2011).

Terrestrial ecosystems

Tundra, low-growing vegetation beyond the cold limit of tree growth, characterizes the terrestrial ecosystems of the Arctic. Tundra vegetation types are composed of shrubs, herbaceous plants, mosses, and lichens. The low rates of nutrient cycling (decomposition is largely limited by low temperatures) largely limit productivity and allow the accumulation of large quantities of organic matter (carbon) sequestered mainly in Arctic soils and permafrost (Ims et al. 2013). The terrestrial ecosystems of the Arctic reflect a very strong latitudinal gradient in environmental conditions, and consequently the physical characteristics of ecosystems vary with this gradient. To reflect this gradual change, the CAVM team (2003) divided the Arctic terrestrial ecosystems into five bioclimatic zones (regions with characteristic climate, flora and vegetation) (Figure 2.1 and Box 2.1). Productivity and diversity increase over a gradient from Subzone A to Subzone E, along with the increase in mean July temperature.

Although this bioclimatic zone classification is useful in understanding the strong latitudinal environmental gradients occurring in Arctic terrestrial ecosystems, on the ground, land cover is much more complex and difficult to predict. Substrate (e.g., carbonates or non-carbonates) plays a great role in plant productivity, and determines the soil pH, which in turn determines which plant species grow where. Glacial history has a great influence on present biodiversity patterns in the Arctic (e.g., land free of ice sheets during the last glacial cycle holds greater diversity). Other factors, such as regional climate, proximity to sea ice or ocean currents, presence of permafrost, geomorphological processes and relief add further heterogeneity to the distribution of ecosystems in the Arctic. To reflect this reality, the CAVM team (2003) further classified the Arctic into 17 vegetation types (Figure 2.1).

Freshwater ecosystems

The Arctic contains a much higher fraction of fresh water than any other biome in the World (Wrona et al. 2013), including wetlands, lakes, deltas and river courses. Arctic freshwater ecosystems are characterized by a high seasonality, which results in strong changes in light availability (due to winter darkness and ice) and short productive seasons. Another key element of many freshwater systems in the Arctic is that they are ephemeral, due mostly to dynamics linked to the presence of permafrost (AMAP 2011). Many water bodies sitting on permafrost display high rates of change (e.g., draining lakes, changes of river courses, etc.) due to the dynamics of the active layer and thermokarst in general.

Freshwater ecosystems are key ecological places since they act as refugia for permanent and transitory organisms, as corridors for animal life, and they are a key element in the provision of subsistence food and transport routes (e.g., boat routes and ice roads) for local communities (ACIA 2004; Wrona et al. 2013). Freshwater ecosystems are especially vulnerable to pollution and land use. Finally, they have been sequestering carbon over millennia and hold great amounts of it stored in their sediments.

Despite the generally low biodiversity of Arctic freshwater systems compared to those at lower latitudes, a wide range of types of freshwater systems exist in the Arctic. In addition to the basic distinction between standing and flowing water bodies, regional climatic conditions and geological and geophysical processes add further spatial heterogeneity. More importantly, the unique and extreme conditions of Arctic freshwater ecosystems have enhanced the evolution of specialized adaptation strategies, including life-history strategies incorporating diapause (periods of suspended development) and resting stages, unique physiological mechanisms to store energy (i.e. lipids) and nutrients, an ability to grow and reproduce quickly under short growing seasons, and extended life spans relative to more temperate species (CAFF 2013b; Wrona et al. 2013).

Box 2.1. Arctic terrestrial bioclimatic zones

▶ **Subzone A**: 0-3°C mean July temperature; very low productivity and diversity; mostly barren with lichens and mosses in favorable sites and very scattered, short vascular plants; vascular plants cover < 5% of the ground; lichens and mosses cover up to 40%.

▶ **Subzone B**: 3-5°C mean July temperature; moss and herb layer and prostrate (i.e., lying flat on the ground) dwarf shrubs; vascular plants cover 5-25% of the ground; lichens and mosses cover up to 60%.

▶ **Subzone C**: 5-7°C mean July temperature; moss layer 3-5 cm thick; herbaceous layer up to 10 cm; prostrate and very short dwarf shrubs; vascular plants cover 5-50% of the ground; open, patchy vegetation.

▶ **Subzone D**: 7-9°C mean July temperature; moss layer and herbaceous/dwarf shrub layer 10-40 cm tall; vegetation covers 50-80% of the ground; interrupted, closed vegetation.

▶ **Subzone E**: 9-12°C mean July temperatures; highest productivity and biodiversity in the Arctic (regionally dependent); moss layer up to 10 cm thick; herbaceous/dwarf shrub layer 20-50 cm tall; vascular plants cover 80-100% of the ground; closed canopy.

(CAVM Team 2003)

2.1.2. Arctic ecosystem services: An overview

As part of this scoping study, an ecosystem services inventory was started, based on literature review, and using the TEEB (2010c) classification framework (provisioning, cultural, regulating, and habitat/supporting services). This draft inventory is available online as supplementary material to this report (www.arcticteeb.net). In addition, a section of the project's online questionnaire (see Section 1.6) requested input from a range of experts on what ecosystem services were seen as important and what were the perceived risks to them.

The result of these exercises is by definition not comprehensive, but gives a wealth of information on the wide range and variety of ecosystem services provided by Arctic nature, which extend from local to regional to global scales. Box 2.2 presents the list of ecosystem services for which the scoping study has gathered information (sorted alphabetically within categories, see Inventory for further information and references therein).

Both the inventory and the TEEB questionnaire highlighted regional diversity of status, trends, and risks for many ecosystem services, and large knowledge gaps, many of which can be at least partially overcome by a full literature search during a TEEB Arctic study. For the services for which data were available, summary tables were developed (see Section 1.6 'Scoping study methods and knowledge base').

Box 2.2. List of ecosystem services in the draft Arctic Ecosystem Services Inventory prepared for this scoping study

CULTURAL SERVICES

- Aesthetic information
- Cultural identity, heritage, and sense of place
- Information for cognitive development
- Inspiration for human creative thought and work
- Knowledge systems and education
- Recreation and tourism
- Spirituality and religion
- Well-being: psychological and physical health

HABITAT / SUPPORTING SERVICES

- Food web maintenance
- Genetic resources
- Nutrient cycling
- Primary productivity
- Soil fertility (including soil formation)

PROVISIONING SERVICES

- Biochemical and medicinal resources
- Food – reindeer husbandry, other terrestrial mammals, berries and mushrooms, birds, marine mammals, commercial fisheries, small-scale fisheries, aquaculture, agriculture
- Fresh water for human consumption and use
- Raw materials – timber, fibres, resins, animal skins, feathers and down, ornamental resources, biomass fuel

REGULATING SERVICES

- Air quality regulation
- Biological control (disease regulation and pest regulation)
- Carbon storage and sequestration
- Climate regulation (e.g., carbon storage and sequestration, atmospheric and oceanic circulation, frequency of extreme events):
- global, regional, and local
- Erosion regulation
- Natural extreme events (e.g., storms, floods)
- Pollination
- Water flow regulation
- Water purification and waste treatment

Systematic conclusions on Arctic ecosystem services and their status and trends cannot yet be made based on the data gathered in the scoping study. This is in line with the general lack of comprehensive information for the whole of the Arctic, and reflects the findings of the ecosystem services chapter of the ABA (Huntington et al. 2013a). Nevertheless, sufficient information exists to allow identification of general characteristics and trends:

1. There is great spatial heterogeneity in relation to ecosystem service identification and status. This is in line with the social component of the decision about what constitutes an ecosystem service (i.e. what people think is important for their livelihoods), but also with the biological, climatic and physical heterogeneity of the Arctic region (i.e. ecosystems' biophysical ability and capacity to provide different services).
2. Certain ecosystem types are key for certain services: for example, polynyas, shore leads, and wetlands are essential for food provisioning and biodiversity maintenance; lichen pastures are essential for winter reindeer herding; erect shrub tundra is important for wood provisioning; ice (including sea ice and permafrost) and snow dynamics are essential for climate regulation. Whereas conservation actions can be taken to preserve these key ecosystems, physical changes such as sea ice and permafrost melt can only be addressed by a global effort in reducing greenhouse gas emissions.
3. Due to the low diversity and simple ecological networks in the Arctic, Arctic ecosystems may not show high adaptability to environmental changes. Species that perform given ecosystem functions are less replaceable than at lower latitudes (there being fewer types of plants or animals that fill – at least partially – specific ecological niches). Services stemming from these ecosystems thus tend to be less resilient.

Ecosystem services come in bundles (Raudsepp-Hearne et al. 2010) – both in terms of their biophysical provisioning and their socio-economic appreciation and value – and it is very difficult to tease them apart: an example of this holistic view can be seen in Figure 2.2, which is a schematic presentation of one response to the questionnaire request to identify important ecosystem services.

Figure 2.2. Pollination of berries: a holistic view of ecosystem services
Example taken directly from one response to the TEEB questionnaire. This figure illustrates how ecosystem services come in bundles that are difficult to tease apart, and that a holistic approach to them is the common approach taken by Arctic peoples. In this case, pollination of berries, a regulating service, affects provisioning and cultural ecosystem services and has an associated set of trends, impacts and concerns.
(J. Eamer)
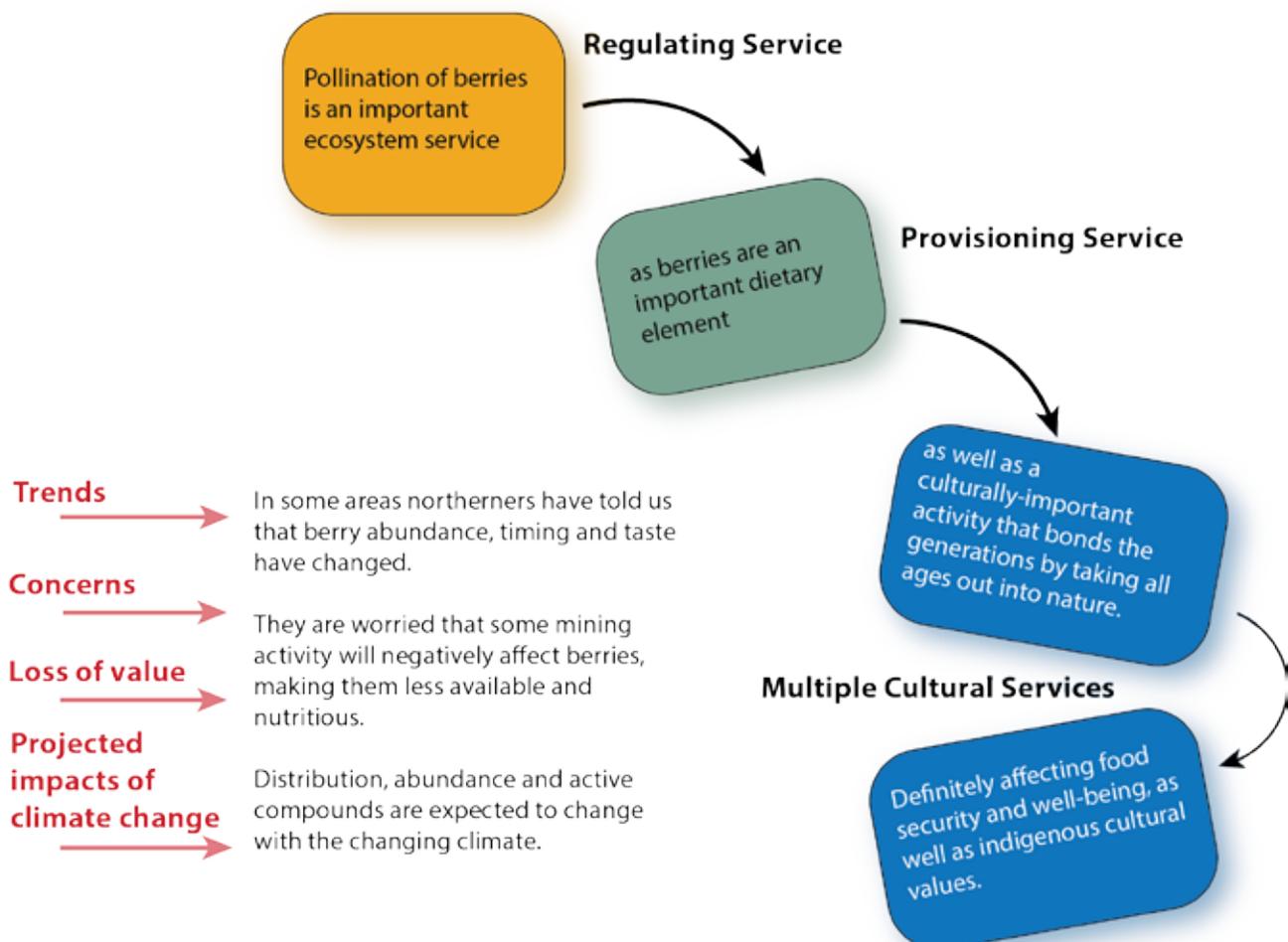
4. The fact that ecosystem services come in bundles that are sometimes impossible to break down emphasizes the holistic perception by Arctic peoples of ecosystems and human well-being, and how these fit within social-ecological systems. For example, hunting or herding is an essential provisioning service that provides subsistence food (sometimes commercial), and it is a cultural service providing many benefits, such as a sense of identity and belonging. This is seen, for example, in walrus hunters in coastal Alaska or in reindeer herders in Northern Eurasia. In this respect, both services are seen as one by Arctic peoples and cannot be treated separately. This holistic approach is consistent with Indigenous world views and Traditional Knowledge (as illustrated through the example, Box 2.3.)

Box 2.3. Inuit monitoring methodologies: a holistic approach

An important principle behind Inuit monitoring methodologies is focusing on the relationships among components of the ecosystems as opposed to individual pieces. As noted by the Inuit Circumpolar Council-Alaska:

> For example, monitoring walrus includes monitoring stomach contents, benthic species, ice thickness, wind directions, water temperatures, and the associated social components. Examples of social components include the transfer of knowledge and importance of a young hunter hunting walrus for the first time and transitioning from one being provided for to one that is providing. Social components also include village feast and sharing systems.

> All of these components; how these components interact; and changes within the connections and/or new connections made are all important monitoring objectives for Inuit survival. This may result in multiple different suggestive research actions, such as the need to identify cultural key stone species as well as ecological key stone species. (Inuit Circumpolar Council-Alaska, p. 11[1])

Similar holistic approaches are part of most, if not all, indigenous cultures in the Arctic.

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1   Inuit Circumpolar Council-Alaska. 2014. How to Assess Food Security from an Inuit Perspective: Building a Conceptual Framework on How to Assess Food Security in the Alaskan Arctic. Progress Report to the 2014 General Assembly.

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5. The extreme environmental conditions experienced in the Arctic make the coupling between physical processes (snow, ice, weather, geomorphology, winds, ocean currents, glacier mass balance, CO_2 concentration), biological processes (species interactions, primary productivity – both terrestrial and marine) and human processes (social, cultural, land use) extremely tight and visible. This tight coupling implies that changes in physical and biological function have very immediate, clear and strong consequences to changes in ecosystem services (for example, changes in sea ice extent and seasonality immediately translate into shifts in hunting grounds).
6. The previous point becomes paramount when combined with the fact that the Arctic has experienced, is experiencing, and is projected to experience very fast rates of climate and environmental change. Thus, a region with special ecological and social sensitivity to changes in climate is in addition experiencing accelerated rates of climate change. This makes the future of ecosystem service provision in the Arctic highly uncertain: the main certainty in it is the fact that large changes are occurring or expected to occur to most ecosystem services. This point comes through clearly in the responses to the questionnaire.
7. Finally, the snow/ice/albedo feedback (see Inventory and Section 2.2.3 for further information and references) implies that changes in the Arctic region have and will have far-reaching consequences well beyond the Arctic, with important effects on ecosystem service provisioning to the Northern Hemisphere, especially linked to regulating services (climate, carbon sequestration and storage).

Apart from the ecosystem services mentioned in this section, some more specific ecosystem services that are seen as important by people researching and/or living in the Arctic were highlighted in responses to the questionnaire (Box 2.4).

Box 2.4. The TEEB questionnaire: responses on ecosystem services

The online questionnaire for this scoping study asked people to identify important ecosystem services and what these services depend on. Many respondents talked about the importance to Arctic residents, particularly Indigenous Peoples, of provisioning and cultural services related to hunting, herding, fishing, and collecting berries and mushrooms, and the dependence of these services on healthy ecosystems. Others pointed out that intact habitats and healthy wildlife populations are also important for their existence values: "*the fact that people throughout the world enjoy knowing that the Arctic and its species exist and are thriving,*" and that these existence values "*should really be seen as closely aligned with [the values associated with] hunting and fishing, since both groups want to see habitats and species remain healthy.*" Climate regulation was also frequently highlighted. A selection of other ecosystem services identified by respondents as important:

"**Materials for cultural art** *especially from marine mammals, skins, fur, ivory, bone, etc. which provide cultural benefits as well as economic benefits, especially in Alaska where the trade of marine mammal products is only allowed if it is a native handicraft. [Depends on] Healthy marine habitats, oceanographic features (sea ice, water temperature, currents, pH, etc.). The economic benefits are extremely important in small villages with little economic development, where jobs are scarce. This is also an extremely difficult benefit to quantify as there is little information on the actual trade that occurs.*"

"**Regulating services** *such as prevention from flooding and exposure to wildfire. [Depends on] plants, animals, habitat, and the physical protection provided by landscapes. Increases in coastal flooding, in combination with sea level rise, or increases in extent of wildfire threaten many communities, now that they are locked in place by permanent infrastructure. Formerly, they could easily move to new locations.*"

"**Ecotourism** *provides opportunities for people to experience wilderness. Arctic residents have the opportunity to gain wage employment and/or apply their Traditional Knowledge and other skills within a commercial sector and generate employment, business activity and income. [Depends on] General wilderness/open space. Frozen tundra. Sea ice and marine mammals.*"

"**Provisioning services of fisheries**. *[Depends on] marine habitats and ecosystems. Clearly there are some fish resources that are going to thrive, and others that will not, under changing conditions in the Arctic.*"

2.2.   Beneficiaries of Arctic ecosystem services

Arctic ecosystem services benefit a range of stakeholders at different scales. Table 2.1 provides a number of illustrative examples of key Arctic ecosystem services and their distribution among beneficiaries at different scales.

2.2.1. Provisioning services

At the global and regional level, both businesses and individuals benefit from a range of provisioning services originating from the Arctic region, such as provisioning of fisheries (e.g., cod and pollock). Commercial fisheries in Arctic and sub-Arctic waters generate the most money of any provisioning service in the Arctic, and are responsible for over 10% of the world's fish catch and 5.3% of its crustacean catch by weight (Huntington et al. 2013a). In addition to issues related to global food security and resource supply, the exploration of genetic resources and development of bio-innovations by using Arctic resources is increasing, with direct commercial benefits and indirect benefits to public health (new and improved drugs). This is the case, for example, in the Nordic countries (e.g., Kettunen et al. 2012).

Reindeer herding is one of the key livelihoods common to the Eurasian Arctic and depends heavily on the quality of ecosystems (e.g., lichen as winter reindeer fodder). The main beneficiaries of the meat produced from reindeer herding are local populations and/or Indigenous Peoples conducting reindeer husbandry and their local communities. In many Nordic countries, reindeer meat is also a highly valued delicacy and in demand at a larger regional and national scale, thus extending the range of beneficiaries of this high quality Arctic meat considerably.

At the local level, food from wild animals, fish and plants provides nutrition and calories for many Arctic peoples and residents (both indigenous and non-indigenous). In addition, local communities and businesses can benefit from the commercial exploitation of these resources if they are involved in the harvest and processing of the good, and/or receive compensation for the use or from the sales of the resource. Spin-off benefits also accrue to local businesses that cater to recreational hunters and fishers. Such spin-off benefits are of high importance to local economies in some areas. Food sharing is central to daily life in Arctic indigenous communities. It is important for food security, as a cultural practice of maintaining community and family relationships, and for a variety of social, spiritual and ethical reasons (Berkes and Jolly 2001; Nuttall et al. 2004; Ford

2008). Fishing, hunting, plant, mushroom and berry harvests often have strong cultural significance. Harvest, husbandry, and cultivation of plant and animal species often take place at a small scale at a local level, often with regional distribution. Rates of replenishment depend very much on whether the harvest is sustainable and the ecosystems supporting the harvested species remain healthy.

2.2.2. Regulating services

Dedicated information on Arctic regulating services, including their scales and beneficiaries, is rather limited. However, a number of key services can be used to illustrate the 'flow' of these services from ecosystems to the beneficiaries. Climate regulation in the Arctic benefits the entire global population through ecosystems' carbon storage and sequestering that mitigates climate change. At the global scale, the social and economic consequences of keeping the ice-snow albedo feedback stable are invaluable. At the local scale, the importance of climate regulation is highlighted in the observation by many marine mammal hunters in the Arctic that they can no longer 'read' the weather as it has become unpredictable (Nakashima et al. 2012). Moreover, the distribution of their traditional prey has shifted due to changes in climate, and the numbers of some prey species have changed (Doney et al. 2011; Kovacs et al. 2011; Wassmann et al. 2011). Also, reindeer herders in Yamal are reported having to modify their migration routes due to previously very rare events, such as icing (rain on snow and subsequent re-freezing), which blocks reindeer's access to winter forage (Forbes et al. 2009).

In comparison to climate regulation, water regulation and the mitigation of natural hazards take place on a more regional and/or local level. Key beneficiaries include regional and local populations who benefit from the natural maintenance of environmental security, including the supply of good quality water and the mitigation of climate-change-induced risks such as flooding and increased risk of wildfires. In addition, indirect beneficiaries include national and regional governments – and even insurance companies – who benefit from the mitigation of environmental risks and related costs. Finally, several industry sectors, such as mining, oil and gas, are also key beneficiaries of ecosystems' ability to regulate water flow and environmental hazards. For example, these sectors depend on water supplies for extraction and processing of hydrocarbons and minerals, and they depend on the regulation and mitigation of flooding, erosion, and natural hazards at the locations of their operations and along transport routes.

Pollination occurs on a local scale, however its effects and benefits span across ecosystems and regions. The persistence of many ecological processes in the Arctic directly or indirectly depends on pollination. Successful pollination allows the reproduction – and thus long-term survival – of many edible and commercially important plants. For example, wild berries (which depend on pollination; Song and Hancock 2011) are a source of food, and of cultural and commercial importance in many Arctic regions (see Figure 2.2, above).

2.2.3. Cultural services

The cultural identity of Arctic Indigenous Peoples is inherently coupled with nature. Arctic nature also benefits local non-indigenous populations who use their natural surroundings as a source of recreation, inspiration and spiritual experience, often coupled with the use of provisioning services such as hunting and recreational fishing.

Arctic regions are a sought-after destination for global and national tourism, based on natural beauty, wildlife and nature-related cultural heritage. Consequently, tourism businesses, from local to global, benefit from the cultural services maintained by and/or associated with Arctic nature. Such businesses include, for example, a variety of tour agencies – ranging from general tourism operators using the image of Arctic natural beauty to operators of specialized wilderness and cultural tours, as well as businesses indirectly linked with tourism, such as hotels and catering services. The use of Arctic areas for tourism sometimes leads to conflicts with local people's use of and access to nature (e.g., Indigenous Peoples' subsistence hunting and fishing). In such cases, the potential conflicts need to be identified and appropriately addressed to ensure equitable sharing of benefits arising from Arctic ecosystems.

2.2.4. Interactions of beneficiaries with ecosystem services

Some of these same stakeholders that benefit from the Arctic ecosystem services are also the ones affecting the status and future availability of these services. International, national and smaller-scale companies using Arctic resources can have significant impacts on the ability of ecosystems to maintain the flow of services. This is through exploiting Arctic ecosystem services directly (for example, via fishing) or causing impacts on and risks to services (for example, via oil and mineral exploration). The large-scale commercial fishing industry, for example, can lead to overexploitation of fisheries resources, potentially becoming a threat to Arctic marine ecosystems and a disturbing factor for Indigenous Peoples.

Furthermore, national and regional (sectorial) decision-makers and stakeholders, while themselves dependent on a range of ecosystem services, also affect the availability of these services through a variety of direct and indirect policies and management actions that influence the quality of ecosystems and related services (e.g., carbon storage and water cycles). Even the global community has an influence, especially through policies and actions influencing ecosystems' capacity to regulate climate. Finally, local and Indigenous communities' management practices play an important role in maintaining

ecosystems in good and well-functioning status, guaranteeing the maintenance of ecosystem services. Ecosystem services frequently influenced by land and resource use decisions made at local and regional level include, for example, recreation (use of land in for its natural beauty and biodiversity), carbon storage (e.g., use of peat lands) and water retention and purification (use of wetlands).

The variety of beneficiaries – ranging from local to global (Figure 2.3) highlights the overall importance of Arctic ecosystem services that goes beyond the immediate inhabitants of Arctic ecosystems. Understanding the flow of ecosystem services and related benefits forms the basis for, first, assessing the value of these services and, secondly, further understanding their governance (see Chapter 3 'Governance of Arctic ecosystem services').

Figure 2.3. Illustration of the flow of ecosystem services from an Arctic ecosystem to a range of beneficiaries at different scales. (M. Kettunen)

Local benefits of Arctic coastal wetlands:
- Food supply and security (e.g. fisheries nurseries, waterfowl habitat) – subsistence and income
- Protection against natural hazards
- Local community livelihood (fisheries, tourism …)
- Purification of coastal water
- Cultural identity (e.g. fishing communities)

Regional and national benefits:
- National food supply and security (fish)
- National and regional recreation and tourism
- Regional natural & cultural heritage

Global benefits:
- Carbon storage / sequestration
- Breeding habitat for migratory birds that provide benefits elsewhere in the world
- Global food supply and security (fish)
- Recreation and tourism at global level

Table 2.1. Illustrative examples of the distribution of a number of key Arctic ecosystem services across different stakeholders

Scale of benefits	Ecosystem service	Who are the key beneficiaries enjoying/using the service?	Who affects the availability of the service?
Global	Commercial fishing Genetic resources	**Global population**, via maintaining food security, mitigation of climate change and providing destination for nature-based tourism. Also via access to new and/or improved drugs.	**Global companies** using Arctic resources (e.g., exploiting Arctic ecosystem services directly or causing impacts / risks on services).
	Climate regulation	**Global businesses and companies** depending on fish supply, the use of genetic resources and/or tourism	**Global community** (indirectly) via a variety of policies and actions influencing climate regulation.
	Recreation and tourism		**Indigenous peoples and their local communities** via management practices that maintain areas with recreation value (natural beauty and biodiversity) and areas with high carbon storage (e.g., peat lands).
Regional (Arctic / sub-Arctic)	Commercial fishing Raw material (timber) Genetic resources	**Arctic people**, via maintaining food and environmental security (e.g. mitigation of climate change induced risks) and cultural identity.	As above, at Arctic level.
	Climate regulation	**Arctic businesses and companies** depending on fish / timber supply or the use of genetic resources. Arctic-wide business directly or indirectly linked to tourism.	
	Recreation and tourism Cultural identify and heritage		
National and regional (sub-national / cross-border)	Commercial fishing Raw material (timber) Genetic resources Reindeer herding Foods from wild animals and plants – value added products Arts and crafts made from local products	National and regional **businesses and companies** using reindeer meat, fish or wild animals and plants (e.g., restaurants, producer of value added products), or depending on fish / timber supply or the use of genetic resources. National / regional businesses directly or indirectly linked to recreation and tourism. Several industry sectors, such as mining, oil and gas, depend on water supply and mitigation of flooding, erosion, and natural hazards at the locations of their operations and along transport routes.	**National and regional companies and businesses** using Arctic resources (e.g., exploiting Arctic ecosystem services directly or causing impacts / risks on services). **National and regional (sectorial) decision-makers and stakeholders** via a variety of direct and indirect policies and management actions influencing the quality of ecosystems and related services (e.g., carbon storage, water cycles).
	Climate regulation Water regulation (retention and purification) Regulation of natural hazards (e.g., flooding, wild fires) Pollination	National and regional **consumers**, via maintaining food security **National and regional governments and population** via maintaining environmental security (e.g., mitigation of climate change induced risks, supply of water) and providing sources for recreation and cultural identity	**Local / Indigenous Peoples and their communities and local governments** via management practices that maintain areas with recreation and cultural value (natural beauty and biodiversity), areas with carbon storage (e.g., peatlands) and water regulation capacity (e.g., wetlands).
	Recreation and tourism Cultural identity and heritage		

(modified from Kettunen and ten Brink 2013)

Scale of benefits	Ecosystem service	Who are the key beneficiaries enjoying/using the service?	Who affects the availability of the service?
Local	Commercial fishing Genetic resources Raw material (wood and timber) Reindeer herding Foods from wild animals and plants (e.g., berries and mushrooms) Arts and crafts made from local products Climate regulation (retention and purification) Regulation of natural hazards (e.g., flooding, wild fires) Water regulation Pollination Recreation and tourism Cultural identity and heritage	**Local / Indigenous Peoples and their communities and local governments** through subsistence / food security, income (e.g., compensation for bioprospecting for genetic resources) and favorable and stable environmental conditions for living (e.g., mitigation of climate change induced risks, supply of water). Also, cultural identity and recreation. Local **businesses and companies** using reindeer meat, fish or wild animals and plants (e.g., restaurants, producer of value added products), or depending on fish / timber supply or the use of genetic resources. Local business directly or indirectly linked to recreation and tourism. Local businesses benefiting from the supply of clean water and mitigation of flooding, erosion, and natural hazards.	As above, at local level

(modified from Kettunen and ten Brink 2013)

2.3. Status and trends of ecosystem services and ecosystems

Ecosystem services within the Arctic region show a very high spatial variability, as do their trends and status, and the research effort made to address these questions. For example, although on a pan-Arctic scale fisheries is the most important ecosystem service in terms of income generation, this statistic is dominated by the valuable Bering and Barents seas fisheries (CAFF 2013b), while many other Arctic regions derive little value from this service. Likewise, the importance of tourism for regional and local economies is highly variable, as well as are current trends, types (e.g., eco and cultural tourism), and scales of tourism activities (e.g., from cruise ships and bus tours to very small-scale wilderness expeditions). Thus, future trends in this activity will vary in totally different directions. In this respect, the Working Group II of the 5th Assessment Report of the Intergovernmental Panel on Climate Change – WGII IPPC AR5 (IPCC 2014b) gives high confidence to the statement that "the impacts of climate change, and the adaptations to it, exhibit strong spatial heterogeneity in the Polar Regions because of the high diversity of social systems, bio-physical regions and associated drivers of change."

2.3.1. Trends, risks and vulnerabilities

There is little information available specifically on status and trends of ecosystem services around the Arctic. The Arctic Biodiversity Assessment reported on important provisioning and cultural services (CAFF 2010; Huntington et al. 2013a), and a comprehensive review of ecosystem services was produced for the Nordic countries, but without separating out the Arctic regions (Kettunen et al. 2012). As part of Canada's national ecosystem assessment (Federal Provincial and Territorial Governments of Canada 2010) a report was produced for the Canadian Arctic (Eamer et al. 2015) focusing on status and trends of ecosystems and selected ecosystem services. More research has been conducted on trends of environmental change in the Arctic, which, given the high coupling between physical, biological, and human processes in the region, has a direct translation to a wide range of ecosystem services. A full literature review that draws out these linkages among environmental change, ecosystems and the services ecosystems produce, within a TEEB Arctic assessment, would fill some of the knowledge gaps that have limited synthesis for this scoping report.

Climate change is identified as the main human-induced stressor on ecosystem structure and function in the Arctic (e.g., CAFF 2010, 2013b). Other stressors include pollution, especially linked to increased shipping and industrial and/or resource extraction activities in the Arctic, in a large part a direct consequence of Arctic warming (Corbett et al. 2010; Ho 2010; Stephenson et al. 2011; Peterson et al. 2012; Smith and Stephenson 2013; Bruckner et al. 2014; R. et al. 2014). Further, although habitat fragmentation in the Arctic is low, it constitutes a concern at the regional level and is likely to become more widespread as human population and industrial development increase (e.g., Eamer et al. 2015). Finally, social, cultural, and economical challenges can develop in Arctic local and Indigenous populations due to increased industrial development and land use changes (Forbes et al. 2009). A full TEEB Arctic Assessment would develop on these human-induced stressors as well.

Risks to ecosystem processes and thus to ecosystem services do not come from isolated triggers, but rather from a series of interacting effects that create compounded stressors and responses (Inuit Circumpolar Council Alaska 2014). As an example, several drivers of change to traditional food security (i.e., food provisioning from fishing, hunting and gathering) are highlighted in Box 2.5. Other drivers (socio-economic, such as globalization and resource development, or industrial/resource extraction pollution, for example) add further complexity to this ecosystem service: that is, the physical, biological and socio-economic impacts of climate and environmental change in the Arctic act in a context of interconnected processes that include not only environmental changes caused by drivers other than climate change but also demography, culture and economic development (IPCC 2014b). The IPCC AR5 states with high confidence that climate change has compounded some of the existing vulnerabilities caused by these other factors: the rapid rates of climate change in the Arctic impact and will further impact natural and social systems, with the danger of exceeding the adaptation ability of some of their components (IPCC 2014b).

Box 2.5. Compounded risks to ecosystem services

Climate change impacts on provision of Arctic foods from fishing and hunting:

▶ For many marine mammals and fish, the dramatic sea ice changes have unquantified but potentially very large consequences. Many Arctic species use sea ice as a hunting platform, as a breeding area, or as a living space (above or under) (e.g., Laidre et al. 2008). Sea ice acts also as a barrier for dispersal of many animals such as marine mammals, but can be a very effective dispersal agent for others such as the Arctic fox or the polar bear. Changes in the area and timing of sea ice formation and melt radically modify the ranges and patterns of all species related to its presence (Eamer et al. 2013). This might result in the disappearance or shift of a hunting resource, or in its loss of predictability by hunters and fishermen (Corell et al. 2013).

▶ Changes in air and water (both ocean and fresh water) temperature, as well as changes in other climatic parameters (including seasonality) also modify the ranges and distributions of many species, hence altering hunting grounds and hunting seasons (Eamer et al. 2013). This has been particularly seen in shifts of fisheries in the North Atlantic, for example, which has already resulted in some conflicts between Arctic Nations regarding access to shifted fishing grounds (Corell et al. 2013).

▶ Changes in land use linked to human activities and infrastructures add pressure on population dynamics of many Arctic species and hence alter the access to food for hunting and fishing. This includes habitat fragmentation (CAFF 2013b).

▶ Changes in tundra vegetation (e.g., shrubification) (Myers-Smith et al. 2011) result in structurally modified ecosystems (Macias-Fauria et al. 2012), which provide new habitats for novel interactions to occur within the ecosystem and hence a modification of the dynamics of species that are sources of food (Eamer et al. 2015).

▶ Ecosystem interactions are, in many cases, identified but not quantified. This results in a large uncertainty as to how a change of a given species will affect other species that might have relevance in the food production of Arctic communities.

Risks related to (1) physical and ecosystem processes directly linked with ecosystem services, and (2) ongoing adaptive human responses linked to these changes, are summarized below.

1 – RISKS TO PHYSICAL AND ECOSYSTEM PROCESSES WITH LINKS TO ECOSYSTEM SERVICES

Snow and ice, rivers and lakes

(Smith et al. 2005; AMAP 2011; Corell et al. 2013; IPCC 2013, 2014b; Eamer et al. 2015)

▶ Decreasing Arctic sea ice extent and volume on all seasons of the year (especially in summer)
▶ Reduction in ice volume in Arctic glaciers
▶ Decreasing snow cover duration across the Arctic
▶ Increased black carbon deposition on snow that further enhances melt
▶ Widespread permafrost degradation, especially in the southern Arctic
▶ Increased winter minimum river flow in most sectors of the Arctic
▶ Increased lake water temperatures 1985–2009 and prolonged ice-free seasons
▶ Disappearance of thermokarst lakes due to permafrost degradation in the low Arctic: new lakes created in areas of formerly frozen peat
▶ Likely increase of CH_4 emissions from wetlands under elevated CO_2 and a warmer climate
▶ Increased productivity (and hence carbon drawdown) and shifts in species assemblages in freshwater ecosystems

Terrestrial ecosystems

(Sturm et al. 2001; Walker et al. 2006; Epstein et al. 2008; Søreide et al. 2010; Myers-Smith et al. 2011; Elmendorf et al. 2012; Hoye et al. 2013; Ims et al. 2013; IPCC 2014b)

▶ Increased shrub cover in tundra in North America and Eurasia. Deciduous tundra shrubs lead this increase, whereas the relative and absolute abundance of cryptogams (mosses and lichens) decreases with increasing temperatures
▶ The tree line has moved northward and upward in many, but not all, Arctic areas
▶ Changed breeding area and population size of sub-Arctic birds, due to snow bed reduction and/or tundra shrub encroachment
▶ Loss of snow-bed ecosystems and tussock tundra
▶ Trophic mismatches due to species-specific changes in phenology
▶ Impacts on tundra animals (e.g., reindeer) from increased ice layers in snow pack, following rain-on-snow events
▶ Increased vulnerability of terrestrial ecosystems to invasions by non-indigenous species, the majority expected to arrive through direct human assistance

Coastal and marine ecosystems

(Wassmann 2011; Bélanger et al. 2013; Corell et al. 2013; Eamer et al. 2013; Michel et al. 2013; IPCC 2014b)

▶ Increased coastal erosion across Arctic
▶ Negative effects on non-migratory Arctic species
▶ Decreased reproductive success in Arctic seabirds
▶ Range shift of some Arctic marine species in response to changing ocean and sea ice conditions: negative impacts are expected on species that depend on ice as habitat (e.g., ice algae, ice amphipods, ringed seals, polar bears, etc.)
▶ Mismatch between phytoplankton blooms and other species in the trophic level due to changes in the seasonality of sea ice and ocean temperatures
▶ Ocean acidification
▶ Northward range expansion of sub-Arctic species of algae, invertebrates, fish (some of which are of commercial interest), mammals and birds, while some Arctic-adapted species lose habitat along the southern edges of their ranges
▶ Changing relationships among species, with new predation pressures and shifts in diets recorded for some animals
▶ Too rapid changes for evolutionary adaptation: species with capacity to adjust their physiology or behavior (i.e. species with high plasticity) will fare better; species with limited distributions, specialized feeding or breeding requirements are particularly vulnerable
▶ Increase in marine primary productivity (e.g., increase by 20% from 1998 to 2009, driven by a 45-day increase in the open-ice period and a reduction in summer ice cover of 27% - not spatially homogeneous)

The above-mentioned physical and biophysical changes directly influence a suite of ecosystem services. Some of them are summarized below.

Climate regulation

Changes in sea ice and snow cover modify the energy budget of the Arctic, which is directly related to climate regulation, through the snow-ice albedo feedback, which determines the amount of incoming solar radiation reflected back to space by the Earth's surface. Lighter and smoother surfaces (e.g., sea ice, snow on tundra, glaciers) reflect a large part of the incoming solar energy and thus contribute to cooling. Reduced sea ice, glacier extent, and snow on the ground, as well as snow darkened by soot (black carbon), expose darker surfaces, retaining a larger part of the incoming solar radiation and contributing to warming (IPCC 2013). This feedback is especially strong in the case of sea ice, since the exposed ocean has a high latent heat and is thus able to absorb large amounts of energy that is slowly released, further reinforcing the feedback (e.g., through later autumn freeze-up). Sea ice affects surface reflectivity, cloudiness, humidity, exchanges of heat and moisture at the ocean surface, and ocean currents (Goosse et al. 2013). The overall effect of the snow-ice albedo feedback is known as Arctic Amplification (Miller et al. 2010). The loss of sea ice observed in recent decades, compounded by changes in the snow timing, amount and duration; and modified surface properties of the Arctic areas (e.g., shrub encroachment, which increases tundra's surface roughness), have radically altered the albedo of large areas within the Arctic, modifying its energy flow with the atmosphere and resulting in further feedbacks. Indeed, sea ice loss has been identified as the main source of recent Arctic temperature amplification (Screen and Simmonds 2010).

These very strong climate feedbacks affect not only regional climate, but potentially have long-range repercussions at lower latitudes: reduced sea ice has been linked with amplified mid-latitude planetary waves (Francis et al. 2009; Francis and Vavrus 2012; Liu et al. 2012), which are in turn linked with more persistent weather patterns – leading to an increased probability of extreme weather events at mid-latitudes (Screen and Simmonds 2014). Increased winter snowfall over large parts of North America, Europe, and East Asia has been associated with this process (Liu et al. 2012). Moreover, changes in the salinity of the ocean surface further contribute to changes in ocean circulation through modifying deep-water formation: model simulations predict a slowing down of the thermohaline circulation – and thus less transfer of heat from the tropics to the poles (Frankcombe and Dijkstra 2011). These predictions have been confirmed by an observed slowing down of this circulation in the last few decades (Maslowski et al. 2012). Although abrupt changes in the thermohaline circulation are associated with a return to quasi-glacial conditions in Europe and large-scale shifts in the Atlantic Intertropical Convergence Zone – affecting the American (north and south), African and Asian monsoons, the projected degree of circulation reduction rates is uncertain and the probability of abrupt changes is considered low (IPCC 2013). Although climate regulation is a fundamental ecosystem service, it is one of the most intangible services and thus might not be perceived by local communities as an 'evident' outcome of ecosystem processes and functions (as opposed to other services such as food and clean water provision, for example).

Increased terrestrial productivity in the tundra modifies the soil's thermal properties via the insulating properties of the vegetation mat and through surface roughness, which is linked to 1) evapotranspiration-induced increases in atmospheric moisture content; and 2) decreases in albedo (Beringer et al. 2005; Bonfils et al. 2012). These effects are likely to shift the role of tundra's increasing productivity from a negative to a positive component in warming (Bonfils et al. 2012; Huntington et al. 2013b).

Carbon storage and sequestration

Overall increased terrestrial productivity in the tundra suggests an increase in carbon sequestration. However, energy-budget-related feedbacks described above complicate this picture. Moreover, increased decomposition rates associated with warming are bound to contribute to enhancing carbon release to the atmosphere (i.e. loss of carbon storage), although species distribution shifts in the tundra (e.g., increase in shrubs that produce leaf litter that takes a long time to decompose) might dampen these effects (Cornelissen et al. 2007). This is compounded by the increase in disturbances linked to the increase in extreme weather events, which further limit the carbon sequestration and storage ability of tundra ecosystems (e.g., Jarle et al. 2014). The net role of tundra vegetation dynamics (sink or source, i.e. negative or positive feedback to climate warming) is still unknown.

Reduction of sea ice has resulted in CO_2 being taken up by very cold water and increased primary productivity (Bélanger et al. 2013; IPCC 2013), which contribute to carbon sequestration. Sea ice loss has also affected wave formation, and hence erosion prevention and storm protection are reduced, which is further compounded by the warming of the permafrost and by changing weather patterns that have included northward displacements of storm tracks. Enhanced rates of erosion affect local communities, but also contribute negatively to carbon storage (see Inventory and references therein for further information).

Food provisioning
(See also Box 2.5)

Changes in ocean temperature, acidity, stratification, and sea ice cover make polar ocean systems highly vulnerable, for example, to invasive species and to loss of Arctic species and associated ecosystems, with reduction of biodiversity and potential losses of important ecosystem services such as food provisioning. The risk is highest for endemic species, and the results of these changes might be mixing of ecosystem types (novel species assemblages), and increased dominance of invasive organisms. Interactions of stressors such as acidification and warming on calcareous organisms might further enhance this risk, affecting plankton communities (e.g., mollusks, and the tiny single-celled Foraminifera), which are at the base of food chains sustaining Arctic ecosystems. Not much adaptation potential within Arctic ecosystems has been identified in this respect (IPCC 2014b).

Food security issues are not limited to marine systems. Changes in the phenology (timing) of many species (which respond individualistically to environmental changes) in terrestrial systems carry the same issues. For example, mismatches between the timing of flowering and invertebrate activity are a concern for plant pollination (Hoye et al. 2013), with direct implications for wild berry production.

A TEEB Arctic study would expand on these links for all identified ecosystem services, deepening the description of the compounded network of triggers of ecosystem change.

2 – RISKS ASSOCIATED WITH SOCIAL RESPONSES TO DRIVERS OF CHANGE IN ECOSYSTEM SERVICES

There is increased evidence that climate change will have large effects on Arctic communities, especially where narrowly based economies leave a smaller range of adaptive choices. Subsistence-based economies will be impacted: "*Changes in the timing and extent of freezing and melting (and associated effects on sea ice, flora, and fauna) have been experienced since the 1990s in the American and Canadian Arctic and especially by indigenous communities (Laidler, 2006), leading to increased concern with climate change because traditional prediction mechanisms no longer can explain these phenomena (Turner and Clifton 2009)*" (IPCC 2014b, Chapter 2).

Indeed, livelihoods of indigenous peoples in the Arctic have been altered by climate change, through impacts on food security and traditional and cultural values. For example, changing sea-ice conditions will result in more difficult access for hunting sea-ice-dependent mammals, both because the availability of reliable sea-ice declines for people to travel on, and because the presence of animals that are hunted declines with the loss in sea-ice (Preston 1999; Nakashima et al. 2012).

In this respect, although Arctic residents have a history of adapting to change, the complex inter-linkages between societal, economic, and political factors, and climatic stresses represent unprecedented challenges for northern communities, particularly as the rate of change might be faster than the social systems can adapt (IPCC 2014c). Impacts on the health and well-being of Arctic residents from climate change are significant and projected to increase, especially for many Indigenous Peoples and for communities located in highly vulnerable locations along ocean and river shorelines (IPCC 2014b).

At the same time, some commercial activities will become more profitable while others will face decline. Increased economic opportunities are expected with increased navigability in the Arctic Ocean and the expansion of some land- and freshwater-based transportation networks. For example, increased shipping traffic (e.g., commercial, fishing, cruise ship tourism) is expected through the Bering Strait (PAME 2013b; Smith & Stephenson 2013; IPCC 2014b) and some Arctic marine fisheries, which are of global importance as well as providing major contributions to the region's economy, are likely to become more productive (ACIA 2004; Cheung et al. 2010).

Besides direct shipping-related activities, overall improved access to natural resources such as minerals and oil will largely alter Arctic ecology, livelihoods and economies, affecting Arctic community resilience. For example, natural gas extraction in Yamal has brought with it the construction of a railroad, large gas extraction facilities, and significant changes in land use over an area traditionally managed by nomadic Nenets reindeer herders, which are in addition affected by changes in climate – e.g., rain-on-snow events that fatally affect winter reindeer survival (Forbes et al. 2009). Such compounded effects and interactions are bound to be the norm in Arctic communities.

Whereas, in the case of the Yamal, the outcome of such interactions is not perceived as necessary negative overall (Kumpula et al. 2011; Forbes 2013), such activities represent a challenge and an increased risk for the resilience of local Arctic communities. There is, for example, ample evidence of profound disruption of cultural identity and social/community cohesion brought by the James Bay Hydroelectric Project to the James Bay Cree in Northern Québec (Niezen 1993; Scott 2002; Coon Come 2004). Road building and the rapid centralization of the James Bay Cree into structured communities that accompanied large-scale development brought abrupt economic changes and social instability, as well as drugs and alcohol into small remote communities, with tragic consequences, including addiction, suicide, and violence. Forbes (2013) identified that avoiding, or at the very least, minimizing, these effects, requires flexibility of institutions that administer indigenous activities to accommodate decision making sensitive to the needs and timetables of indigenous traditional livelihoods (reindeer herding in the case of Yamal). This flexibility, together with the existence of governance regimes run by indigenous agencies, is essential in ensuring resilience of these social-ecological systems.

Increased human industrial activity in the Arctic brings with it risks to biodiversity and ecosystem function. Areas most likely to be damaged are sites with human disturbance and sites located along pathways of human activity (such as shipping activity, port facilities, railroad corridors and roads). Risks include 1) invasion of non-Arctic species into Arctic habitats; 2) habitat destruction and fragmentation; and 3) sources of pollution. These risks are small/local so far, but increasing fast in the Arctic (CAFF 2010).

Figure 2.4 highlights the current range of impacts of climate change to physical, biological, and human systems globally (IPCC 2014b). The Arctic stands out as it shows impacts attributed to climate change on all systems included in this depiction. Moreover, the direct effect of climate change on these systems is high, more so when seen in a global context.

Tourists on zodiac, Svalbard, Norway. Photo: Peter Prokosch/UNEP GRID Arendal

Figure 2.4. Global patterns of observed climate change impacts.
Each filled symbol in the top panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the bars. Regional-scale impacts where climate change has played a minor role are shown by outlined symbols in a box in the respective region. Sub-regional impacts are indicated with symbols on the map, placed in the approximate area of their occurrence. The Arctic is shown as including the largest number of climate-change attributed impacts, including all types of studied systems, thus showing a large sensitivity to climate change.
(Figure 18-3, IPCC 5th Assessment Report - Working Group II Technical Summary, IPCC 2014b)
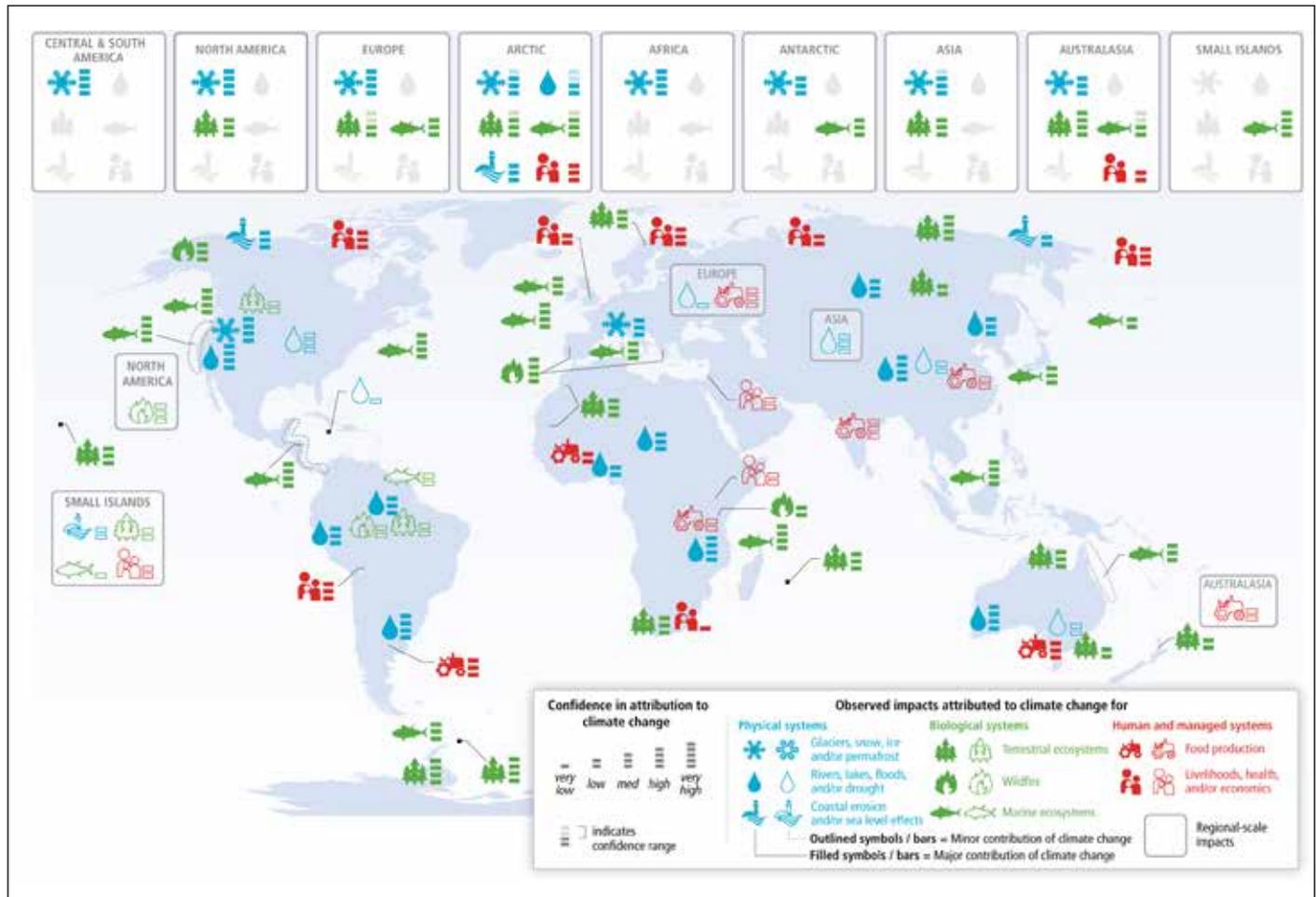
2.3.2. Knowledge gaps

The remoteness, difficult accessibility, and harsh environment of the Arctic has meant, and still means, that pan-Arctic studies are bound to be biased due to poor spatial coverage (unless remote sensing is used). The establishment of long-term observation networks in the Arctic region is thus highly needed (e.g., CAFF 2010).

The incomplete nature of the evidence on ecosystem services in the Arctic gathered in this scoping study prevents a comprehensive assessment of knowledge gaps. However, for some relevant research areas, knowledge gaps have been explicitly listed and identified, such as:

- ► Freshwater Arctic ecosystems in remote areas (Wrona et al. 2013)
- ► Ecological networks of nutrient recycling in the Arctic (Lovejoy 2012)
- ► Quantification of the net effect of tundra vegetation changes to the carbon budget and climate, lacking due to the diversity of feedbacks involved (Beringer et al. 2005; Cornelissen et al. 2007; Bonfils et al. 2012; Huntington et al. 2013a)
- ► Full calibration of the sea/ice albedo feedback (e.g., Serreze 2011)
- ► Dynamics of the deep continuous permafrost, largely unknown and with very large inertia. Insufficient understanding of the relevant soil processes during and after permafrost thaw precludes any quantitative assessment of permafrost degassing and associated feedbacks (IPCC 2013). Thus, potential future release of methane from marine gas hydrates in response to seafloor warming is poorly understood (IPCC 2013).
- ► Less visible services, including pollination (TEEB – The Economics of Ecosystems and Biodiversity 2010c), which have in the past, for the most part, been taken for granted and thus are poorly researched. There is a strong lack of long-term monitoring and study of Arctic invertebrates and plant/pollinator processes in high latitudes (Michel et al. 2013).

The added value (quantifiable and non-quantifiable) provided by most ecosystem services in the Arctic remains a major knowledge gap.

Finally, efforts undertaken by the Arctic Council such as the Arctic Biodiversity Assessment (CAFF 2010, 2013b) and other technical and assessment reports (e.g., Eamer et al. 2013) make information relevant to these topics more accessible, although so far this information has not been provided comprehensively in terms of ecosystem services (but, see Huntington et al. 2013a).

Berta Tokeinna and son Jeffrey pick berries on the tundra, Serpentine river delta, Alaska, United States. Photo: © Global Warming Images / WWF

Chapter 3. Governance of Arctic ecosystem services

Authors: M. Sommerkorn and A. E. Nilsson

Contributors: F. Katerås (national TEEB follow-up), M. Geitz (tourism), IPIECA (the global oil and gas industry association for environmental and social issues: oil and gas industry perspective section)

3.1. Ecosystem services as a lens for policy integration

The concept of ecosystem services has its origin in efforts to include in policy processes the role that ecosystem functions have for human well-being. The concept is thus intrinsically linked to **governance** in general and to formal **policy** processes in particular. This role becomes clear when looking at ecosystems and governance as part of **social-ecological systems**. As can be seen in Figure 3.1, ecosystems and the social world are linked both through social processes and through human activities that affect ecosystems services.

The concept of ecosystem services is a tool to make the benefits people receive from nature visible. Mainstreaming ecosystem services is a means of making the value of ecosystem functions explicit for policy making, drawing attention to the biodiversity and biophysical processes that provide these functions.

Traditionally, environmental policies have focused on the impacts of human activities and have attempted to guide human behavior through various policy tools. Depending on policy priorities, such guidance has been directed at, for example, protecting biodiversity (genetic diversity, diversity of species, habitats and ecosystems) from exploitation, preventing pollution that affects ecosystems, and regulating various practices, such as resource exploitation and land use. None of these actions are directly dependent on the relatively new concept of ecosystem services, but incorporate goals based on values, ranging from human security, aesthetic values, cultural values, or a wish to maintain long-term productivity in natural-resource-based sectors such as forestry and fisheries

Governance (of ecosystems): The sum of many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative action taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest.

Policy: A course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions. (Merriam-Webster dictionary). Public policy: The organizing framework of purposes and rationales for government programs that deal with specified societal problems.

Social-ecological system: An integrated system that includes human societies and ecosystems. The functions of such a system arise from the interactions and interdependence of the social and ecological subsystems. Its structure is characterized by reciprocal feedbacks (Arctic Council 2013c). The social subsystem includes the cultural and economic dimensions, such as world views, beliefs, customs, practices and behaviors that contribute to well-being.

The concept of ecosystem services is a tool to make the benefits people receive from nature more visible. Mainstreaming ecosystem services as a policy framework is a means of making the value of ecosystem functions explicit for policy making, drawing attention to the biodiversity and biophysical processes that provide these functions.

Ecosystem services became a more popular concept in connection with the Millennium Ecosystem Assessment (MA 2005b), which introduced it within the UN systems and thus to the international governance context. In spite of its scientific success, the MA had limited policy impact (UNEP 2009) and there was a need to develop frameworks for further use. In 2007 the G-8 countries initiated the study 'The Economics of Ecosystem and Biodiversity', which highlighted how values from ecosystem services often go unrecognized by decision-makers across society, be they policy-makers, administrators, businesses or citizens.

TEEB's starting point is that human societies have been steadily drawing on Earth's natural capital without sufficient recognition that the services nature provides are produced by functioning ecosystems, and that, therefore, continued well-being and development is critically dependent on maintaining the natural capital base for generating interest. A major purpose of TEEB is to mainstream the values of ecosystem services and biodiversity into economic policies and governance. This mainstreaming includes explicit recognition of non-market values, such as cultural values and the capacity of nature to buffer disturbances (TEEB – The Economics of Ecosystems and Biodiversity 2010a). The ecosystem services approach thus becomes a way to capture linkages among environmental, economic and social development that are at the core of the policy goal of sustainable development. In 2012, the United Nations Secretary-General's High-Level Panel on Global Sustainability (2012) highlighted that this closer integration of economic, social and environmental policies is needed in order to consider the long-term effects of human activities in ways that are reconcilable with the limited resources and regenerative capacity of our planet (Figure 3.2).

Figure 3.1. Conceptual framework of the linkages between ecosystems and the social world
Ecosystems and the social world are linked in two basic ways. One is by the social processes and negotiations by which we assign value to ecosystem functions (lower pathway). The other is by the human activities that affect ecosystems (upper pathway). (Further developed from Sommerkorn et al. 2013, Arctic Resilience Interim Report 2013)
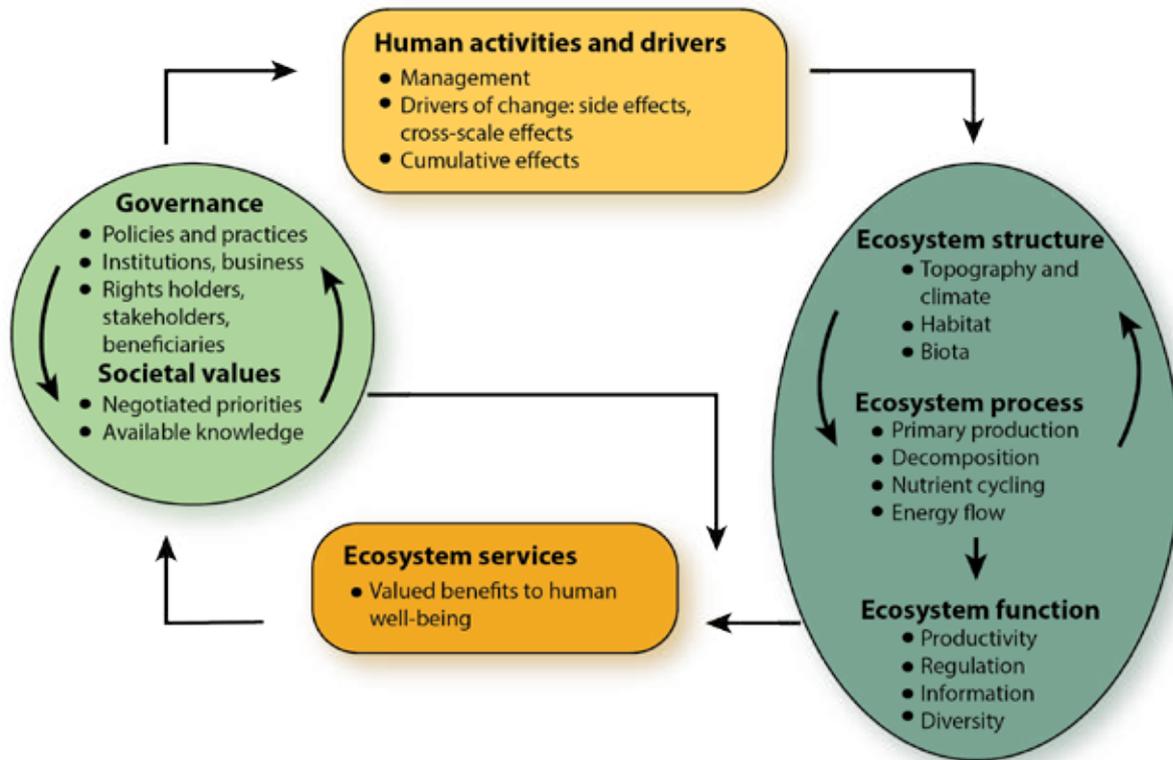
The 'TEEB lens' of ecosystem services makes explicit how and why aspects of biodiversity and ecosystems are relevant for society, and thus relevant for governance practices that relate to economy in the widest sense of the term (i.e., the production, distribution or trade, and consumption of, limited goods and services). Moreover, the approach provides a tool for assessing the broader economic impacts of human activities that affect biodiversity but are currently decoupled from their consequences on the functioning of ecosystems and biodiversity. The TEEB approach aims to help decision-makers recognize and demonstrate the wide range of benefits of ecosystems, landscapes, species and other aspects of biodiversity and, where appropriate, pursue policies to safeguard them.

In order to be successful in an Arctic context, the approach needs to build on a range of different types of knowledge. Information derived from economic valuation (whether market or non-market) is but one source of knowledge. Accounting for the importance of biodiversity and ecosystem services to the Arctic economy and society equally requires information derived from ethnographic and other social-scientific methods and from ecosystem sciences, and on Traditional Knowledge sources. Interdisciplinary teams need to include a broad range of expertise and abilities to understand and work with multiple world views and knowledge systems. Widely used decision-support frameworks based on multi-criteria analysis can accommodate different metrics and modes of explanation without depending on a single common metric.

Figure 3.2. An ecosystem services approach facilitates increased integration of functioning ecosystems into other policy fields, improving the effectiveness of governance for sustained human development
(M. Sommerkorn)
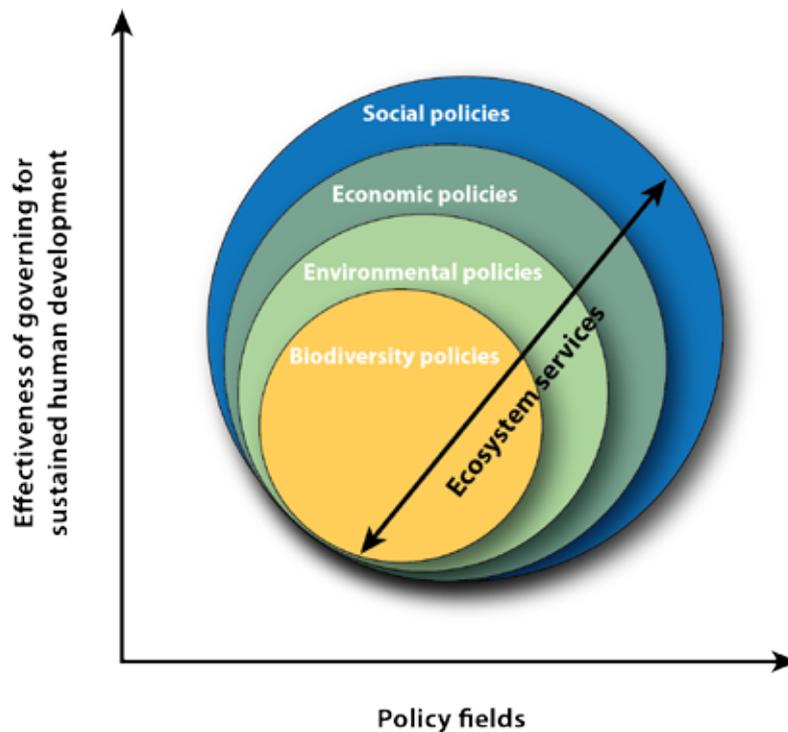
The value we place on particular ecosystem services in making decisions about policies that govern human activities is based partly on our knowledge, but also on negotiations among social actors who may have different priorities, as well as different power positions (Ernstson and Sörlin 2013). An example is the on-going negotiation about the management of large predators, such as wolves, in areas where reindeer herding plays an important economic and cultural role for Saami people. Another example is the conflict in views about the importance of forests, where some look to the market value of the forestry industry, others point to the market value of tourism, and a third group of people may highlight recreational, aesthetic or spiritual values that cannot be captured in monetary terms and are, therefore, often difficult to compare with market values (see Chapter 4 'Valuing ecosystem services in the Arctic').

Often the values that motivate specific policies relate to norms negotiated at a particular governance level. They may, for example, have evolved locally and be integrated into Traditional Knowledge systems and world views. However, despite some examples of governance responsibilities devolving to various local and sub-national bodies, many policies affecting the Arctic are shaped in national capitals outside the region, where different world views, norms and knowledge may play decisive roles. Values also become explicit as a result of international negotiations such as those associated with the CBD or the United Nations Framework Convention on Climate Change (UNFCCC). The Arctic is also strongly influenced by global trends that have impacts on ecosystems – including global climate change, trade and resource demand. Knowledge about Arctic ecosystems and their local significance plays only a limited role in decision making that affects these trends. TEEB recognizes that values are a product of different world views and perceptions about the relationship of humans and nature, and treats these views and perceptions as legitimate and valid in their respective socio-cultural contexts.

What works against taking ecosystem services approaches? *"Governance structures where decisions are taken far from the Arctic, by non-Arctic residents (or where Arctic residents hold little sway) and where the decision-makers are influenced by (and beholden to) non-Arctic residents and their priorities"* (TEEB questionnaire input)

A particular challenge related to the Arctic is that actors at various levels of governance often hold different perceptions of the Arctic and have different priorities. As a result, individual policies often come in conflict when implemented on the ground. Johnson et al. (2010), for example, identified four general perceptions of the Arctic that are important for policies on biodiversity conservation and sustainable development, each represented by groups of powerful actors: homeland (local resource use and extraction, local knowledge), laboratory (science), frontier (national and international commerce), and wilderness (biodiversity conservation and environmentalism). Both conflicts and synergies among the policies of the respective actor groups shift through time as positions are re-negotiated. The explicit valuation of ecosystem services in economic and non-economic terms has the potential to provide transparency for the analysis of how policies and practices affect these values and who benefits from them. Such information may also be useful for conflict mitigation and trade-off negotiations.

In such a complex governance context, the TEEB approach can make the various functions of ecosystems visible by assessing and communicating the role of biodiversity and ecosystem services in the economy and to society. This includes making the local interdependencies between human well-being and various aspects of nature visible to people who may lack local knowledge. It also includes making the role that local ecosystems play in broader geographic contexts apparent to people who may lack knowledge about large-scale systems (for example, understanding of the many aspects of global climate systems). Ideally, an explicit mapping and assessment of ecosystem services can serve as input to co-production of knowledge across knowledge traditions that includes attention to interactions across geographic scales – from the local to the global. Such a function would, however, require governance mechanisms not only for the co-production of knowledge, but also for using the knowledge as a basis for policies at the relevant governance levels. This challenge is further discussed in Section 3.2.2 'Governance fit and scalability'.

It is important to note at this early stage that, despite the explicit economic context, embarking on an ecosystem services approach as an integrated part of all political decision making does not assume the use of only economic instruments as policy tools. Use of legal instruments (e.g., environmental regulations) or resource management regimes may be just as effective and legitimate as vehicles for adopting an ecosystem services approach (NOU 2013). Regardless of the mechanism, the mainstreaming of nature's values by means of ecosystem services – ensuring that the impacts of policies on ecosystems and their services are considered in all policy design and the policy implementation – will most likely require adjustments to existing policies and instruments, as well as the development of new ones. This transition will also require institutional changes as well as evolving cultural values and norms to be reflected in decision making. As such, TEEB would act as a catalyst to help accelerate the development of a new economy: one in which the values of nature are better reflected in public and private decision making.

"Disempowerment [is] caused by the perpetuation of an environmental narrative that pits economy and environment as two separate things, one competing against the other. This does not have to be... The economic system is and will always be the main interface between humanity and nature; how we practice economy is society's current challenge. We are not practicing it well, considering rapid population growth and certain perverse cultural and societal values. By maintaining the antagonistic and separateness of nature, "environmentalists" are creating a dogmatic situation that economically driven policy-makers don't care much about. It is time for "economics" to be converted rather than letting economics convert nature." (TEEB questionnaire input)

"Make more links to people and to people's welfare and well-being, going beyond some present biodiversity and environment biased approaches. [This] can create room and more common language for cooperation across sectors - doesn't take away conflicts, but may rub down some sharp edges on environment versus development." (TEEB questionnaire input)

3.2. Governance of ecosystem services: Critical elements

Governance of ecosystem services can be understood as the interaction of laws and other norms, institutions and processes through which society exercises powers and responsibilities to make and implement decisions affecting ecosystem services. Ideally, governance processes accommodate diverse interests for taking cooperative action, and include a strong participatory element that integrates the needs and perspectives of different actors. In practice, governance processes involve interplay of governmental, inter-governmental and nongovernmental institutions, the private sector and civil society. They may include interaction from multinational to local levels, and, at each level, institutions that directly govern biodiversity, ecosystems or ecosystem services, or that govern human activities that affect these (Greiber and Schiele 2011).

Within this landscape of interacting governance mechanisms, applying an ecosystem services framework to mainstream the values linked to nature into policies and practices is likely to be more relevant in some contexts than in others. The following sections highlight areas of governance that are particularly relevant for Arctic ecosystem services. This is intended to highlight important principles that cut across the policy options that a TEEB Arctic study could pursue, inform the proposed follow-up actions from this scoping study, and potentially inform the follow-up actions from other assessments and initiatives, for example, those at the national level.

3.2.1. Integrated approaches

Many policies have been developed in relation to particular sectorial interests, such as fisheries and forestry. At some point, however, interests almost always intersect with a need for more integrative approaches. Examples include municipal spatial planning, as well as more strategic environmental planning. Recent policy development includes increasing attention to EBM, which explicitly takes into account knowledge about status and trends of ecosystem functions.

The ecosystem approach to management, or EBM, has an important role to play for the governance of ecosystem services in the Arctic. Parties to the CBD adopted the ecosystem approach as the 'primary framework for action' under the Convention (CBD 1995). Policies for EBM exist in many countries, though the concept has so far only been implemented through a limited number of legal frameworks in the Arctic. For those, the necessary steps of fully integrating key sectors and their governing institutions, or societal and economic scope, or the entire ecoregion, have not yet been accomplished (see discussion in Olsen et al. 2007 for the example of Norway's Barents Sea management plan). Nonetheless, there is political consensus at the level of the Arctic Council, and elsewhere in the Arctic, to establish EBM as the underpinning policy for natural resource management (e.g., Arctic Council 2013b).

EBM is defined as "...*comprehensive integrated management of human activities based on best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of ecosystems thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity...*" (Arctic Council 2013a). Focusing on both sustainable use and ecosystem integrity, EBM takes a systems view, rather than attempting to manage individual issues or resources in isolation. Schemes are implemented at the level of large ecosystems (e.g., LMEs at sea, watersheds on land, ecoregions – see map, Figure 2.1) and governed according to agreed ecological quality objectives, based on a participatory approach that considers ecosystem functioning and integrity in securing long-term delivery of valued ecosystem services. The setting of ecological objectives is a societal choice, made after considering the balances between sustainable use and conservation, and the balances among diverse societal needs. These ecological objectives are usually agreed on through a participatory process and preceded by a scoping exercise (Levin et al. 2009). The central idea is to take into account the multi-functionality of a particular ecological context within a regime that provides the environmental analyses and decision frameworks oriented to maintain the health of the ecosystem.

"The need to implement ecosystem-based management and to balance preservation of natural ecosystems with economic activities could enhance consideration of ecosystem services in practical administration." (TEEB questionnaire input)

Both valuing of ecosystem services and governing for their sustained delivery are integral parts of EBM. As such, the governance mechanism of a particular EBM scheme defines both jurisdiction and legitimacy, and provides a context in which stakeholders can cooperate in an integrated way to manage human activities affecting the ecosystem. Regardless of this opportunity, existing EBM frameworks in the Arctic, such as Norway's Barents Sea management plan, so far lack explicit consideration of ecosystem services, which could include the use of both monetary valuation and non-monetary, **participatory valuation** methods.

Participatory valuation: A participatory approach to valuation recognizes stakeholders as active collaborators in a decision process. Participatory valuation is a tool to unlock stakeholder values, experiences and insights about the management of ecosystem services across the whole decision-making cycle (Fish et al. 2011).

The advantages of using EBM as a governance context for assessing the value of ecosystem services is that it provides a platform for co-production of knowledge, including mechanisms for participation by relevant actors. The extent to which a particular EBM regime lives up to this ideal will, of course, vary. Mapping and valuing ecosystems services is not normally the limiting step – analyzing and comparing trade-offs is more likely to be limiting, especially where this needs to be done across traditional sectors (Primmer and Furman 2012). An important task for assessing the potential of using ecosystems services in EBM would therefore be to study actual practices. TEEB may help to advance the governance of ecosystem services through developing and synthesizing knowledge co-produced by EBM projects that explicitly consider ecosystem service valuation and trade-off procedures across governance scales and involve the respective actors.

3.2.2. Governance fit and scalability

The treatment of **externalities** is a major challenge for all place-based integrative management approaches, or, more generally, for policies conceived at a specific governance level or for a specific sector. Externalities include drivers of change that are not within the remit of the defined governance setting, but have effects elsewhere – such as on different actors or places. Many ecosystem services have characteristics of 'common goods' in that they are shared by many people and their benefits can be felt differently in different places and over different time scales. In few places is this clearer than in the Arctic: the costs of impacts from global greenhouse gas emissions on local Arctic ecosystems and communities, for example, are not paid for by those who benefit: the global community of producers, and the users, of fossil fuels. Another example of the lack of accounting for externalities in an Arctic setting is for shipping: the risk cost for coastal communities is currently not integrated in international policy instruments governing trans-Arctic shipping. Risks and opportunities are associated with values, and may therefore be perceived differently by actors at different scales or in different sectors. Rarely are risks and opportunities distributed equally among those actors, and economic incentives that may exist for certain sectors exacerbate such imbalances.

Externality: A consequence of an action that affects someone other than the agent undertaking that action and for which the agent is neither compensated nor penalized. Externalities can be positive or negative.

The issue of externalities also applies to impacts of local decisions on processes that work at other scales or in relation to priorities where actors elsewhere have legitimate interests. For example, forest management is relevant not only in relation to local or to national interests but also for the international community, who have legitimate concerns about carbon storage capacity of the world's forests. These examples highlight the issues of governance 'fit' and scalability for ecosystem services in a globalized world.

How could an ecosystem services approach provide incentives for stewardship?

"Recognition that there are real impacts and trade-offs to be considered, that we cannot have it all, all the time, everywhere.

Recognition that ecosystem services depend on a healthy ecosystem, which is more than just the preservation of a few areas of representative habitat or a few individuals of an iconic species." (TEEB questionnaire input)

"From my perspective, "stewardship" is undertaken by those who already recognize the values of ecosystem services. Governance structures or systems that are based on stewardship concepts are needed." (TEEB questionnaire input)

"I'm not sure that knowledge about ecosystem services is a limiting factor. Power politics (urban vs. rural, state vs. federal) seems to be the bigger issue." (TEEB questionnaire input)

"Oil and other mineral extractive companies push the government to consider the shelf mineral extraction as a mainstream of development of the Arctic regions. Poor inter-agency cooperation, lack of incentives for decision-makers, and prevalence of big business interests [work against the consideration of ecosystem services]." (TEEB questionnaire input)

Two aspects highlight potential opportunities for incorporating the values of nature into policies and practices to improve stewardship. First, there is a need to address the legitimacy of policies across scales – or to what degree the policies respect the needs of the actors at various scales. This can be addressed through identifying existing policies and mechanisms that provide this legitimacy across scales, and then looking at how to expand on these policy options through adopting an ecosystem services perspective. This requires an evaluation of existing governance structures and approaches with a focus on how ecosystem services could be used as a tool for closing the communication gaps between governance levels and for explicitly linking drivers to effects. This will facilitate policy convergence across scales. Local, regional and international policies, as well as sectorial policies (both voluntary and legislated standards) need consideration, plus the applicable environmental and economic legal frameworks and their interfaces.

On the economic side, three closely related principles can guide the choice and further expansion of policy instruments, and can provide incentives for integrating the value of nature into policies to improve stewardship: (1) the polluter pays principle, (2) the user pays principle and (3) the full cost recovery principle (Box 3.1). On the environmental side, the principle guiding the policies and practices of integrated ecosystem based approaches for terrestrial and marine planning and management, including strategic biodiversity conservation ("sustainable use of ecosystem goods and services, and maintenance of ecosystem integrity," see above) can be mapped across scales and sectors to improve policy convergence.

The Arctic Ocean and its ecosystems hold many challenges and opportunities for these approaches, as the boundaries of international waters (areas beyond national jurisdiction) are different for different uses and related sets of policies. For living marine resource use, international waters lie beyond each nation's Exclusive Economic Zone. For shipping and rights of passage, they are beyond territorial waters. For mining, international waters are beyond the extended continental shelf. Furthermore, the institutional arrangements for securing control of activities are different for each use sector.

A second opportunity lies in the recognition that policy and governance settings today are more complex than simply following local, sub-national, national, regional and international scales. The governance landscape also includes hybrid forms of governance that involve local, indigenous, industry and government actors; and NGOs, international forums and multi-lateral agreements Figure 3.3). Coalitions of actors recognizing the value of ecosystem services can improve the representation of natural capital in regulatory frameworks by bridging governance levels and by providing a means of expediting their consideration in policy making.

Box 3.1. Three principles for integrating the value of nature into policies

The **polluter pays principle** (PPP) requires costs of biodiversity loss and ecosystem degradation to be 'internalized' and reflected in the price of goods and services. The polluter has to take prevention or reduction measures and in some cases pay taxes or charges and compensate for pollution impacts. For ecosystem degradation, the polluter should pay directly for clean-up and restoration or pay a fine to help offset damage costs.

The **user/beneficiary pays** principle is a variant of the PPP. Recipients benefiting from ecosystem services should contribute towards the cost of maintaining the service. For example, users of clear water should contribute towards the cost of conserving and/or sustainably managing the wetlands responsible for water purification.

The **full cost recovery principle** provides that the full costs of protecting or sustainably managing an ecosystem service should be recovered from the entity benefiting from the service.

(TEEB Nordic, Kettunen et al. 2012, Box 6.3)

Figure 3.3. The position of actors in the governance landscape across scales and along the continuum from influence to policy making
The arrows indicate how hybrid forms of governance could stimulate more effective stewardship of nature by means of the concept of ecosystem services.
(J. Eamer and M. Sommerkorn)
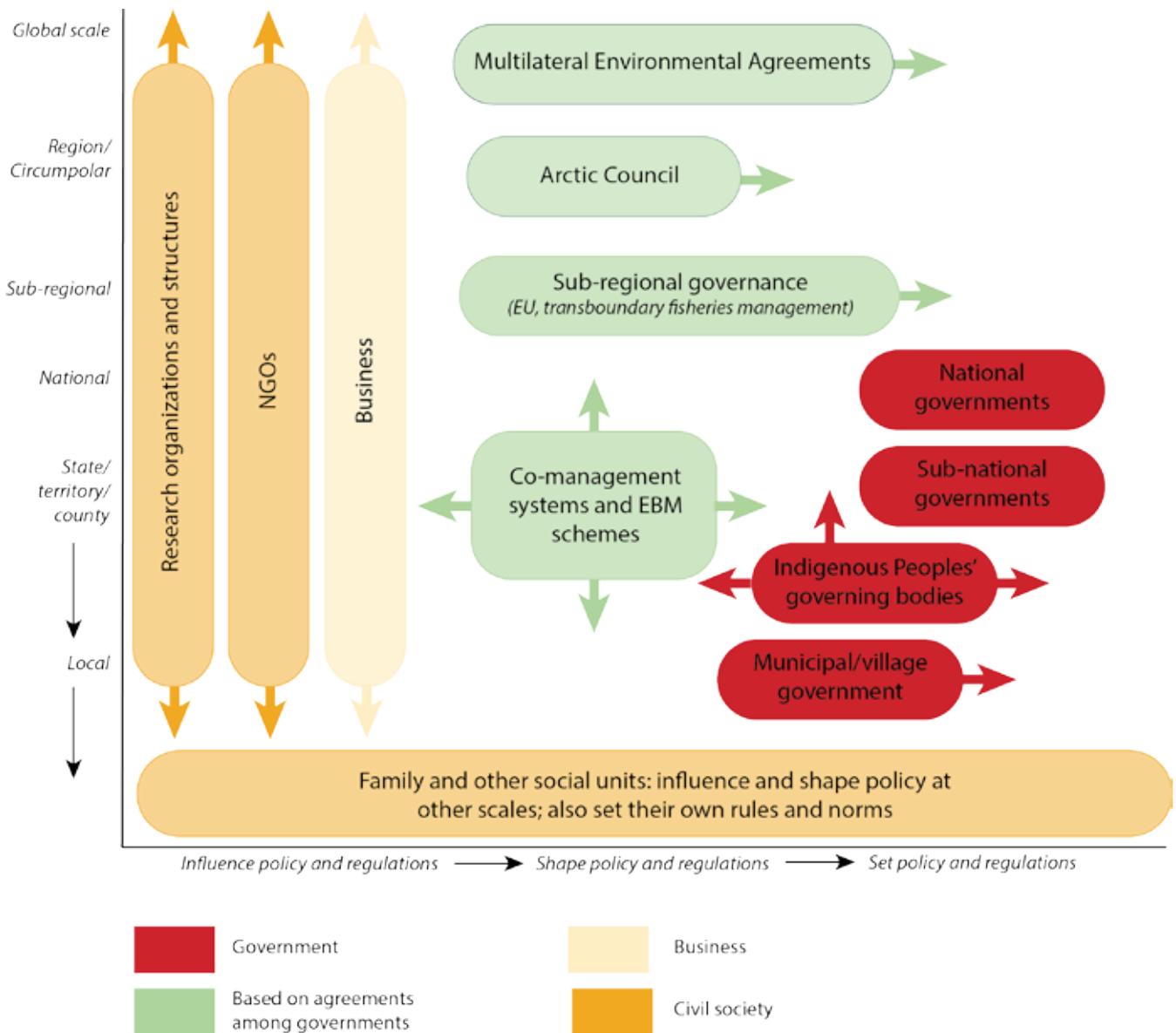
Such hybrid forms of governance often make use of voluntary agreements, such as between local communities or subsistence use organizations and industry, or NGOs. They can provide an efficient way for communicating critical values of nature to other sectors and scales and for pushing the incorporation of these values into policies addressing priority concerns. In this regard they can potentially be implemented more swiftly, and therefore be more effective in the short-term than more comprehensive governance regimes that require national, regional or international negotiations. However, the legitimacy of such activities can also be criticized when decision making is not transparent or when people affected by the policies are not properly represented. The long-term effectiveness of these forms of government is thus an empirical question that also depends on how effectiveness is defined.

 Some of the more informal instruments, tested at the local or sector level, can also potentially be scaled up and applied more broadly, and thus lead to development of improved institutions and regulations at higher (national or regional) levels. A major issue to address for advancing the incorporation of Arctic ecosystem services into policies and practices is: who has jurisdiction, on the one hand, and who has legitimacy and credibility, on the other, to carry out valuation of ecosystem services and to integrate them into decision making.

"If we will have real TEEB assessments for the marine ecosystems, including fishing grounds, we could attract fishermen and indigenous people as partners in promoting recognition of values of the ecosystem services... it could help to protect the structure and productivity of marine ecosystems, especially in the fishery field and in relations between different industries." (TEEB questionnaire input)

3.2.3. Governance participation and learning: Co-production of knowledge

The values of all ecosystem services are rarely made explicit in economic policy processes. Even if economic decisions are made in the contexts of negotiated social agreements about other values and potential threats to them, the economic value of alternative policy options are not always apparent. A TEEB approach aims to incorporate the value of all ecosystem services into the policy process. This has implications for governance, as it emphasizes a need for participatory elements that strengthen not only policy legitimacy but also societal learning. Policy processes that use ecosystem services as a way to facilitate knowledge co-production could be a means to integrate and bridge different knowledge systems (MA 2005b). Joint production of knowledge can also contribute to reducing power imbalances between actors (Berkes 2012).

As values evolve, and because decisions that affect ecosystem services also affect human well-being and ecosystem condition, policies need to be revisited based on re-assessment of values and status of ecosystem services. Major policy change is often slow, but the need for reassessment provides both motivation and context for implementing more adaptive governance regimes. Such adaptive governance is especially important because Arctic ecosystems are currently in a state of rapid change, with potential for major transformational change (Arctic Council 2013c). As reviewed by Kofinas et al. (2013), it has been suggested that the pervasiveness, speed and potentially transformative character of changes in the Arctic require a change in decision-making practices, moving from trial-and-error decision making dominated by interests, to reflexive processes that systematically view past experiences as natural experiments. Such a culture change includes integrating monitoring, questioning assumptions, building and testing appropriate innovative approaches, and iterating aspects of governance systems that facilitate social learning (at several levels – Armitage et al. (2007)). The capacity for responding to change and for transformation is also needed (Figure 3.4).

Figure 3.4. Iterative loops of adaptive governance and their relation to social norms and rules through knowledge co-production and social learning
In this scoping study we explore how using or altering suitable policies and incentives can improve the long-term viability of human-nature relationships. Such (double-loop learning) policy and incentive changes have more transformational power than adjusting only the design of existing policies to account for changing conditions (single-loop learning), and they may also contribute to transforming the norms and mind-sets that underpin societal visions, goals and collective actions, and that shape change (triple-loop learning)
(modified from Folke et al. (2009) and Ozkaynak et al. (2012)).
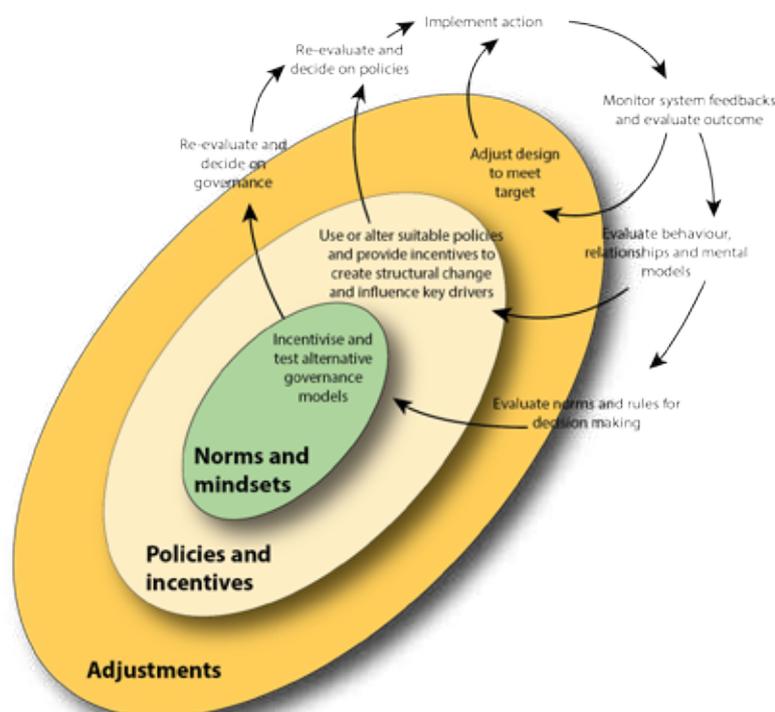
3.2.4. Enhancing resilience: Towards embracing the social-ecological system

Enhancing resilience has become central to many policies that focus on resource use and management, including in the Arctic. The resilience of ecosystem services (the capacity of a social-ecological system to sustain a desired set of ecosystem services in the face of change and disturbance), is critical for continued human well-being and for meeting current and future societal needs (Beier et al. 2009). The importance of a resilience focus is emphasized by the rapid ecological and social changes occurring in the Arctic that are likely to produce surprises, so governance must be responsive, flexible and appropriate for a broad range of conditions (Arctic Council 2013c).

Enhancing the resilience of ecosystem services requires specific governance and management policies that embrace the entire social-ecological system, including its ecological, economic and social components. A recent review identified seven generic policy-relevant principles for enhancing the resilience of desired ecosystems services in the face of disturbance and ongoing change (Biggs et al. 2012) (Figure 3.5). A first group of principles relates to key attributes of the social–ecological system that is the target of governance. These are maintaining diversity and redundancy, managing connectivity, and managing slow variables and feedbacks. A second group of principles relates to key attributes of the governance system, and comprises encouraging learning and experimentation, broadening participation, promoting polycentric governance systems, and fostering an understanding of social-ecological systems as complex adaptive systems. In practice, these principles often occur together and are interdependent. Accordingly, several of these principles are explicit in critical elements of ecosystem service governance discussed above, such as participation and learning. Others are implicit or overlap, such as polycentric governance in aspects of governance fit and scalability. Several others, however, go beyond governance elements that can be identified as coming from an economic perspective.

Figure 3.5. Resilient ecosystem services as an outcome of governance targeting principal properties and attributes of social-ecological systems
As ecosystem services are co-produced by nature and society, the principles to enhance ecosystem service resilience need to embrace environmental, economic and social policies and must target both the system to be governed and the governance system (modified from Biggs et al. 2012).
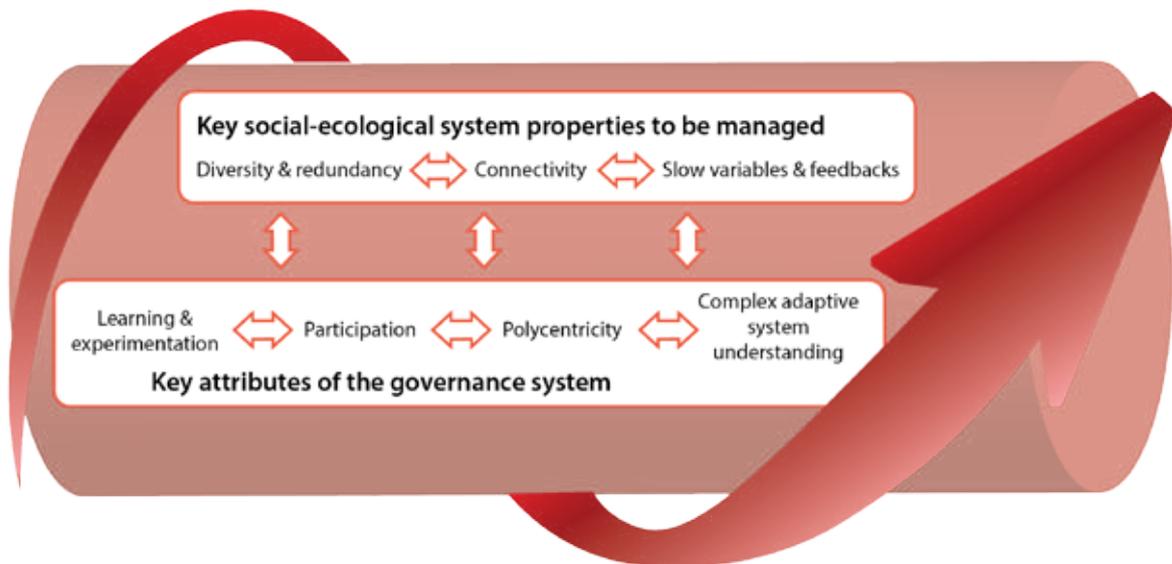
The urgent need to establish policies that enhance the resilience of ecosystem services in the Arctic means that future work on integrating ecosystem services in policies and practices should develop concrete practices that advance these principles. In doing so, it is important to consider that ecosystem services are co-produced (by nature **and** society) in social-ecological systems, and that the principles to enhance ecosystem-service resilience therefore apply to both these domains. Connectivity and diversity, for example, need managing for in both society and biodiversity to ensure resilience of ecosystem services. There is substantial work ahead to operationalize and apply the principles in the context of policies and practices, including biodiversity management and economic instruments (Biggs et al. 2012), and doing so requires novel cooperation between scholars and practitioners from diverse fields.

3.3. Policy options for integrating ecosystem services

Most human activities have some impacts on ecosystem services, either directly or indirectly. Governance of ecosystem services thus encompasses all political processes that affect human activities, including, for example financial and trade politics, land use planning, and also politics related to a range of security concerns. Many ecosystem services are 'common goods' and markets fail to capture many of these values. Public policies therefore have an essential role to play in ensuring that the main types of benefits are identified and taken into account in decision making.

A range of existing policy tools is relevant for directing human activities in ways that protect and support ecosystem services. The following sections introduce some policy tools that may lend themselves to advancing the capture of the wider values of biodiversity and ecosystems.

3.3.1. Legal frameworks

A number of local, national and international governance mechanisms already affect ecosystem services in the Arctic, directly or indirectly. These range from international norms or rights (for example, of Indigenous Peoples, and of the use of oceans), through regulation of activities that may harm the environment (including conventions on pollution and industrial activities), to international, regional or bilateral conventions and agreements that directly protect specific aspects of biodiversity. While enforcement is often an issue, international agreements nevertheless serve a role in setting common norms. Environmental regulations exist also at national and sub-national scales, either as dedicated rule sets, or as implementation of a legal framework to which a country is committed.

"International agreements may be quite effective and in many cases pivotal to success, but unfortunately not always. National back-up in the form of information campaigns, legislation and law enforcement is a prerequisite to success." (TEEB questionnaire input)

Box 3.2 provides an overview of some relevant governance regimes. To what extent can the incorporation of ecosystem services make these regimes more effective for the stewardship of Arctic biodiversity? Answering this question would require focused studies of regimes that may be considered especially relevant for the Arctic (such as those pertaining to governance of biodiversity and pollution, and of international trade and transport), to test their ability for increased scalability, participation, knowledge generation and learning, and social-ecological system resilience (see previous section) through the integration of ecosystem services. Such detailed exercises go beyond the scope of the present study and would need to include relevant national and sub-national environmental laws, as well as laws that are indirectly relevant and that are not considered here explicitly (e.g., taxes and other incentives or disincentives, legislation on planning, land tenure and property rights, and law related to public participation).

Domestic reindeer. Photo: Alexey Solodov/Shutterstock.com

> **Box 3.2. Examples of international commitments and agreements that affect ecosystem services in the Arctic**
>
> *International rights declarations*
> - ▶ UN Declaration on the Rights of Indigenous Peoples (UNDRIP), specifically UNDRIP article 3, the right to self-determination of economic development
> - ▶ UN Framework Convention on Climate Change (UNFCCC)
> - ▶ Stockholm Convention on Persistent Organic Pollutants
> - ▶ Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the Gothenburg Protocol
> - ▶ Montreal Protocol on Substances that Deplete the Ozone Layer
> - ▶ Minamata Convention on Mercury
>
> *Important bilateral or multilateral environmental agreements (MEAs) focusing on biodiversity*
> - ▶ Ramsar Convention on Wetlands
> - ▶ Convention on Biological Diversity
> - ▶ UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage (WHC)
> - ▶ Convention on Migratory Species (CMS) and its associated agreements such as the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
> - ▶ the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
> - ▶ Regional and/or species-specific agreements, such as the Bern Convention on the Conservation of European Wildlife and Natural Habitats, the International Convention for the Regulation of Whaling (ICRW), the Agreement on the Conservation of Polar Bears, the bilateral agreements on the conservation of the Porcupine Caribou Herd (US-CA)
>
> *Important international agreements focusing on marine areas*
> - ▶ UN Convention on the Law Of the Sea (UNCLOS)
> - ▶ within UNCLOS: the development of an international instrument relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction (BBNJ)
> - ▶ within the International Maritime Organization (IMO); Conventions and Protocols: the development of an international code of safety for ships operating in polar waters (Polar Code)
> - ▶ Convention on the Prevention of Marine Pollution (London Convention)

3.3.2. Examples of policy instruments for the governance of Arctic ecosystem services

Making values explicit can strengthen existing instruments and can help build support for new instruments to change the decision equation facing stakeholders using or benefiting from, managing, affecting or investing in Arctic natural resources.

At the national scale, such policy instruments are often macroeconomic ones. Box 3.3 introduces broad instruments that exist at the national scale and that lend themselves to advancing stewardship of natural capital and sustainable development through explicit incorporation of ecosystem services.

"Companies must pay completely for the consumed ecosystem service but not according to the opportunistic state standards." (TEEB questionnaire input)

"Decision making is a process of weighing costs and benefits, so anything where the benefits are considered great will outweigh the cost to the environment. The profits to be made from oil and gas development are considered a great benefit and as such oil and gas development is likely to occur regardless of the cost to the environment and the people that hunt and fish there. Also, many politicians don't represent the average rural Arctic resident. They are usually from big cities, wealthy backgrounds, with much education so it is difficult for them to appreciate the benefit of a clean river to fish in." (TEEB questionnaire input)

At the local to sub-regional scale, policy instruments that lend themselves to making the value of nature explicit in decision making often focus on the planning stage, where different interests are explicitly taken into account, as are the management of natural resource use and of space. Adding an ecosystem services approach to such schemes can strengthen participation, knowledge co-production and scalability of the management of natural capital, and can improve their grounding in functioning ecosystems, thereby advancing stewardship of natural capital, sustainable development and human well-being.

Box 3.4 lays out examples of relevant planning and management instruments. According to the principles of EBM (see also above), such policies should be implemented on the basis of a functioning ecosystem unit. While such units exist across a variety of scales, planning and management schemes are often implemented at sub-national scales (watersheds or national

Box 3.3. Policy instruments at the national scale for advancing stewardship of natural capital and sustainable development through explicit incorporation of ecosystem services

More specific tools and instruments are available for each of the categories, but reviewing them in detail goes beyond the scope of this study. Modified from TEEB for National and International Policy Makers (TEEB – The Economics of Ecosystems and Biodiversity 2011a).

1. Governance aspect: Measuring to manage natural capital

Objective Develop capacity to measure and monitor biodiversity, ecosystems and the provision of services as an essential step towards better management of natural capital. Providing relevant and accessible information will require not only a wider and more adequate use of valuation, but also progress on indicators of biodiversity and ecosystem services and on the integration of natural capital into macro-economic indicators and accounts.

Instruments and rationale (mechanisms are in red print)

▶ **MEASUREMENT OF BIODIVERSITY AND ECOSYSTEM SERVICES THROUGH INVENTORIES AND INDICATORS**

Inventories and indicators are particularly useful for policy-makers as they can show the state of resources and trends in the pressures affecting these resources, enabling policy-makers to identify the policies needed to better manage them. A primary area for improvement is development of tools to better assess biodiversity trends and changes in the capacity of ecosystems to deliver services. From the economic perspective, the most important gaps to be filled relate to the measurement of ecosystem services and of the condition of the ecosystems that provide them.

▶ **LINKING NATURAL CAPITAL TO MACROECONOMIC AND SOCIETAL INDICATORS AND NATIONAL ACCOUNTS**

The need to complement current GDP indicators to measure sustainability and human well-being is increasingly recognized. Most services provided by the natural environment to human society are not captured by GDP or other conventional macroeconomic indicators. The value of natural capital calculated using techniques available today is only part of its possible worth. A System of Economic Environmental Accounting (SEEA) has been developed, covering land, water, environmental expenditures and social issues in monetary and physical terms, and adopted by some countries. However, further progress is needed to catalyze progress on measurement and incorporate ecosystem services into national accounts. Meanwhile, new approaches to measurement give rise to new terms and concepts. A well-known example is the 'ecological footprint'. Also, indicators based on the concept of inclusive ('extended') wealth, involving regular measurement of per capita physical, natural, human and social capital underpins work by the World Bank and the EU.

▶ **INFORMED MANAGEMENT OF NATURAL CAPITAL BUILDING ON ECOSYSTEM SERVICES ASSESSMENTS**

Integrated national assessments can estimate the value of and analyze interconnections among natural capital, its benefits and the economic sectors concerned. Integrated ecosystem assessment regimes provide status information. Not having or not using information on biodiversity, ecosystem services, and their values can compromise effective and efficient management of natural capital and the economy. In light of the rapid changes in the Arctic, tools and indicators that can capture the value and status of natural capital for adaptive and transformative capacity are needed for efficient and strategic targeting of protection and investment efforts, as are tools and indicators identifying and locating natural assets that serve as a basis for social-ecological resilience.

2. Governance aspect: Investing in natural capital

Objective Investing in natural capital supports a wide range of economic sectors and maintains and expands options for sustainable development for people and economies. Such investments, which entail financial support for maintaining or improving ecosystem functions, can be a cost-effective response to climate change, offer value for money, support local economies, create jobs and maintain ecosystem benefits for the long term.

Instruments and rationale

▶ **INVESTMENT IN ECOLOGICAL INFRASTRUCTURE.**

Ecological infrastructure refers to nature's capacity to provide freshwater, climate regulation, soil formation, erosion control and natural risk management, among other services. Investing to maintain nature's capacity to fulfil these functions is often cheaper than having to replace lost functions by investing in alternative

heavy infrastructure and technological solutions. Adaptation is a key policy area for Arctic nations. Adaptation strategies based on broader investments in ecological infrastructure can contribute to protection against natural hazards and thereby decrease society's vulnerability and moderate the impacts of global warming. Investing in natural capital is an investment in the adaptive capacity of social-ecological systems, and investing in natural capital conservation measures such as protected area networks strengthens ecosystem resilience.

3. Governance aspect: Improving the distribution of costs and benefits

Objective By taking distributional issues into account when using and protecting natural capital, policy-makers can simultaneously address social and environmental concerns. This involves discussions about the fair distribution of costs and benefits – both locally and globally. It also means looking at property and use rights and potentially easing any transition pains.

Instruments and rationale

▶ **POLLUTER PAYS PRINCIPLE - MAKING SURE THE RIGHT PEOPLE PAY**

The social impacts of environmental harm can be addressed by applying the 'polluter pays principle', the 'user/beneficiary pays principle', and the 'full cost recovery principle'. If properly designed, management of natural capital considers the distribution of costs and benefits across the full range of ecosystem services.

▶ **PROVIDING INCENTIVES AND SETTING THEM IN LINE WITH THE DISTRIBUTION OF NATURE'S BENEFITS**

Local ecosystems generate benefits in a wider area – and even globally – but are rarely rewarded for doing so. Distributive issues can and need to be addressed both nationally and internationally. Payments for ecosystem services (PES) reward providers of benefits who have previously been taken for granted. PES can be used for local or international transfer. PES requires careful design, including attention to property rights and unequal power relations (e.g., between local and non-local users), and differentiation between subsistence and intensive resource use, but has the potential to provide additional income to local stewards of nature.

▶ **CLARIFYING RIGHTS TO RESOURCES**

Where the free provision of ecosystem services is regulated, their value tends to become better recognized. Where traditional rights are not registered, they risk being ignored unless rules explicitly respect former uses. The process of defining and officially recognizing rights to resources is fundamental for conservation and sustainable resource use regimes. Along with clear principles and functioning policies for distribution of rights to resources, collectively or cooperatively managing common goods, fostering collective rights to common property helps to secure the future provision of ecosystem services.

▶ **MANAGING TRANSITION**

Shifting towards a more sustainable regime of resource use is essentially about managing transition – a challenge in its own right that merits the particular attention of policy-makers in a rapidly changing Arctic. More complete information about the full range of costs and benefits can support economic evaluation of transitions. Re-evaluating and possibly removing subsidies that are harmful to biodiversity and ecosystem services is one of the most urgent steps for ensuring coherent and efficient policies, in particular those to correct the economic signals to private sector actors and to society as a whole. Reforming environmentally harmful subsidies can free up public funds to promote resource-efficient and equitable growth – preferably those rewarding the unrecognized benefits of ecosystem services and biodiversity. Policies that manage transitions change the distribution of benefits and costs among different groups. Government intervention is particularly helpful where the benefits of a conservation policy become effective only after a time lag. During this transition period, targeted governmental support is required. Public compensation mechanisms, such as tax breaks, ecological fiscal transfers or special credit lines, can help to provide the necessary incentives.

Box 3.4. Policy instruments for planning and managing natural resources and space

Modified and amended from TEEB for Local and Regional Policy Makers (TEEB – The Economics of Ecosystems and Biodiversity 2010b).

Governance aspect: Regulating activities and use through planning and management

Policy instruments

▶ **ECOSYSTEM-BASED MANAGEMENT**

Objective and benefits

EBM manages human activities according to the overarching goal of maintaining functioning ecosystem. The benefit of EBM is sustained and resilient delivery of ecosystem services to all beneficiaries. EBM uses available knowledge about the ecosystem and applies participatory processes for scoping beneficiaries and their values in the building of integrated management plans (McLeod and Leslie 2009).

Rationale

EBM schemes involve beneficiaries of ecosystem services in setting ecological quality objectives and integrating ecosystem status monitoring and knowledge for regulating key sectors affecting the ecosystem. EBM is premised on the identification of functionally defined social-ecological units. It provides a platform for co-production of knowledge about ecosystems and their beneficiaries. Both the assessment of the value of ecosystem services and governing for their sustained delivery are integral parts of EBM. As such, the governance mechanism of EBM schemes sets both jurisdiction and legitimacy in a function-oriented and transparent manner and provides a context in which stakeholders can cooperate in an integrated way to manage human activities affecting the ecosystem. EBM schemes provide a framework for sector regulation, often across governance scales, and increasingly encompass regions across sub-national and national administrative boundaries. By integrating stakeholder values yet remaining grounded in functioning ecosystems, and by relating to jurisdictions and legitimacies appropriate to their respective settings, EBM schemes provide a prime policy instrument for considering ecosystem services.

▶ **MARINE AND TERRESTRIAL SPATIAL PLANNING.**

Objective and benefits

The overriding benefit of spatial planning is that it can encompass the cumulative impacts of incremental decisions on ecosystems and their services. It examines the 'parts' to make decisions that affect the 'whole.' An effective and inclusive planning framework can make the policy and planning process transparent and inclusive, assessing who benefits from which ecosystem service, helping to avoid conflicts (Douvere 2008).

Rationale

Spatial planning frameworks involve development of policies to guide planning by formulating objectives and key areas of intervention, processes involving local stakeholders, and legal plans that define rules of action. Open and collaborative spatial planning helps to make agreement between diverse stakeholders with a variety of agendas, backgrounds and landscapes possible. Spatial planning integrates sector planning and is carried out by government departments or agencies that manage specific resources. In addition, spatial planning schemes integrate planning at different scales of governance – from local to regional to national and even beyond. Their shape is as variable as the mechanisms and bodies that implement them, reflecting both their scope and purpose. It can be influenced by broad and specific goals, geography and relevant legislation. Where spatial planning schemes are value-driven, they place importance on sustaining habitats that underpin ecosystems and biodiversity, consider functionally defined social-ecological units and ecological quality objectives, and they are recognized as a way to implement spatial, integrative and participatory aspects of EBM.

▶ **STRATEGIC ENVIRONMENTAL ASSESSMENTS AND ENVIRONMENTAL IMPACT ASSESSMENTS.**

Objective and benefits

Strategic environmental assessment (SEA) and environmental impact assessment (EIA) assess the impacts of development on ecosystem services before they are affected. They can highlight the development opportunities provided by biodiversity and functioning ecosystems (Hanna 2009; Fischer 2010).

Rationale

Environmental impact assessment is the process of identifying, predicting, evaluating and mitigating the biophysical and other relevant effects of development proposals prior to major decisions being taken and commitments made. It is often conducted as a mandatory step to obtain planning approval for development projects. Strategic environmental assessment addresses development choices at a strategic level – it considers alternative options, weighing and discussing the risks and opportunities they present. Future opportunities for development are often unknown, but potentially hidden in ecosystems and biodiversity, as they provide direct or strategic support to all human activities. SEA and EIA have a major role in bridging economic, social and biophysical planning dimensions to assess future development opportunities. When conservationists and planners disagree on biodiversity issues, assessments of impacts on, and benefits of, ecosystems services can help reconcile biodiversity conservation with development by highlighting the role of natural capital and ecosystem services as the basis for continued human well-being and livelihoods. SEA can contribute to ensuring that natural capital is not 'traded in' to meet short term needs in a manner that limits the freedom of future generations to choose their own development paths.

▶ **PROTECTED AREAS NETWORKS**

Objective and benefits

Protected areas networks are networks of areas that are specially managed for biodiversity conservation. Their purpose is to protect and restore biodiversity, ecosystem function and special natural features, preserve cultural heritage resources and strengthen ecosystem resilience. Networks of protected areas fulfil these aims more effectively and comprehensively than individual sites could alone (IUCN-WCPA 2008).

Rationale

Protected area networks constitute a core strategic biodiversity conservation element within the broader context of sustainable development practices, such as spatial planning and EBM. While there is widespread agreement that protected areas contribute to human well-being, including contribution to traditional lifestyles, tensions exist over policies that restrict access to natural resources for local communities. The social and economic cost of maintaining protected areas has caused local conflicts. However, the way in which a protected area is implemented determines whether it is a problem or an asset for local development – coordinating regulation and management inside and outside protected areas can decrease conservation-related costs and increase conservation-related benefits. An understanding of such costs and benefits can be achieved through a thorough examination of the flows of ecosystem services. This understanding of costs and benefits can be used to build political support for conservation. Incorporating the costs and benefits into local development schemes can enable sustainable financing of protected areas through, for example, payments for ecosystem services.

▶ **CO-MANAGEMENT OF NATURAL RESOURCES**

Objective and benefits

Co-management of living natural resources empowers local actors in policy processes and seeks to resolve issues between communities and government (Armitage et al. 2007).

Rationale

Findings from policy studies suggest that problems are most effectively addressed when institutions are at least in part developed with participation from the level of social organization closest to the problem. In a co-management setting, this can help ensure the inclusion of local knowledge and Traditional Knowledge and norms, in addition to scientific input that can bring attention to external costs and benefits. Co-management is one model of governance that empowers local actors in the policy process. Such schemes are established in many places in the Canadian and US Arctic. They often focus on fish, mammal and habitat management, but with the significance of living resources for indigenous communities, co-management has wider importance because it gives local communities the opportunity to manage their own resources. This, in turn, has links to self-determination. Co-management embodies a number of values, such as participation and collaboration, accountability, learning and trust. Successful schemes reconcile world views and are inclusive of existing benefits and knowledge bases. Their effectiveness is strongly influenced by partners' willingness to share power, jointly identify issues and solutions, and accept both science and Traditional Knowledge. Co-management policies are affected by both social and ecological drivers. Making assessments of ecosystem services explicit would improve transparency and may thereby contribute to lessening some of the tension between communities and government.

coastlines, for example), but may in some cases necessitate bilateral, or even multilateral, coordination, where, for example LMEs, habitats or populations of important species span multiple jurisdictions. Comprehensive implementation of planning and management schemes based on the ecosystem approach contributes to national inventories and status assessments, and is an approach to implementing national economic policies addressing ecosystem services.

Additional economic instruments

By setting monetary incentives, economic instruments can influence which resources are exploited and how. Some economic instruments that are specific to ecosystem services have been introduced above, but also more traditional measures like taxes and fees, trading schemes and certification schemes could consider ecosystem services explicitly.

Taxes and fees can discourage consumption of natural resources by raising prices and still leaving the decision to buy at a higher price to individuals. Taxes on fuel, water or energy consumption, or fees for accessing parks or for licenses for timber logging or fishing, are examples. While taxes are often not earmarked to directly benefit the supplier of the service, the financial resources generated through fees related to use of natural resources are more often earmarked to directly benefit ecosystems and services linked to those resources.

Public information instruments. One way of providing information to actors making economic decisions is the use of product certification or eco-labelling. Consumer preference for products with eco-labelling or product certification can create an incentive for industries to meet the standards to acquire the label. A familiar example is the MSC (Marine Stewardship Council) certification of fisheries. In the Arctic, currently about 90% of Greenlandic shrimp and Barents Sea cod and haddock fisheries are MSC certified.

Trading schemes are the creation of a market by government, in which a system of property rights is established. For example, a government unit can develop a system to sell fish-catch allowances. Such a market requires determining a finite allowed catch, often based on estimates of sustainable yield, e.g., the number of fish that can be caught without reducing the population of a specific fish stock over time. When individual fishermen are issued a transferable quota, they can either use it or sell it at the fish quota market. Such schemes also exist for wildlife in the Arctic, for example, for polar bear hunting in Canada's Northwest Territories and Nunavut, where quotas are established on scientific management principles, and do not consider international demand for polar bears. Inuvialuit and Inuit communities often decide to allocate part of their existing polar bear quotas to visiting sport hunters as guided hunts, which provides a range of important cultural and economic benefits and strong incentives to abide by the quota system (Huntington et al. 2013a, Box 18.6). Sometimes, as in this example, trading schemes are similar to payment for ecosystem services schemes.

Governance of ecosystem services is also established through non-market economy tools (barter), or mixed economy tools (compensation trade), which are practiced in Arctic Indigenous communities and are common in northern communities in general.

Comments related to environmental impact assessment

"How to include cumulative effects at regional levels is (still) not well developed and implemented in decision making." (TEEB questionnaire input)

"I think most Arctic countries have a form of an Environmental Impact Statement […]. Through this process much information is gathered, and study like this could contribute information to the process. Public opinion is also a driver that can shape policy, so if the general public is more aware of the value of ecosystems they will elect like-minded people, and support decisions that take the value of ecosystem services into account." (TEEB questionnaire input)

3.4.   Governance of ecosystem services and the Arctic Council

The 1996 Ottawa Declaration established the Arctic Council as a high level forum for *"promoting cooperation, coordination and interaction among the Arctic States with the involvement of the Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, **in particular issues of sustainable development and environmental protection**"* (Arctic Council 1996, emphasis added). The Iqaluit Declaration (Arctic Council 2015) re-affirms the *"commitment to sustainable development in the Arctic region, including economic and social development, […] and […] to the protection of the Arctic environment, including the health of Arctic ecosystems, conservation of biodiversity in the Arctic and sustainable use of natural resources."* As a concept conceived to explicitly link these policy fields, ecosystem services can be viewed as a legitimate concern of the Arctic Council. However, the role of the Arctic Council in the governance of ecosystem services needs clarification.

The Council is concerned with *"provid[ing] a means for promoting cooperative activities to address Arctic issues requiring circumpolar consideration"* (Arctic Council 1996). On this basis, and enabled by the work of its working groups, the Council has

been successful as an international agenda-setting and policy-shaping body (Nilsson 2012; Kankaanpää and Young 2012). However, the Council does not by itself implement policies and is therefore dependent on other bodies, especially national governments, for the move from agenda setting to getting specific policies in place that might affect behavior. The pace of change in the Arctic, particularly the opening of the region to increased levels of economic activities and the increasing international interest in the region, have raised concern about whether the pace of policy implementation can keep up. This leads to concerns about safeguarding of the Arctic environment and Arctic sustainable development. In light of this challenge, the Council itself is developing, for example, by negotiating a number of legally binding agreements (the Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic, and the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response), and by founding an Arctic Economic Council to engage more effectively with business.

While the Council does not directly manage human–environment interactions, it does undertake assessments of knowledge and the contextualization of issues in a circumpolar context, both needed for governance of ecosystem services. The Arctic Council's track record as a leader in bringing together knowledge across the circumpolar North places it in a good position to take on a similar role with regard to Arctic ecosystem services, including the values assigned to them from the perspective of key Arctic stakeholders and rights holders. Such comprehensive understanding of the issues surrounding regional environmental and resource governance as well as sustainable human – including economic – development under current and anticipated conditions would serve as a foundation also for effective implementation of relevant policies both in the region and internationally. This particular added value of the Arctic Council becomes all the more important with the utility of ecosystem services as a concept that integrates policy across sectors and institutions.

The task of generating knowledge about and assessing the value of Arctic ecosystem services resonates directly with the Arctic Council commitment to sustainable development (Arctic Council 1996). Defining sustainable development requires substantiating the linkages and underlying interdependencies between environmental, social and economic concerns. Moreover, weighing current and future human–environment relationships requires the transparent incorporation of values and choices (Arctic Council 2013c). While ecosystem functions serve as a foundation for both social well-being and economic development, rather than being a separate concern, pursuing a sustainable development agenda often necessitates weighing a range of long-term and short-term priorities. The concept of ecosystem services, and especially its application in policies and practices through the TEEB approach, gives guidance in the making of trade-offs between development options or bundles of ecosystem services by improving the representation of ecosystem functions and their value for people into decision making. An inclusive analysis of the values of ecosystem services could therefore assist the Arctic Council in pursuing a more comprehensive sustainable development agenda that takes the full range of issues into account. In line with its successful history as an agenda-setting forum, the Arctic Council is in central position to ascertain the information and norms governing Arctic ecosystem services.

3.5.   Some related TEEB initiatives in the region

(By F. Katerås)

Many TEEB recommendations have been reflected in international commitments related to biodiversity and to national accounting. A key example of this is the inclusion of ecosystem services and valuation aspects in decisions and targets set under the CBD. The Arctic governments have been supportive of the TEEB initiative since its inception, including through political involvement and through advancing and promoting TEEB approaches in international agreements and instruments. A wide range of donors, including the European Union and Norway, are providing significant funding for TEEB efforts, including for the thematic report on TEEB for Agriculture and Food, TEEB for water and wetlands and ongoing initiatives on natural capital accounting.

Most of the Arctic countries have taken steps to recognize, demonstrate and capture values of biodiversity and ecosystem services in national policy. This includes efforts related to improved mapping of ecosystems, enhanced valuation of ecosystem services and inclusion of ecosystem values in national accounts and statistics. However, experience is still limited in several areas. Below are some examples of national TEEB-related activities. This scoping level review focuses mainly on EU, Norway and Sweden. A TEEB Arctic study would benefit from a more comprehensive comparative review including all the Arctic nations. It should be acknowledged that other Arctic states are also undertaking significant efforts to consider and/or to implement a 'TEEB approach', or other approaches to integrating ecosystem services into policy.

3.5.1. Examples of European Union follow-up

The EU member states, including Denmark, Finland and Sweden, are urged to map and assess the state of ecosystems and their services in their national territories by 2020 as follow-up to the EU Biodiversity Strategy to 2020 (EU 2011). As part of this strategy, the EU is developing an analytical framework (EU 2013), which has been framed by a broad set of key policy questions and structured around a framework that links human societies and their well-being to the environment. Important advice to EU policy is developed by the expert group on mapping and assessment of ecosystems and their services (MAES).

3.5.2. Examples of Norwegian follow-up

In order to see how TEEB may be used in a Norwegian setting, in 2011 the Norwegian Government appointed an expert commission on values of ecosystem services. The Commission was asked to describe the consequences for society of the degradation of ecosystem services, to identify how relevant knowledge can best be communicated to decision-makers, and to make recommendations about how greater consideration can be given to ecosystem services in private and public decision making.

The Commission submitted its recommendations to the Minister of the Environment in August 2013 (NOU 2013). In summary, the Commission concluded that the ecosystem services approach can be a useful supplement to Norway's environmental and resource management in order to show more clearly why protecting nature is important to our well-being. The Commission argued that the values of ecosystem services must be better demonstrated and reflected in decision making, and that values in nature must be communicated through policy instruments, regulations and incentives.

The Commission concluded that the state of Norwegian ecosystems is relatively good, but the country's biological diversity and ecosystems are also under pressure from many directions. Important ecosystem services from Norwegian Arctic ecosystems include fish and seafood, biologically derived chemicals, genetic resources and nature-based tourism. The greatest threats to biological diversity and to many ecosystem services in Arctic Ocean and coastal areas are climate change and ocean acidification.

The Commission pointed to the need for improved knowledge about biological diversity and ecosystem services in Norway, and made recommendations related to increased research and enhanced monitoring. It underlined that there is a need for more knowledge about Arctic ecosystems, where the effects of climate change, ocean acidification and environmental toxins will be particularly important.

In September 2013 the report was distributed for a broad public consultation among affected stakeholders, including the authorities, business and industry, academic communities and NGOs. Based on this consultation, the Government is considering how to follow up on the work, including general policies and specific measures. Key policy follow-up to the report will be presented in the 2015 National Action Plan on biodiversity under the CBD.

Significant efforts are going on to recognize, demonstrate and capture values of biodiversity and ecosystem services in national policy. The Norwegian Environment Agency, for example, is actively involved in mapping and assessment of ecosystems and in valuation of ecosystem services, including through socio-economic analysis, environmental impact assessments and planning efforts. Statistics Norway is furthermore involved in improved national statistics and environmental accounts, both at the national and international level. The Norwegian Research Council is also increasing its focus on ecosystem services, including through the funding and development of new research programs.

Overall assessments and consideration of ecosystem services are reflected in several recent (2012 and 2013) policy documents, including in Government's reports to the Parliament and strategies related to climate change, public protection against floods and avalanches, sea food, adaptation to climate change, public health and outdoor recreation.

3.5.3. Examples of Swedish follow-up

A similar exercise has been undertaken in Sweden, with the initiation in January 2013 of an expert review on making the values of ecosystem services visible. The objectives were to analyze actions and suggest methods and measures to better evaluate ecosystem services and to improve the knowledge base of the societal value of ecosystem services, as well as to propose measures that will mainstream the importance of biodiversity and the value of ecosystem services, so that they can become better integrated into economic positions and other decisions in society where this is relevant and reasonable.

The findings and recommendations were presented to the Swedish Minister of the Environment in October 2013 (SOU 2013). The Inquiry concluded that inclusion of ecosystem services in social planning and business development is becoming increasingly urgent with the on-going loss of biodiversity. They found that measuring the value of ecosystem services in monetary terms can sometimes help make them visible and ensure that the benefits of biodiversity and ecosystem services are effectively taken into account in decision making. However, they also stressed that monetary valuation is less reliable or even inappropriate in complex situations that involve a variety of ecosystem services, or where there are different ethical convictions regarding what values are possible or appropriate to express in monetary terms.

Based on these findings, and other work, in March 2014 the Swedish government presented a Bill to the Parliament with a Swedish strategy for biodiversity and ecosystem services. The Bill highlighted giving visibility to, and including the value of, ecosystem services in regional and municipal spatial planning and business development. The Bill presented results of work on strengthening biodiver¬sity and securing ecosystem services such as water purification, production of food and fibers, and recreation and outdoor activities. The Bill also presented five new national milestone targets in the environmental objectives system to strengthen efforts to protect nature and develop sustainable forestry.

Significant efforts are also being made in Sweden to recognize, demonstrate and capture values of biodiversity and ecosystem services in national policy. The Swedish Environment Protection Agency, for example, has published overviews related to ecosystem services in Sweden, both in general and relating to particular ecosystems including forests and the Baltic Sea. The Government has assigned the Agency to develop a communication strategy for ecosystem services, directed at actors who in turn can inform others. Statistics Sweden is improving national statistics and environmental accounts, both at the national and international level, including publication of an inventory of data sources for quantification of ecosystem services (Statistics Sweden 2013). Significant efforts on using the ecosystem services approach are also taking place at the regional and municipal levels, including in the City of Stockholm, and efforts are also made to better include ecosystem services in environmental impact assessments and planning processes.

3.5.4. TEEB initiatives in the region and the TEEB Arctic Scoping Study: looking forward

The TEEB Arctic Scoping Study will provide Arctic governments with a valuable first overview of the benefits and values associated with Arctic ecosystems. The study will also provide important perspectives on how the Arctic is valued, both in monetary terms and in other ways. This may help individual countries, as well as the Arctic Council, in finding effective ways to enhance understanding of what the Arctic means to the people who live there, and to the world.

However, ecosystem services is still relatively new as a concept and approach, and there is limited experience with using it at the national level. We also know that valuation, in particular monetary valuation, is a complex and challenging area. Governments also recognize that Arctic Indigenous Peoples have strong viewpoints on this, and it is critical that we understand and acknowledge such critical views.

TEEB acknowledges the plurality of values that people hold for nature, and this was also highlighted by, for example, the Swedish and Norwegian expert commissions on values of ecosystem services. It is also widely acknowledged that the challenges relating to economic valuation are considerable, and it is important to see how qualitative and/or quantitative descriptions in many contexts may give decision-makers better and more relevant information.

There is also a need to recognize that valuation of ecosystem services involves a certain degree of subjectivity because of the social and cultural context. This is in particular the case for cultural services and for intangible values. Changes in ecosystems will, in most cases, interact with changes in socio-cultural systems. It is therefore important to include awareness in valuation exercises, and the use of their results, that values assigned at one point in time and in one specific context reflect how certain people perceive their natural environment, and their relationship to it in that specific setting (Sukhdev et al. 2014).

Berry picking in Scandinavia. Photo: Tamara Kulikova

3.6.   Ecosystem services in Arctic oil and gas development: An industry perspective

(By IPIECA - the global oil and gas industry association for environmental and social issues)

As the oil and gas industry moves into the frontier Arctic environment, extensive infrastructure will be built in ecologically sensitive areas. Since productivity in polar ecosystems is limited to a short season, these ecosystems may take a particularly long time to recover from potential disturbance. In more remote polar habitats, disposal of waste products, chemicals, cuttings and mud can be particularly challenging.

The need to identify and appropriately manage ecosystem service impacts and dependencies is therefore very important, and the International Association of Oil and Gas Producers (IPIECA) recently developed and launched guidelines and checklists to support such efforts. The guidelines follow the ecosystem service classification presented in the Millennium Ecosystem Assessment and include provisioning, regulating and cultural services. Arctic Indigenous Peoples place a high value on the livelihood and spiritual importance of many ecosystem services, and seek to maintain their traditional ways of life and use of natural resources.

In the publication Ecosystem services guidance (IPIECA 2011) four key advantages are listed for adopting an ecosystem services approach in oil and gas developments:

1. **Understanding human values and livelihoods**

   Assessing ecosystem services provides a better understanding of how people interact with, benefit from, and value the environment. This may be in terms of nature providing products, services, incomes and livelihoods.

2. **Evaluating trade-offs**

   By having a better understanding of the importance to various stakeholders of different environmental features and activities, more informed decisions can be made about development options with alternative outcomes and implications.

3. **Assessing dependencies**

   The approach brings an added dimension through highlighting the ecosystem dependencies that oil and gas operations have on the environment that are often overlooked. As ecosystems decline, so too will the services nature provides that oil and gas companies depend upon (e.g., water), thus presenting additional risks.

4. **Identifying impacts that may otherwise be missed**

   The ecosystem services approach can help identify a more complete spectrum of impacts (including higher order impacts) that may otherwise not be considered, and thus help to avoid or mitigate them at the outset. This is particularly the case for provisioning services occurring offsite (e.g., fisheries) and some regulating services (e.g., impacts to habitats that provide erosion control, water filtration and flood control). In addition, the supply/demand component of the ecosystem services approach necessitates the consideration of cumulative dependencies and impacts that may be overlooked using more traditional methods.

The guidance document suggests to industry to consider ecosystem services in a four-step process and provides checklists with biome-specific examples of key ecosystem services to consider at each stage of a petroleum activity project's life cycle (Table 3.1). These steps cover identifying the potentially significant ecosystem service dependencies and impacts associated with relevant oil and gas sub-activities and issues, and identifying risks and opportunities that relate to these dependencies and impacts. Finally, the process considers implementation measures and measures for mitigating risk and for enhancing opportunity.

Types of impacts and dependencies will vary across the different stages of oil and gas development, ranging from seismic surveys through exploratory drilling to construction, production and decommissioning. Table 3.1 gives a sample checklist for identifying dependencies and impacts on ecosystem services during the seismic surveying stage in the polar biome. The guide highlights that these checklists are not exhaustive and that they represent a starting point covering some of the more common examples.

Table 3.1. Example of a checklist for seismic surveying, from the IPIECA ecosystem services guidelines and checklists

Sub-activity/ issue	Potential environmental and biodiversity impact / change	Dependencies on ecosystem services			Impacts on ecosystem services		
		Provisioning	Regulating	Cultural	Provisioning	Regulating	Cultural
Offshore							
Vessels: Mobilization, operation and general presence	Noise and light. Physical presence of ships leading to disturbance to fauna. Visual presence. Alien-invasive species associated with water and sediment ballast				Possible reduction in artisanal or commercial fisheries and fish or shellfish for consumption. Possible impacts on fisheries due to disturbance and alien-invasive species.		Visual impacts to communities, tourism and recreation.
Exclusion zones: Temporary exclusion of boats from a defined area	Reduced human access to an area. Protection of habitats and species (e.g. reduced fishing effort).				Temporary reduction in local people's ability to fish (restricted access to fishing grounds and/or landing sites); perceived impacts in particular. Potential increase in key species due to protection from overuse.		Temporary loss of access to cultural, livelihood and recreation features. Protection of habitats and species from misuse and overuse by people.
Seismic shooting: At the sea surface	Noise impacts to marine mammals / benthic fauna from acoustic blasts. Physical effects from streamers				Possible reduction in artisanal or commercial fisheries and fish or shellfish for consumption. Possible negative impacts on fisheries due to disturbance and alieninvasive species.		Disturbance (visual, auditory and physical) of iconic species (e.g. whales, seals, otters).

3.7. Ecosystem services and Arctic tourism

(By M. Geitz)

Tourism, the activity of traveling to a place for pleasure, has a relatively long history in the Arctic. People from outside the region have been drawn North since the early 1800s (Huntington et al. 2013a). Both the range and scope of Arctic travel has expanded considerably since then, especially in the past decades in which technology, political changes and climate change have opened up areas that were previously very difficult to access. The general increase in international tourism has also pushed more experienced travelers to new and more exotic destinations like the Arctic.

Arctic tourism covers everything from solo kayak or walking trips to cruise ships with several thousand passengers – all making their way north to experience some or all of the unique Arctic features so exotic for 'outsiders': vast wilderness and breath-taking scenery, charismatic species – both small and large, indigenous cultures, dramatic history and unusual culinary experiences. The majority of efforts undertaken to govern, regulate and guide Arctic tourism are aimed at managing its impact on Arctic ecosystem services (Box 3.5).

But governing Arctic tourism isn't an easy task. The diversity of tourism, activities, actors and tools makes it hard to define its scope and limits. Tourism in the Arctic developed gradually and often has exploratory elements. Therefore, it has a history of being governed retroactively rather than proactively. This fact and the profound diversity of actors, ranging from international tourism companies from the South to small-scale local outfitters, leads to the situation that the governance and policy framework for Arctic tourism activities is often diverse or fragmented, or sometimes simply non-existent.

The Arctic tourism industry is, by and large, dependent on well-functioning social-ecological systems, and, thus, businesses have an in-built incentive to do as little damage as possible. In addition to self-interest, the customers, local communities and authorities have become more aware of the potential of tourism to have negative impacts, and expect more from a tour operator than they did a few decades ago. Tour operators have reacted to increased interest and scrutiny for social and environmental accountability not only by making sure their marketing material addresses those aspects, but also with self-regulating measures. At the same time, communities and local authorities have taken a more active interest in governing tourism, both with regard to benefit-sharing, which provides local income, and in the form of fees for deriving benefit from local ecosystem services.

The following examples of self-governance around tourism operations have the potential to incorporate an ecosystem services perspective:

▶ Certification schemes are well known for food, timber and other consumer products, but become a more complex issue when a service product or business has both nature and culture as the key ingredients. Transparency, independent verification and accountability are important criteria for credible programs. Currently, there are at least three tourism certification programs in Arctic countries and for affiliated operators working within the Arctic that focus on ecotourism/sustainable tourism: Nature's Best (Sweden), Ecotourism Norway (Norway), and Adventure Green Alaska (US).

▶ The Association of Arctic Expedition Cruise Operators (AECO) was founded in 2004 as a response to intentions by the Norwegian government to better manage cruise tourism activities in the Svalbard Archipelago. Since then, the organization has expanded both its guidelines and its geographical range (now including also Jan Mayen, Greenland, Arctic Canada and the 'Russian Arctic' National Park). Members of the industry group confirm that they "*operate in accordance with national and international laws and regulations and agreed upon Bylaws. Members have, in addition, agreed to follow an extensive set of guidelines, developed by AECO, to ensure operations are in accordance with the group's objectives, including operational guidelines, wildlife guidelines, a number of site-specific guidelines and guidelines for visitors to the Arctic*".[6] The guidelines contain a mix of standards that are based on legal requirements, best practices, common sense and voluntary minimum standards. Practices and voluntary standards are usually not verified in any way other than through self-monitoring and through publication and customer control.

▶ The Svalbard Environmental Protection Fund is a public fund that was established in 2007 by the Norwegian Ministry of Environment "*to be used to the best effect for Svalbard's environment" and to "contribute to secure Svalbard's special wilderness as the basis for experience, knowledge and value added*"[7]. The fund, which is first and foremost financed by a visitor fee applicable to all non-resident visitors to the archipelago, provides money for environmental measures that assess, detect, monitor or restore environmental degradation; and support the preservation, maintenance and study of cultural heritage, information, education and accessibility measures. In 2014 the fund allocated more than 12 million NOK, significantly contributing to the knowledge base for local ecosystem-based management. Taking on an explicit ecosystem services lens through TEEB could considerably advance the inclusion of natural capital in local policies and could help with decision making and transparency of funding allocation by, for example, funding management, conservation or restoration projects.

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6   http://www.aeco.no/membership/ accessed Nov 7 2014
7   http://lovdata.no/dokument/SF/forskrift/2007-04-30-599 accessed Nov 7, 2014

Box 3.5. Tourism as a cultural ecosystem service

The ecosystem services that underpin tourism and motivate tourism development in the Arctic come from all ecosystem service categories, adding up to a distinct cultural service mostly referred to as 'recreation' or 'ecotourism,' whose beneficiaries are spread across geographies and scales (local to global; private households and businesses to governments).

Cultural services are "the result of ecosystem processes and functions that inform human physiological, psychological and spiritual well-being, knowledge and creativity. Cultural services are tightly bound to human values and behaviour, as well as to human institutions and patterns of social, economic, and political organization. Thus perceptions of cultural services are more likely to differ among individuals and communities than, say, perceptions of the importance of food production" (Preston et al. n.d., adapted from MA 2005).

3.8.   Challenges and limitations for the governance of Arctic ecosystem services

The following section provides an overview of challenges and limitations for the governance of Arctic ecosystem services. It does not strive to discuss all possible issues, but is structured into topics that are relevant for the region and its stakeholders in the context of a TEEB approach. The issues discussed also provide important background information for the findings of this scoping study, and for recommended options for follow-up actions, including by the Arctic Council. While elements of all critical views presented are discussed in the relevant scientific literature, some offer perspectives important for Arctic Indigenous Peoples, while others concern the scientific, managerial or economic communities in Arctic countries.

3.8.1. Holistic world views

Not all aspects of human interactions with nature can be captured through an ecosystem services approach. In the Arctic, specifically, Indigenous Peoples' holistic world views are at odds with the notion that the value of elements of this world can be recognized or captured in isolation, let alone be traded off against each other. Within Indigenous world views, policies and governance have often succeeded in sustaining viable human–nature interaction through means other than by explicitly recognizing ecosystem services framed in such terms. While it is clear that Arctic Indigenous Peoples' traditions and world views inform the principles of governing for sustainability, a practical challenge for improving governance in the Arctic with help of the ecosystem services concept lies in clarifying the interface, synergies and limits of this approach in relation to Indigenous understanding of human–nature relationships. TEEB, with its claim to advocate for the best available estimate of value for a given context and purpose (Sukhdev et al. 2014), may be able to contribute to such much-needed clarification.

"Arctic peoples […] traditionally view themselves as part of a system that is structured by a web of mutual relationships and obligations, not one defined by a one-way flow with humans as the ultimate beneficiaries […]. If this is true, then perhaps we should not impose comparative valuations on these places, implying that trade-offs in terms of potential land uses have no moral content. Or at least making final decisions on land use should not be based solely on measurement-based information. Linking indigenous knowledge with scientific knowledge in different assessments in the Arctic is developing […]. However, the difficulties of conveying the millennia-old relationships that the Indigenous Peoples have with their homelands should be recognized. Recent studies from remote Chukchi subsistence communities from north-eastern Siberia indicate that the indigenous sense of place is multidimensional and hard to document or capture using scientific quantitative terminologies or paradigms […]. Care should be taken when applying scientific values or measurements to places which may be very different in character."

(Arctic Biodiversity Assessment, Huntington et al. 2013a, Box 18.1)

3.8.2. Knowledge gaps

A general constraint for all decision making that considers Arctic ecosystem services is the lack of comprehensive availability of knowledge and understanding (referred to as information in an economic context).

Current scientific understanding does not fit neatly into the ecosystem service framework – to date very little ecological research has been conducted within such a framework (Norgaard 2010). Ecology provides knowledge related to population dynamics, food webs, energy flows, biogeochemical cycles, spatial organization across landscapes, and co-evolutionary processes, among others, and for the most part does not address human well-being. Similarly, most of the research on human behavior and social systems does not connect to the ecosystem services or to how social systems drive ecosystems. Today's insight into ecology does not have sufficient predictive capacity to identify the sustainable use of any particular ecosystem

service, or to describe the trade-offs between uses of ecosystem services (Carpenter et al. 2006; Palmer and Filoso 2009) in support of the application of the concept. Viewed the other way around, the ecosystem services concept does not consider already existing complex understanding of social and ecological systems (Norgaard and Baer 2005).

Furthermore, lack of knowledge in two categories is of particular importance.

First, there is an under-representation at national and regional levels of knowledge that describes the non-monetary values Indigenous Peoples and Arctic residents ascribe to Arctic biodiversity and functioning ecosystems (Kettunen et al. 2012). Many ecosystem service values, especially those relating to local benefits, are context specific. Cultural values feature high in this category, but also landscape values, as well as the values of traditional foods for human well-being, culture, health and family economy. For Indigenous Peoples, these value sets overlap and are expressed in Traditional Knowledge and understandings within a context of ecological complexity. Cultural values are consistently recognized but not yet adequately defined or integrated within the ecosystem services framework (Daniel et al. 2012), because the methods that do exist for eliciting less tangible value and characterizing their changes, for example, ethnographic methods in anthropology, are not part of commonly accepted economic frameworks and thus not easily included alongside other services in decision making (Chan et al. 2012a). There are few institutions and there is limited capacity to scope these values and establish their status and trends collaboratively with the people who directly depend on and value these linked bundles of services, and it would require broader interdisciplinary collaboration than is common today. TEEB can facilitate such processes by, for example, organizing collaborations that involve not only environmental economists and Indigenous Peoples, but also social scientists with relevant methodological and cultural experience. In sourcing that information, it will be important to highlight the context of how knowledge is produced. Scientific knowledge and Traditional Knowledge, for example, are produced differently and by different actors. The state of knowledge about, and the values associated with, certain services are related to who produces that knowledge and how that knowledge is produced (Escobar 1998). This is important for understanding ecosystem services themselves, but also for understanding the values surrounding ecosystem services.

"Perhaps most importantly, these analyses underline the vital importance of including valuations of the non-market goods generated by ecosystem services within decisions. The results show that such inclusions radically change the outcome of decision analyses. Indeed, failure to include such values leads to a continuation of errors in resource allocation which arise when decisions are based upon market-priced goods alone." (from UK National Ecosystem Assessment (NEA 2011)

A second concern is associated with biophysical values that relate to the capacity of ecosystems to continue providing ecosystem services. Loss of biodiversity or degradation of an ecosystem often does not translate directly or immediately into loss of services. Limited information is available to assess the status and trends of biophysical values in Arctic ecosystems, as well as their functions and the associated biodiversity (Kettunen et al. 2012). Such information exists in the Arctic from a limited number of places and case studies only, and, despite the effort of the Arctic Biodiversity Assessment and monitoring initiated by the Circumpolar Biodiversity Monitoring Program, an inventory of Arctic natural capital and the ability to assess status and trends in a spatially comprehensive fashion is far from complete. Remote sensing and biophysical modeling exercises help to synthesize information, detect trends and prioritize research needs, but should be used with care in assessments as their accuracy is often constrained by sparse data sets (models) or limited capacity to infer causal relationships (remote sensing). The matter is further complicated by a generally short time span of observations in combination with a shifting baseline, due to the impacts of climate change and substantial natural variability. This knowledge gap is particularly significant in Arctic marine ecosystems. Given the limited understanding of Arctic ecosystems and the scale of the anticipated changes, the application of indicators per se for assessing ecosystem status is debated among ecosystem scientists. Scrutinizing existing and emerging Arctic monitoring schemes for their ability to detect changes in the flow of important ecosystem services may be a valuable first step.

It is therefore difficult to relate observed changes in particular ecosystem services to the wider status of natural capital. As a consequence, thresholds may be reached unrecognized, particularly where single species yields are used as indicators for the status of natural capital, as is often the case in fisheries. The situation also hampers establishment of policies for more pro-active management of ecosystems using an ecosystem services approach. Assessment tools are available, however, to do so with the help of existing information (Christie and Sommerkorn 2012).

Issues such as these hamper the understanding of important Arctic ecosystem services. They may in fact constitute a substantial information imbalance for the region in which mixed economies remain important and cultural values are an important context for biodiversity conservation. Without adequate mechanisms for sourcing all relevant information in context and through appropriate institutions, integration of ecosystem services into economic policies and practices may perpetuate past inequalities (Pascual et al. 2010).

"As the ecosystem service declines (…), less people have access to its benefits; the people with less access begin to care less or know less about the service. More education on the values of the ecosystem service is important during times when the resource is limited so that difficult stewardship decisions are made and supported." (TEEB questionnaire input)

"For subsistence harvesting I think there is already a great appreciation of the value at the local level, but this needs to be extended to the regional, state and federal decision-makers. It is a matter of effectively communicating this value to 'outsiders' or decision-makers." (TEEB questionnaire input)

"A good and transparent information flow and exchange between researchers, policy-makers and stakeholders would do a lot for improving nature stewardship." (TEEB questionnaire input)

3.8.3. Limited future outlook

Another important constraint of the present scoping exercise stems from the fact that the ecosystem services for which the policy and governance context are elucidated here only capture the benefits of nature at one point in time – today – and do not consider changing ecosystems or future societal needs, or any as yet unknown or uncertain long-term consequences of current policies on biodiversity and ecosystems. Future generations cannot make decisions that affect today's markets, the behavior of people today, and they are not available to answer valuation questionnaires (Howarth and Norgaard 1992). In other words, scoping for Arctic ecosystem services only relates to currently available value information on nature. This is not only an issue for advancing sustainability at large, but becomes an especially problematic limitation in light of the rapid environmental and social changes occurring in the Arctic, where society has to prepare for the unknown and thus for ensuring that capacity is adequate to adapt to the changes and transform where necessary.

Natural capital is an essential aspect of that adaptive and transformative capacity (along with social capital, human capital, knowledge assets, financial capital, infrastructure and cultural capital) (Kofinas et al. 2013). In using economic approaches, such as TEEB, to contribute to governing for the resilience of the Arctic, it is therefore necessary to include some type of insurance premium that can safeguard ecosystem services that may not appear as essential for human well-being in the present, but may become essential in the future (Admiraal et al. 2013). Decisions about how much to invest in insurance remain challenging and also depend on how we perceive risk, rather than depending on valuation of the ecosystems services as such. In general, the larger the uncertainty and the potential costs associated with risks, the greater the need for insurance.

Such economic policies or governance instruments exist in theory (Brock and Xepapadeas 2002), but are not in place today. The current exercise, therefore, leaves unaddressed fundamental aspects of the major societal and economic challenge of the 21st century, namely how to pro-actively manage to assure the provision of Arctic ecosystem services in a rapidly changing future and across spatial scales – also known as sustainable use of ecosystems (Fisher et al. 2008; Perrings et al. 2009) or managing for resilience (Folke et al. 2010). It also points to a need to analyze the potential and the limitations of TEEB in relation to the advantages and disadvantages of other decision-making frameworks. The Arctic Council has initiated projects such as the Adaptation Actions for a Changing Arctic (Arctic Council 2014) and the Arctic Resilience Report (Arctic Council 2013c) that explore some of these important aspects of introducing the concept of ecosystem services into governance. However, as of the time of writing, they lack dedicated involvement of environmental economists.

3.8.4. Concerns about commodification and marketization of nature

The public and scientific debate on integration of ecosystem services into **economic** policies and governance practices through TEEB points at implementation challenges due to, for example, ecological complexity; ethical considerations, including the adoption of economic rationales for environmental policy making; and short termism (Robertson 2004; Ernstson and Sörlin 2013; Sukhdev et al. 2014). Issues with information availability (as discussed above and including the lack of communication across scientific disciplines and knowledge traditions), commensurability (comparability of values measured in different ways) and the shortcomings of established economic practices for mainstreaming non-use ecosystem services into national economies are contributing to the debate about reform of the current economic model to address the challenges of the Anthropocene. Regarding the issue of value (in) commensurability, money metrics are deemed of limited use for capturing socio-cultural values attached to cultural ecosystem services, especially among Arctic Indigenous cultures for whom many different ecosystem services are intertwined with practical experience (Chan et al. 2012b). TEEB stresses the validity of alternative valuation languages and participatory processes in ecosystem services valuation and that economic concepts and monetary language need not exclude other value dimensions (TEEB – The Economics of Ecosystems and Biodiversity 2010a). However, due to its tangibility and seemingly easy usability, there is a risk that monetary valuation will trump other value dimensions in practice. This risk could increase if it becomes the dominant language actually employed for discussing ecosystems, and if other value dimensions must be expressed in monetary terms (Jax et al. 2013).

"The practical, methodological and theoretical challenges relating to valuation are considerable. The knowledge base and experience are limited". (TEEB questionnaire input)

"Despite the development of "green economics", the mainstream economic concepts utilized in most private and public venues are quite simply unequipped to grasp most dimensions of value (e.g. biological, aesthetic, ethical, religious), especially the most important ones (e.g. life vs. death, health vs. illness)" (TEEB questionnaire input)

The majority of benefits provided by nature are not adequately integrated into national accounting systems or captured by existing macro-economic indicators (e.g., Gross Domestic Product – GDP), despite the important role they play in supporting well-being and continued development. Moreover, current valuation methods only help to make visible the ecosystem services from within an economy that we have, rather than the economy we are trying to attain. Making ecosystem services a useful concept for correcting market inefficiencies caused by lack of attention to ecosystem values would therefore require major institutional changes at national and global level (Nowotny et al. 2001); (Norgaard 2010). These issues highlight the need for public information and debate (NOU 2013) to shape and create acceptance for adequate and useful economic practices that allow TEEB to be used as a systematic approach to mainstream the values of Arctic ecosystem services into economic decision making.

3.8.5. Looking ahead

Despite these limitations and challenges, consideration of ecosystem services has significant potential to lead to more coherent understanding of the benefits people receive from nature, and improve the governance of human-nature interactions. TEEB acknowledges the valid concerns for a commodification of nature but argues that essential ecosystem services are already being 'traded', but sometimes for an implicit price of zero (Costanza et al. 2012). TEEB offers a model for communicating to decision-makers in economic terms and a toolkit for evaluating and integrating stewardship into their decisions. TEEB's message – that the importance of, the scarcity of, and the wide range of benefits from ecosystem services must be communicated to private and public decision-makers by means of laws, regulations, financial incentives and other policy instruments – provides the motivation and framework for scoping the benefits of integrating ecosystem services into suitable policy instruments that govern the management of Arctic nature, or of the human activities affecting Arctic nature.

Oil and gas operations. Photo: Jack Dagley Photography/Shutterstock.com

Chapter 4. Valuing ecosystem services in the Arctic

Authors: Å. Gren, J. Eamer and T. Patterson

4.1. Introduction

This section is an overview of concepts and techniques for valuing ecosystem services in the context of the Arctic. Valuation methods suitable for raising the profile of specific ecosystem services would be addressed in a TEEB Arctic study (see Chapter 7 'The way forward').

The purpose of taking an ecosystem services approach (in this preliminary assessment and within TEEB more broadly) is to account for the importance of life support, security, and benefits to well-being that humans depend on from healthy ecosystems. This is achieved by using a suite of methods from Traditional Knowledge, natural sciences and social sciences, including economics. An assessment of ecosystem services can support and inform a range of decision-making processes (Preston et al. n.d.). The ecosystem services link is crucial when striving for sustainable management of complex social-ecological systems (Folke et al. 2011), and valuation in this context can provide powerful information for better understanding trade-offs and for evaluating alternative management strategies (NRC 2004; TEEB – The Economics of Ecosystems and Biodiversity 2010b, 2011b, 2012).

With an array of new opportunities and challenges opening up in the Arctic, the need for sustainable management strategies is pressing. Identifying, characterizing and assessing the social, cultural and economic values of change in social-ecological systems can greatly assist in this endeavor. Although there are some economic assessments of the impacts of climate change in the Arctic in the context of economic activity, infrastructure and sustainability (e.g., Anisimov et al. 2007; Larsen et al. 2008), there is a need for cohesive, integrated and commonly accepted frameworks for assessing the values of Arctic ecosystems in the pursuit of sustainable management strategies (Díaz et al. 2015a).

Information contributing to a TEEB approach to Arctic ecosystems is designed to help decision-makers recognize, demonstrate and, where appropriate, capture (via regulation, taxes, subsidies, innovative finance or supporting emerging markets) the values of Arctic ecosystems and biodiversity. Any effective, equitable and sustainable policy must account for a diversity of perspectives and encompass a diversity of value systems and knowledge systems.

A resilient policy strategy will both identify a diverse suite of available policy actions and interventions and also cultivate means by which diverse audiences can participate in articulating the associated trade-offs in the present and future. Thus, the first step toward identifying, eliciting and documenting the plurality of values (both monetary and non-monetary, use and non-use) for Arctic biodiversity and ecosystems is the first step toward identifying the broadest range of possible policy actions and interventions.

This section includes input from expert consultation (through the online questionnaire, see 1.6.1) on how to value ecosystem services in the Arctic both, as content in the main text and summarized in Box 4.1. Feedback was solicited in order to articulate approaches that would improve decision-support and policy, in particular in cases where Arctic ecosystem services are providing high values to humans in ways that have not been adequately taken into account by decision-makers.

The questionnaire responses, along with feedback from the project review through Arctic Council and discussion at the project workshop, made clear the variety of viewpoints involved, underscoring several challenges for efforts to introduce an ecosystem services approach into policy and management. Many of these are well-known challenges that are examined in the body of academic literature related to ecosystem services: assessment of cultural and spiritual aspects, existence values, functional values, representation of supporting services derived from diverse ecosystems, and how values change over time. These challenges take on special significance given the tight linkage between Arctic people and their environment. More broadly, this scoping study has initiated a dialogue between Arctic experts and experts on ecosystem service valuation. This conversation continues to shed important light on topics that challenge all who work in the field of natural resource management in the Arctic, whether or not they work directly with ecosystem service concepts or valuation.

Box 4.1 Summary of questionnaire input on valuing ecosystem services

The online questionnaire asked for guidance on ways of recognizing the value of ecosystem services, including methods that assign a monetary value and other approaches, with a focus on relevance to the Arctic. The 60 respondents included people involved with research, public policy, Arctic economic sectors, indigenous organizations and NGOs (see Section 1.6.1, footnote).

A theme running through many responses was the need for systematic approaches to ecosystem services valuation. Frameworks are needed to move away from "*ad hoc lists of issues and concerns in narrowly defined geographies and with little attention to linkages…. We need to come up with some common agreement on a fundamental framework that policy or decision-makers, researchers, developers and community members can use and refine.*"

Several respondents urged a broader look at the values of Arctic nature in relation to current economic policy, pointing out the "*dangers in applying an economic narrative to nature instead of working to apply a natural or ecological narrative to the economy.*" Responses also included ways to improve economic policy: applying the triple bottom line approach (social, ecological and financial), evaluating how taxes and royalties would be assessed if they were to reflect the true environmental costs, and cultivating longer-term views. "*Unspoilt nature can be a long-term renewable resource, but will (almost) never yield quick profits.*"

Some points and suggestions from respondents:

▶ **Raise awareness of the values of nature** by "*describing how we as individuals and societies relate to ecosystem processes, and how these interactions affect everyday lives and concerns. Important to be concrete rather than referring to abstract concepts such as culture.*" "*Just listing ecosystem services serves a useful purpose in making sure we are aware of what we have already, before risking degradation through industrial activity.*" "*Our experience is that increasing awareness has a substantial effect upon people's valuation.*"

▶ **The values of wild foods tend to be neglected or underestimated**. Replacement values can be used to put equivalent dollar figures on fish and meat that is not bought and sold. But this really underestimates the true value because it does not include the social and cultural values.

▶ **Put a focus on human well-being**. Finland, for example, is testing ways to measure the physical, psychological and social well-being benefits of nature to park visitors. Two other ideas were to use measures of well-being (happiness and health) of Northerners in relation to 'traditional' versus 'modern' ways of life, and to encourage discussion of ethical values.

▶ **"Ask local people."** Involve the people whose cultural practices and systems of valuing nature are being assessed when developing the methods and criteria for evaluation – as "*the evaluation process is the tool of power here.*"

▶ **Develop or promote methods appropriate for the Arctic**. Show the importance of ecosystem services in units other than money: for example, percent of households serving more than 75% of protein from wild meat. But, "*we need methods that are non-numerical as well as non-monetary. Visual, narrative, participatory and open-ended research methods hold promise.*"

4.2. Economic values

Valuing ecosystem services is a task that must integrate ecosystem and social sciences and must deal with multiple and often conflicting value dimensions (Martinez-Alier et al. 1998; Chan et al. 2012b, 2012a; Martín-López et al. 2014). Certain values simply cannot be measured in the same units (they are incommensurable). Monetary estimates should therefore clearly distinguish which dimensions they do and do not cover. Combined methodologies are sometimes needed to address multiple services and perspectives (Boyer and Polasky 2004; Costanza et al. 2006; Escobedo et al. 2011).

The usefulness of estimating economic values for ecosystem services lies in their contribution to making informed trade-offs. These values are always relative (as opposed to absolute) because they depend on the context. If the context changes, the value changes. Values can be measured in a variety of units, depending on the context and goal of the valuation exercise (e.g., dollars, tonnes per hectare, a measure of noise produced per unit area). Values can also be expressed as a score or an index. For example, Beier et al. (2009) proposed a value score that assimilates three forms of data collected about various sites in Alaska, with data proxies selected to represent ecosystem service supply, use and disturbance.

Economic values, therefore, should not be confused with monetary values. Economic values may be measured and compared using a monetary unit as the common point of reference, but they do not have to be. Monetary valuation is often cited and

used to emphasize the importance of a set of ecosystem services, but monetary methods are not always appropriate (e.g., Goméz-Baggethun et al. 2013; NOU 2013), particularly when ecosystems are approaching critical, irreversible, or high-cost thresholds (Pascual et al. 2010).

In some cases, economic valuation, irrespective of unit of measurement, is neither appropriate nor needed. Key policy issues may not require economic valuations to be performed when identification and articulation of the relevant ecosystem services is sufficient to support the policy question at hand. Methods of valuation based in other social science disciplines also generate both quantitative and qualitative accounts of how people benefit from ecosystem services and the significance of those benefits. In combination, these approaches inform decision making on alternative management strategies. But valuation is not an end in itself. The policy-related goal should determine the selection of the valuation methodology. Two important considerations for design of valuation studies are presented in Box 4.2.

Box 4.2. Considerations for design of valuation studies

Marginal values tend to be more meaningful and less open to interpretation than total values

Valuation should always be policy focused, avoiding doing valuation for the sake of valuation. Scenario planning is a useful tool to generate policy relevance. Assessments focus on marginal changes in ecosystem services between different scenarios (as opposed to attempting to estimate total service provisioning for each ecosystem service.) Usually one scenario will be the 'business as usual' or 'do nothing' which extrapolates the status quo into the future.

Distributional effects should always be considered

Economic valuation almost always entails value effects for different groups of people, including values for different generations. For considerations of social or intergenerational justice it is important to spell out these distributional effects. A key advantage of looking at the human–nature relationship through the ecosystem service lens is that it allows for a careful consideration of how benefits from nature are distributed among different stakeholders or groups in society. Consideration of distributional effects is needed to meet equity goals and to guard against unintended negative consequences for vulnerable members of society.

(adapted from the Guidance Manual for TEEB Country Studies, TEEB – The Economics of Ecosystems and Biodiversity 2013)

4.2.1. Ways to attribute value

This literature survey of valuation of ecosystem services is intended to assist multiple actors in diversifying approaches to assessing or attributing value in the Arctic. The survey is arranged by types of values, including monetary, biophysical, insurance, health and especially socio-cultural values held by indigenous communities and other Arctic communities. We place special emphasis on cultural and indigenous values. Box 4.5 discusses the value of TEEB for the business sector.

4.2.1.1. Monetary values

Monetary values are often used when a common denominator is needed in a policy context to help describe a trade-off. The method used to assign a monetary value often has to do with the ease by which a given good or service can be described and how easy it is to survey a particular human population's assessment of that value. When a population cannot be directly surveyed (due to cost or access limitations), data to estimate those values can be used – but this is subject to many constraints. Methods (reviewed in Barton et al. 2012) include:

- ▶ Hedonic pricing, in which the impact of environmental quality attributes on prices is distinguished from other factors that affect prices. For example, a natural scenic view or proximity to a nature reserve might raise the price of a house. This method looks at revealed preferences (preferences shown through people's choices, as opposed to preferences that people state).
- ▶ Travel cost, which infers the value people assign to visiting a nature area or engaging in a recreational activity such as fishing. Travel cost can be estimated based on the related costs people will pay for the experience (another revealed preferences method).
- ▶ Choice experiments, also known as 'stated preference' method, involve analyzing the values on which people make decisions.
- ▶ Contingent valuation, a stated preference-based valuation method, is based on surveys that ask how much respondents would be willing to pay for specific benefits.
- ▶ Production function/damage cost and the replacement cost method: A production function is used to estimate how much an ecosystem service (especially regulating services like flood protection) contributes to another service or commodity that has a market value.

The end goal (and its context) strongly influences which valuation method is most appropriate, or if alternative valuation approaches are more appropriate. An example of an alternative valuation approach is observing and documenting information related to traditional markets for ecosystem services, where they exist. As different valuation methods all have their pros and cons, it may ultimately be necessary to identify a rank ordering, based on a predefined criteria list and adapted to the specific context, from the least to most preferred valuation methods for different services, to avoid double counting and enhance data comparability. De Groot et al. (2002) provide a useful starting point for such considerations.

Examples of monetary valuation

For many examples of monetary valuation of ecosystem services, what is being valued is the cost of irreversible damage or damage that is only reversible at prohibitive costs. This type of monetary valuation can provide a powerful argument for taking a precautionary approach to avoid the damage and the cost of the damage, either by taking measures to reduce the risk of other damaging events (as in the oil spills example), or by making the argument for changes in current policy by showing the costs of the consequences of a 'business as usual' approach (as in the climate change example). It is often difficult to capture, through economic valuation, situations where biodiversity and ecosystems may approach critical thresholds – not least of all because we typically do not know where the threshold is until we cross it. TEEB approaches are well suited to proactive policy development: using economic valuation of ecosystem services to influence policy before the thresholds have been crossed and the damage has been done, as in the example below on marine protected areas.

Example 1: Oil spills – Costs of clean-up and values of environmental loss

The Arctic is not a well-studied area in the context of oil spills, despite important ecosystem services at risk (OECD/IEA 2008; CAFF 2010). While the existing literature on oil spills does not take an ecosystem services approach (Hasselström et al. 2013), dollar values derived from estimating the cost from the Prestige oil spill along the Spanish coast in 2002 show the benefits and drawbacks of using market prices of lost catches in commercial fisheries and other seafood industries, such as fish farming and the fish processing sector, as a basis for valuation. The associated studies also estimated the cost of environmental losses by using reposition costs of birds and mammals and clean-up costs. Methods used included contingent valuation (e.g., Noring et al. n.d.; van Biervliet et al. 2006; Ahtiainen 2007) and choice experiments (e.g., Loureiro et al. 2006; Liu et al. 2009). The response to the 1989 Exxon Valdez oil spill off the Alaskan coast boosted efforts to develop methodologies to capture the value of biodiversity and ecosystems. The economic analysis of the losses incurred was used to assess compensation payments, but it also led to policy changes, including domestic pollution prevention legislation and international maritime regulations (TEEB – The Economics of Ecosystems and Biodiversity 2011a). Due to the sensitivity of ecosystems, increasing human pressure, and inherent natural conditions (such as cold water and harsh weather), the Arctic region and its biodiversity and ecosystems are particularly vulnerable to oil spill damages that may not be represented in existing temperate oil spill valuation studies.

Example 2: Climate change and the social cost of carbon

The frozen Arctic provides substantial services to all nations by cooling Earth. The cryosphere works as an air conditioner for the planet. As the Arctic thaws, this critical, climate-stabilizing ecosystem service is being lost. Euskirchen et al. (2013) quantified global economic effects arising from additional increases in global temperature from losses of sea ice and snow, plus from the methane that is emitted when permafrost thaws. The additional planetary warming caused by these three changes in the Arctic cryosphere was converted into annual CO_2 equivalents in order to calculate the global economic costs of this extra warming. The unit they used, 'the social cost of carbon', is a measure of the value of economic damages from the extra warming arising from emission of 1 tonne of CO2. The global costs imposed by the breakdown of the natural cooling functions of the Arctic were then estimated for 2010, and cumulatively through the years 2050 and 2100. Between 2010 and 2100 the estimates for the annual cumulative cost to society from this extra warming (expressed as a present value) ranged from US\$7.5 trillion to US\$91.3 trillion. The wide range reflects uncertainty about the extent of climate feedbacks, but to a greater degree it reflects uncertainty about the magnitude of economic damage, which in turn depends to a large extent on the discount rate used (i.e., how much future losses are discounted).

Example 3: Ex ante (before the event) ecological economic assessment of marine protected areas designation in the UK

A study commissioned by the UK government presented an estimate of the benefits of the proposed designation of a network of marine conservation zones (MCZs) (Hussain et al. 2010). This ex ante analysis informed the implementation of the proposed UK Marine and Coastal Access Bill. This bill is part of an ambitious plan to designate and manage UK Marine areas using an ecosystems approach. Benefits were measured in terms of anticipated increases in the value of ecosystem goods and services provisioned by MCZs, in comparison to different MCZ network scenarios. The study highlighted 11 ecosystem services and determined for each combination of marine habitat-type/ecosystem service what the impact of a protected area designation would be. The authors considered, for example, the impact of reef protection in terms of climate regulation.

In order to describe ecosystem services in monetary terms, a benefit estimate was carried out using the benefits transfer method, ensuring that the studies used were applicable (ecosystems similar to the UK's temperate marine ecosystems). The

estimates of the present value of these benefits ranged from US$16.4 to US$36.1 billion. The costs were estimated as between US$0.6 and US$1.9 billion. Where monetary values were not appropriate, a qualitative analysis was provided.

This analysis was a significant factor in creating legislation (the formation of the UK Marine and Coastal Access Bill). Using the ecosystem perspective was useful in terms of justifying conservation on economic grounds. It also demonstrated that the cost-benefit ratio of marine conservation in this case was 10:1.

4.2.1.2. Looking beyond monetary valuation

There are many approaches that can help account for complexity in decision-making processes. Preferences can be ranked, for example, without the need to convert everything to a monetary value. Non-monetary valuation can also be achieved through rigorous analysis of data gathered using narrative and descriptive methods employed in other social sciences, such as through interviews, focus groups, social survey questionnaires, and analysis of existing documentation (for example, statements and submissions made in planning hearings or public meetings). Transcripts of ethnographic interviews are especially relevant in the Arctic, as is published ethnography. In some regions, indigenous communities have published accounts of their subsistence practices and associated ways of knowing and experiencing their home ecosystems, and this can also be a rich source of information to support non-monetary valuation. Working with indigenous communities to ensure that such information is appropriately used is an important part of such valuation.

There is a persistent risk that social and cultural attributes of ecosystem services are neglected while the monetized economic benefits and ecological causes of ecosystem service change are over-emphasized, as seen in much research to date (Chan et al. 2012b; Daniel et al. 2012).

Valuing cultural ecosystem services

"Saami culture depends on ecosystem services. In northern Norway, continuous settlement is traced back over 13,000 years, and Saami culture is at least 5,000 years old. Saami ancestors passed down nature and services for us to respect and sustain ourselves. For us and our culture, ecosystem services are of immeasurable value. We see ecosystem services as eternal. In Arctic Council terms it is socioeconomics, but for us it is the basis of life." (Summarized from a presentation by Gunn-Britt Retter, Saami Council, at the project workshop, May 2014, Reykjavik.)

Cultural ecosystem services (Box 4.3) are considered more challenging, less studied and ultimately less likely to be integrated into decision making (de Groot et al. 2002; MA 2005c; Schaich et al. 2010). However, including cultural ecosystem services in valuation efforts is essential for meeting goals of inclusiveness, equity and respect for cultural differences (Eamer et al. 2014); for building awareness of the diversity of ecosystem services; for enhancing ecosystem-based decision making; and for motivating meaningful representation and analysis of how human well-being may change alongside ecological change (Chan et al. 2012b). As such, they warrant special attention in the Arctic context, where social identity and well-being are so closely tied to ecology and landscape, and where rapid change is pervasive.

Box 4.3. Cultural ecosystem services

Cultural ecosystem services are linked to the different kinds of benefits that people receive/depend on from interaction with nature, either individually or at the scale of communities, or even entire cultures.

Types of cultural ecosystem services

- ▶ Cultural identity and heritage
- ▶ Spirituality and religion
- ▶ Knowledge systems and education
- ▶ Cognitive development, psychological and physical health and well-being
- ▶ Aesthetic experience
- ▶ Inspiration for human creative thought and work
- ▶ Recreation, ecotourism
- ▶ Community cohesion
- ▶ Sense of place

(Preston et al., n.d, amended)

Valuing cultural ecosystem services needs to include methods from economics, from anthropology, and from human geography, as each of these disciplines applies a particular set of assumptions about human nature, and these assumptions have a strong influence on the methodologies and interpretations of the results. Novel interdisciplinary partnerships are necessary for valuing cultural ecosystem services, and an Arctic TEEB could serve as a context for establishing these partnerships, for developing or refining methods to gather and express information while respecting the privacy of Indigenous Peoples, and for producing information on cultural ecosystem services.

Cultural values reflect the significance of ecosystem services, as experienced and understood in a cultural context. Values can be researched and reported using a wide range of analytical methods, but in all cases the outcome is an understanding of how, and how much, a given ecosystem service matters to people.

Methods for valuing cultural ecosystem services may include qualitative measures, narration and constructed scales (Satterfield et al. 2013). Narration of local knowledge and of Traditional Knowledge can serve to articulate social and cultural values and bring them into decision making (Gómez-Baggethun et al. 2010). Deliberative processes (Fish et al. 2011), locally defined metrics, and other valuation methods based on qualitative description and narration, help to present these values in ways that make them more visible in decision making.

Mediating or replacing ecosystem services once lost or degraded can be cost-prohibitive or, especially in the case of cultural services, not possible (MA 2005c; Beier et al. 2009; Hernández-Morcillo et al. 2013). Cultural heritage and traditional activities, through long-standing associations with landscapes and ecosystem features, can be crucial to cultural integrity, identity and well-being (Grant Thornton 2008; Burger et al. 2008; Burger 2011; Daniel et al. 2012; Holmes and Jampijinpa 2013; Huntington et al. 2013a). Thus, the risks of neglecting cultural values by inadequate consideration of cultural ecosystem services, the links between cultural and other types of ecosystem services, and the context in which they are framed, are of particular importance to indigenous communities in the Arctic.

Indeed, success or failure in valuing cultural services may be the primary determinant of the success or failure of a broader ecosystem services management strategy (Mascia et al. 2003). Inclusivity is an important feature of an ecosystem service assessment. In particular, space must be made for indigenous perspectives and Traditional Knowledge, as these may differ sharply in world view, value systems and knowledge systems, as compared to the dominant perspectives of many non-indigenous land and resource managers.

"Engaging Indigenous Peoples in this exercise raises a question of language: we speak of life and nature in different terms and vocabulary. Traditional Knowledge holders speak a different language in two aspects: specific language differences, and different terminology. The process of putting value on nature is awkward for us. This may be a question of approaches to communication. How do I explain to the people at home why an approach that puts value on ecosystem services is needed?" (Summarized from a presentation by Gunn-Britt Retter, Saami Council, at the project workshop, May 2014, Reykjavik.)

Cultural ecosystem services represent more than ecological attributes. They encompass complex and dynamic relationships, can cover vast spatial and temporal scales, and can be highly normative (strongly influenced by prevailing values), making them difficult to quantify (Van Berkel and Verburg 2012; Fagerholm et al. 2012; Plieninger et al. 2013). Often, attempts to value cultural ecosystem services in purely economic terms (e.g., Martín-Lopez et al. 2009) (and thus the management actions that result) fail to substantiate the broad and deep meanings and values people hold for them (Chan et al. 2012b).

Cultural ecosystem services are often determined by local cultural values (preferences, principles and precepts upheld by individuals or groups (Chan et al. 2012a)), and this makes them vulnerable to error when using methodologies that use estimates and valuation studies taken from places that might have very different cultural contexts. This presents a substantial challenge to ecosystem service valuation with respect to these services, because developing a reliable assessment of the monetary value for a cultural ecosystem service, or weighing a trade-off, requires the population to be defined – but cultural values are often tacit, or held within a community, or subject to cultural change in ways that cannot easily be documented (Martín-López et al. 2012; Sagie et al. 2013). Thus, a strong focus on cultural ecosystem services should also shed light on differences in perceived trade-offs as articulated by different stakeholders or cultural groups (Fagerholm et al. 2012).

Representatives of Arctic Indigenous Peoples attending the project workshop questioned whether cultural values can or should be captured within an economic framework (Eamer et al. 2014). This concern is also increasingly raised in the expert literature (Chan et al. 2012b). Brosius (2010) argues that cultural values are not amenable to trade-offs in existing analytical frameworks because (1) they are central elements of world views, and so to lose or ignore them is to risk all the basis for meaning and value; (2) they need to be examined discursively before they can be traded off; and (3) cultural values are a function of experience and so difficult to articulate.

Even when provisioning ecosystem services are not in 'high use' (meaning, either not high producing, not easily accessed, or not much used), cultural uses of a landscape, such as for spiritual/religious purposes (Daniel et al. 2012) or tourism (Stynes 2005) have proved persuasive in support of conservation rationales (Sagie et al. 2013). Intuitive, easily understood links to ecosystems may thus be the most effective way to communicate the importance of protecting some ecosystems (Gobster et al. 2007; Orenstein 2013).

Considering multiple values

Multi-Criteria Analysis, among other methods, helps to make sense of multiple values after each has been assigned a relative weight (Munda 2004). As with many monetary valuations, Multi-Criteria Analysis can entail bias and power asymmetries. Transparent deliberative processes can reduce such risks (Gómez-Baggethun and de Groot 2007). Structured Decision Making is designed to deliver insight to decision-makers about how well their objectives may be satisfied by potential alternative courses of action. It helps find 'win-win' solutions across groups, clarifies the irreducible trade-offs, and helps to communicate how people view these various options (www.structureddecisionmaking.org).

Guidance on valuation of ecosystems and biodiversity is also being developed through the IPBES. The IPBES conceptual framework encompasses both **intrinsic values**, which are not related to the benefits humans derived from nature, and anthropocentric values and valuation methods, which are applicable to ecosystem services. Another feature of the work on valuation methodology through IPBES that makes it very relevant to the Arctic is the emphasis on inclusivity of multiple value systems and knowledge systems (Figure A1-1) (Díaz et al. 2015a).

Health values

Parameters such as nature experiences, local identity and natural heritage are tightly linked to human health values. However, the majority of detailed studies on the connection between nature and human health tend to fall within an urban context (see Strife and Downey 2009; Selhub and Logan 2012; Goméz-Baggethun et al. 2013).

Health values are often overlooked in ecosystem services analyses, although research in this field is on the rise (Louv 2012). This topic is linked to food security and to contaminants for the Arctic (see, for example Box 4.4) but encompasses values associated with a broad range of physical and psychological health benefits from nature.

Box 4.4. Reducing the risks to human health from contaminants in the Arctic

The Arctic Monitoring and Assessment Programme (AMAP) working group of Arctic Council is concerned primarily with Arctic contaminant and climate change issues, with a strong connection to human health. The monitoring of biophysical parameters in the context of human health and well-being is highly relevant in an ecosystem service valuation context, whether or not it explicitly applies ecosystem service terminology.

A good example of work through AMAP that is in an ecosystem service value context is the assessment of risks to public health from contaminants deposited in Arctic ecosystems through long-range atmospheric transport. Monitoring and research that started in the 1990s and is ongoing found that the highest Arctic exposures to several persistent organic pollutants (POPs) and mercury are faced by Inuit populations in Greenland and Canada, linked mainly to consumption of marine species as part of traditional diets. Identifying and quantifying the negative human health effects of increased concentrations of contaminants in marine species provided a way to demonstrate the impact on a food provisioning service via the use of biophysical measures linked to human health (AMAP 2003). This work has been, and continues to be, instrumental in achieving international action to reduce POPs and mercury contamination (Fenge and Downie 2003; AMAP 2010b, 2011). Public health issues include both the direct effects of contaminants and indirect effects on health when concern about contaminants in traditional foods leads people to change to a less nutritious diet (Donaldson et al. 2010).

Box 4.5. Business and Valuation of Ecosystem Services

Whether or not a business directly uses natural resources, the current trends in ecosystems will present both challenges and opportunities (MA 2005d). Thus, the ability to factor ecosystem values into business decision making is becoming an increasingly pressing need.

In a business context, a TEEB approach examines the relation of sectors and businesses to their impacts and dependencies on biodiversity and ecosystem services, and looks at policy options that would integrate these impacts and dependencies into private sector functioning. Possible starting points may be the emerging opportunities identified by businesses in the Arctic that have current or potential impacts on biodiversity and ecosystem services. These include increased opportunities for commercial fishing, tourist traffic, and mineral and gas extraction.

Business often has a two-way relationship with nature that can be made clear through a TEEB analysis (TEEB-The Economics of Ecosystems and Biodiversity 2012). A TEEB study sheds light on 1) the external environmental **costs** of products and services that are not included in current prices, and 2) the **dependencies** of production of goods and services on biodiversity and ecosystem services. This type of analysis not only informs public policies and regulations (at national, regional and international levels), but also informs business by helping to foresee risks, particularly reputational and legal risks.

Business risks associated with biodiversity and ecosystem services are often not, or not comprehensively, internalized by businesses. Most do not take into account the entire value chain (TEEB – The Economics of Ecosystems and Biodiversity 2012).

Several entities, including NGOs, business associations and individual companies, have developed tools and materials on ecosystem services for use by business. One tool that helps with conceptualizing TEEB in a business context is the World Business Council of Sustainable Development's guide for Corporate Ecosystem Valuation (CEV) (WBCSD 2011). The CEV is designed to strengthen business performance by considering social benefits, sustaining revenues, reducing costs, revaluing company assets and determining levels of liability and compensation.

4.2.1.3. Biophysical measures and indicators

Biophysical measures help to support assessment of ecosystem performance and productivity (e.g., EEA 1999). Most provisioning and some regulating ecosystem services can be quantified through direct measures, such as tonnes of food per hectare per year, or tonnes of carbon sequestered per hectare per year. For example, Gunn et al. (2011b) estimated that migratory tundra caribou herds contribute to nutrient recycling in Arctic tundra, forest and freshwater ecosystems by returning, on average, 150 to 300 kilograms of faecal pellets per km2 of each herd's range over the course of a year. In most cases, measurement in biophysical terms involves the use of proxies and indicators. Where direct measures are not available, biophysical proxies or indicators are often a prerequisite for sound monetary valuations and provide powerful information in their own right (e.g., Goméz-Baggethun et al. 2013). CAFF, for example, through the CBMP, commissioned the Arctic Species Trend Index (ASTI) in cooperation with partners. The ASTI, in tracking over 300 Arctic vertebrate species, describes overall trends across species, taxonomy, ecosystems, regions and other categories (Böhm et al. 2012).

Modeling platforms can help to integrate diverse information over long time horizons and diverse spatial scales and can assist in examining assumptions, causal linkages and alternative scenarios. Numerous platforms exist, such as InVEST, ARIES and others (see ValuES Methods Database for overview: www.aboutvalues.net). Many, if not all, of these platforms describe and quantify current and potential future relationships between the physical and biological components of the environment with the help of ecosystem models. It is important for biophysical valuation exercises to have well-calibrated models available to quantify Arctic ecosystem services and to forecast their future under various scenarios of human activities. The information that the CBMP provides and synthesizes (and has plans in place to synthesize), through its indicator and modeling work, would be an important basis for biophysical valuation in the context of TEEB.

4.2.1.4. Insurance values in the context of resilience

The contribution of ecological infrastructure and ecosystem services to increased resilience and reduced vulnerability of societies to shocks has been referred to as a form of insurance value (Pascual et al. 2010). Insurance in this context means providing protection against a possible eventuality, as opposed to the insurance financial sector. Empirical research shows that the likelihood of ecosystem regime shifts may increase when humans reduce resilience (Folke et al. 2004), resulting in impacts on biodiversity and ecosystems through climate change and releases of waste and pollutants, and altering the magnitude, frequency, and duration of disturbance regimes. The effects of those pressures can make ecosystems more vulnerable to changes that previously could be absorbed.

Active adaptive management and governance of resilience will be required to sustain desired ecosystem states and transform degraded ecosystems into fundamentally new and more desirable configurations (Folke et al. 2004). Because local and Traditional Knowledge systems embed accumulated knowledge and practices to cope with environmental change, maintaining these bodies of knowledge can be essential for maintaining and building resilience to shocks (Barthel et al. 2010; Gómez-Baggethun et al. 2012).

Chapter 5. Policy focus for a TEEB Arctic study

Authors: J. Eamer and M. Sommerkorn (plus all project participants in discussion on policy focus)
Contributors (policy examples): M. Kettunen, G. Stetson, L. Wakelyn, G. Bussidor, M. Fidel, S. King, A. Gunn, M. Sommerkorn, T. Barry, A. Medeiros, C. Armstrong, T. Declerq

An important objective of this scoping study is to provide recommendations for policy areas that would benefit from further analysis through a TEEB Arctic study. Recommendations for policy focus (Chapter 7) are informed by

▶ Review and synthesis of: (Section 1.7) current Arctic issues, (Chapter 2) Arctic ecosystem services, their vulnerability and their beneficiaries, and (Chapter 3) Arctic governance and policy issues and options
▶ Input received via the online TEEB questionnaire, the Reykjavik workshop and through the Project Steering Group, the CAFF Board and others contributing to the development of the scoping study and review of this report (Box 5.1)

Box 5.1. Selected input on policy from the TEEB Arctic scoping study questionnaire and workshop

Selection of recommendations on policy areas that would benefit from a TEEB approach

"The economic trade-offs between commercial, sport, and subsistence fishing are often a point of contention in allocation battles. Thinking about the wider scope of ecosystem services (e.g., cultural, etc., not just monetary) may help recognize that getting the most amount of money per fish is not always the best way to allocate catch quotas." (TEEB questionnaire input)

"Introduction of ecosystem-based management for fisheries: spatial planning, protection of essential habitats, ocean integrated management, best practices of fishery development. We should be able to assess ecosystem services and use them in decision-making processes… [specifically using] the Marine Stewardship Council certification process for introducing ecosystem based management." (TEEB questionnaire input)

"Understanding how fishing or mining or Arctic transport are likely to affect other (usually un-measured) ecosystem services is a critical first step towards including ALL impacts of our actions in policy and decision making." (TEEB questionnaire input)

"Local planning: tools that include explicit ecosystem services accounting could be relevant as a way to encourage more long-term monitoring and evaluation than environmental impact assessments." (TEEB questionnaire input)

"Oil and gas extraction will add to climate change (CO_2 from combustion), which is the single most serious threat to Arctic nature and biodiversity (according to the IPCC, more than two-thirds of the ALREADY known oil, gas and coal resources must stay in the ground if global warming should be kept within the 2 °C increase decided by world leaders.) Furthermore, it includes risks of heavy pollution (accidents) and will reduce the appreciation of Arctic nature among people worldwide. I'm afraid that this is a fight that nature is going to lose." (TEEB questionnaire input)

"It will be a challenge to transition to a low-carbon and resource-efficient society while reducing CO2 emissions. At the same time, the Arctic is expected to contribute significantly to global energy demand -- knowledge about the value of ecosystem services will help to elucidate positive, negative and win-win effects of decisions in this policy area." (TEEB questionnaire input)

Examples of perspectives on the policy focus for a TEEB Arctic study

The scoping study should point at the need for tools to assess risks to ecosystem services, or visibility of ecosystem services, in policies that are already proposed or implemented: for example, marine spatial planning, land-use planning, landscape approaches, and strategic environmental assessment in relation to mining and offshore oil development.

From a business perspective, a TEEB analysis would focus on multi-disciplinary approaches to spatial planning and to options for multiple uses. This means not just looking at go/no-go policy decisions, but taking a more balanced approach looking at how multiple objectives can be achieved, and how values can be reflected in decision-making procedures. Business can take operational control over conserving specific ecosystem services, for example, through location and design of infrastructure.

From an indigenous perspective, food security is an example for a policy. It is defined from an indigenous local perspective compared to all the afore-mentioned global policies.

Summarized comments of participants, Reykjavik TEEB Arctic workshop (Eamer et al. 2014)

5.1. List of potential policy areas for a TEEB Arctic study

An important part of a TEEB scoping study is to identify policy areas that will most benefit from further assessment using the TEEB methodology.

The following lists synthesize input from the TEEB questionnaire and the Reykjavik workshop in response to questions and discussion on identifying policy areas for consideration for a TEEB Arctic study. There is overlap in this list, as issues were often framed from different perspectives. In addition, the list is a mix of policy areas, social-ecological systems and sectors associated with high risks to ecosystem services, and policy areas and tools and methods that have a high potential to benefit from an ecosystem services approach. Policy areas are interlinked: starting with any one policy area or policy type inevitably brings several others into consideration.

Broad policy areas

▶ Marine shipping and marine oil and gas development; increased vessel traffic (Bering Strait)
▶ Land-based mining and oil and gas – resource extraction; environmental assessment of northern projects; decisions on land-use permits
▶ Climate change, both through increasing the global awareness of the significance on Arctic climate change for climate regulation, and in relation to adaptation in the Arctic
▶ Food security
▶ Infrastructure development

More specific policy areas

▶ Reindeer herding
▶ Northward movement of commercial fisheries; fisheries and aquaculture policies and regulations
▶ Tourism, cruise ship and land-based; cultural tourism
▶ Introduction of new species for harvest (aquaculture, for example); invasive species, e.g., introduced through ballast water
▶ Wildlife and fisheries harvest allocation; wildlife management
▶ Research policy: framing research more in terms of ecosystem services, change ways that research is presented; enhancing or restoring Arctic research agendas
▶ Additional specific policy areas raised (less frequently than those listed above) as options to consider included bio-prospecting, contamination of foods, and waste disposal

Types of policies, tools and governance mechanisms

▶ Strategic planning: land-use planning and management, or, more broadly, spatial planning, including protected areas; industrial development and land-use strategies; conservation strategies
▶ Participatory processes: co-management; more local control in decision making; increased participation of Indigenous Peoples and local people of the Arctic in decision making; broad stakeholder involvement in decision making
▶ Resource rights issues, restrictions and responsibilities in relation to ecosystem services; benefit sharing; indigenous community–industry joint ventures; prevention of negative impacts on traditional ways of life
▶ Economic and fiscal policies; allocation of funding; subsidies; natural capital accounting; transformation of conventional economics to account for nature
▶ Circumpolar governance and cooperation

The Reykjavik workshop participants concluded that the third category (types of policies, tools and governance mechanisms) can best be considered as part of the analysis of specific policy areas: for example, analysis of fiscal policies or circumpolar governance mechanisms considered in relation to oil and gas development, or strategic planning techniques considered in relation to application to industrial development on land.

Policy areas from the first two categories in the list were reviewed by the project team and steering group in relation to suitability for assessment using the TEEB approach, based on criteria developed at the Reykjavik workshop. Criteria considered governance, ecosystem services affected, impacts on services, costs and benefits and affected parties, potential for positive impact on Indigenous Peoples, and the degree and nature of uncertainty and applicability of precautionary approaches.

Based on this review, three broad policy areas were selected as candidates for application of a TEEB approach with the understanding that aspects of several other policy areas (for example, food security) would be covered within the context of the selected topics, and that this selection of policy focus areas for further TEEB assessment would form part of the initial consultation stage of a TEEB Arctic study. Two of the three policy areas selected for follow-up at this scoping stage were further assessed (referred to as 'policy examples' and described in the next section). Assessment of the third policy area, reindeer herding, was not completed.

5.1.1. Illustrating the TEEB approach: Hypothetical examples for identified policy areas

Two hypothetical examples (Box 5.2 and Box 5.3) illustrate the approach a full TEEB study could take for policy areas selected from the above list, and applying some of the types of policies and governance mechanisms identified by workshop participants. These examples are for illustrative purposes in the context of this report and were not presented in this form at the Reykjavik workshop. The examples were also chosen to explain how TEEB can play an important role and add further value to specific policy foci identified in the recommendations of the Arctic Biodiversity Assessment (beyond recommendations 4 and 12 that directly relate to biodiversity mainstreaming).

Box 5.2. Illustration of a hypothetical TEEB study in the policy areas of marine food security and commercial fisheries

Context

Arctic waters provide habitat for fish that are caught to be sold for local subsistence and also contribute to food security beyond the Arctic. But some commercial fisheries are treating these waters in a way that does not consider local implications – even treating Arctic fisheries as a 'free lunch'. The total landed value of marine species in the Arctic region may not represent a critical share of an Arctic country's GDP, but it is a fundamental revenue share for the coastal communities and subsistence fishers. By-catch of king salmon in the Bering Sea, for example, affects Yupik fishermen on the Yukon River. This may endanger their basic livelihood and even deny some fundamental dimensions of human well-being, such as freedom of choice and the right to food.

TEEB approach

A TEEB analysis may demonstrate the benefits of a network of marine conservation zones and inform accompanying policy instruments. The study would follow the TEEB approach by bringing stakeholders together to identify a network of marine conservation zones and accompanying policy instruments that would benefit from valuation of ecosystem services and biodiversity. This would entail scenario mapping, identifying the 'business as usual' scenario and spatially explicit future policy scenario alternatives. This would be followed by assessing subsequent changes in ecosystem services provisioning (in biophysical terms) and valuing them so they can be part of the economic calculus of policy-makers. A core part of the analysis would be to assess distributional impacts of policy decisions, in particular with respect to indigenous groups and coastal communities, and to provide policy recommendations.

ABA policy context (recommendations 5A and 10C)

▶ Build upon existing and on-going domestic and international processes to complete the identification of ecologically and biologically important marine areas and implement appropriate measures for their conservation.

▶ Support efforts to plan and manage commercial fisheries in international waters under common international objectives that ensure long-term sustainability of species and ecosystems. Encourage precautionary, science-based management of fisheries in areas beyond national jurisdiction in accordance with international law to ensure the long-term sustainability of species and ecosystems.

5.2. Scoping of policy areas

The purpose of the two policy examples is to prepare the groundwork for a TEEB Arctic assessment in selected areas of policy and governance. A third policy example, on reindeer herding, was originally envisaged, but not completed. This means that the current coverage for terrestrial policy issues is for North America only. Much of the discussion, however, has broader application. The policy examples include overviews of important ecosystem services and current policy and governance settings. Policy approaches that focus on sustainability of ecosystem services are presented and discussed in relation to the added benefits these policies may provide to selected important ecosystem services.

Below are summaries of the policy examples, including the conclusions sections from Annexes 3 and 4. Each policy example also contains a selection of excerpts related to the policy area from the online questionnaire (Annexes 3a and 4a) and a study that provides a more regional examination of the issues and a local perspective (Annexes 3b and 4b).

Box 5.3. Illustration of a hypothetical TEEB study in the policy areas of reindeer herding, industrial development, land-use planning and adaption to climate change

Context

Reindeer herding remains a common livelihood in northern Eurasia where it is also the source of cultural identity for many Indigenous Peoples. For many of them, herding provides a very significant source of income and a dominant element of food security. However, reindeer herders also pursue hunting, production of decorative items, and tourism, all of which are linked to an ecosystem shaped by the reindeer. Reindeer herders have to negotiate climate change, infrastructure development (roads and other infrastructure related to oil and gas, hydropower, mining and wind-energy projects, as well as leisure cabins), consequent freshwater and terrestrial environmental degradation, and the interaction of these factors with reindeer movement patterns.

TEEB approach

The study following the TEEB approach would bring stakeholders together to identify land-use decisions that would benefit from valuation of ecosystem services and biodiversity. For example, TEEB may inform an incentive mechanism for the conservation and restoration of areas important for biodiversity and ecosystem-based reindeer management. The TEEB study would model impacts of land use at the landscape level, assessing subsequent changes in ecosystem services provisioning (in biophysical terms), and valuing them so they can be part of the economic calculus of policy-makers. A core part of the analysis would be to assess distributional impacts of land use decisions, in particular with respect to the reindeer herders, and provide policy recommendations.

Ecosystem services that may be part of the analysis include provisioning services (subsistence and commercial food, fresh water); regulating services (carbon sequestration and storage, moderation of extreme events, erosion prevention and maintenance of soil fertility, and biological control); supporting services (habitat for species, maintenance of genetic diversity); and cultural values (sense of identity, tourism, recreation, aesthetic appreciation). This would include monetary analysis only for the services that stakeholders, through participatory process, identify as appropriate for monetary valuation.

Policy changes that may be attributed to this analysis include, for example: (1) enhanced awareness, knowledge and supporting evidence leading to investment in the productive assets of Indigenous Peoples, such as soil; (2) policy shift towards climate-smart reindeer herding, particularly investments in ecosystem-based adaptation; and (3) landscape-level analysis leading to increased habitat connectivity and reduced land fragmentation, thereby reducing pressures on biodiversity-rich areas.

ABA policy context (recommendations 10E, 5C and 2)

▶ Develop and implement, in cooperation with reindeer herders, management plans that ensure the sustainability of reindeer herding and the quality of habitat for grazing and calving.
▶ Promote the active involvement of Indigenous Peoples in the management and sustainable use of protected areas.
▶ Incorporate resilience and adaptation of biodiversity to climate change into plans for development in the Arctic.

5.2.1. Expansion of marine oil and gas activities and marine shipping

This policy example includes and draws material from the regional study on the Aleutian Islands and the Unangax people, Annex 3b.

The policy and governance setting is by definition transitional, as this example is about change: the current and projected expansion of industrial activity in a rapidly changing Arctic marine environment. Although these activities bring potential economic benefits, they also bring considerable risk, especially to users of ocean resources who depend on these resources for nutrition, income, and cultural identity. Harvesting from the sea plays an important role in food security and traditional economies in many indigenous communities.

Ecosystem services also provide economic value to Arctic residents through commercial fishing and tourism. Large-scale fisheries in some regions are also important to national and, in some areas, local economies. The importance of Arctic fisheries extends beyond the major commercial fisheries, but other commercial and subsistence fisheries are less well-documented, and their values may be less visible when decisions involving trade-offs are made. Like the shipping and oil and gas industries,

the commercial fishing industry is expected to change and to expand in the Arctic. Marine-based tourism represents the largest sector of the Arctic tourism industry. Cruise ship tourism is on the rise.

The greatest single risk from increased shipping and oil and gas development is the risk of major accidents (especially oil spills) with major damage to marine ecosystems. There is also potential for chronic pollution problems and impacts from other stressors, including noise and disturbance, to affect biodiversity, ecosystems and ecosystem services. Many potential impacts affect habitat/supporting services through less visible, indirect routes, such as introduction of invasive species or sublethal effects of contaminants affecting predator-prey balances. The combined effects of increasing climate change and increasing marine industrial activities introduce additional risks and uncertainties. Services most affected (or potentially affected) are provisioning, cultural and habitat/supporting. Anthropogenic emission of greenhouse gases is the main driver affecting the important climate regulating service of the Arctic.

The current governance framework related to oil and gas and shipping in the Arctic is based on a combination of regional and international agreements, many based on a soft law approach that focuses on scientific advice and policy recommendations. There has been significant recent progress on policies and governance regimes to address the impacts of oil and gas and shipping in the Arctic at the international level. Shipping regulation is more amenable to international regulation. Oil and gas development is subject to the jurisdiction of coastal states and to operational procedures that rely on industry standards. Overall, the current state of international and regional governance reflects coordination and goodwill at the international and regional levels, but relies heavily on the capacity of individual Arctic states to implement measures at the national or sub-national level, leaving a fragmented governance regime that will be hard pressed to respond to the rapidly changing Arctic environment, where biodiversity and ecosystems services are at risk.

The following policy shortfalls and alternative policy approaches (Table 5.1) were identified and suggested for consideration in a TEEB Arctic assessment:

Table 5.1. Marine policy example: identified policy shortfalls and alternative policy approaches

Policy shortfall	Policy taking an ecosystem services approach
Governance and policy reflect cost, benefits, and risks according to the presence or absence of different stakeholders and rights holders. The current governance approach in oil and gas and shipping has relied to a large extent on international and regional level agreements and venues that are not well represented by local stakeholders and rights holders.	1. Governance mechanisms that cross scales and address distributional impacts, bringing the interests and voice of local actors (Indigenous Peoples, coastal communities) to complex multilateral governance arrangements
Indigenous knowledge and value systems are not adequately integrated into policy making.	2. Inclusion of multiple knowledge and value systems in policy making from local to international scales
The current approach to policy and governance is generally reactive, dealing with the immediate impacts of expanding oil and gas and shipping industries, rather than a comprehensive approach that is based on long-term sustainability of Arctic biodiversity and ecosystems.	3. Positioning of ecosystem services as priority, using the precautionary approach: first, securing Arctic biodiversity as the guiding principle and, second, managing the opportunities of shipping and oil and gas development

Making the values of ecosystem services more visible may contribute to the adoption of a precautionary approach in Arctic marine governance (an approach that is at least partly applied now in regulation development), specifically through highlighting the importance of marine ecosystem services that are less visible but at risk, including habitat/supporting services, and provisioning and cultural services that are not well-known at the international level.

A TEEB approach could be used to address identified policy shortfalls related to scalability and governance fit and the incorporation of multiple knowledge and value systems into decision making, working from the local scale outwards to the multiple scales at which decisions are made. Bringing analysis based on multiple value systems and multiple knowledge systems into policy directions and governance mechanisms will not only ameliorate the ongoing provision of services, but make the distribution of benefits from, and risks to, these services more equitable.

This scoping study identifies next steps in implementing a TEEB approach in Arctic marine policy development:

- ▶ Build on this scoping study, through a collaborative process, with a cross-disciplinary approach and with strong leadership from Indigenous Peoples.
- ▶ Identify options for ecosystem services approaches (including TEEB methodology) through ongoing and emerging Arctic Council initiatives and through policy initiatives at national and regional scales.

5.2.2. Industrial development activity in terrestrial ecosystems, with a focus on cumulative effects (North American Arctic)

This policy example includes and draws material from the regional case study on co-management for the Beverly and Qamanirjuaq caribou herds, Annex 4b.

Human population in the North American (NA) Arctic is sparse, with a high proportion of indigenous residents throughout the region. Mineral, diamonds, and oil and gas extraction industries are major economic drivers for the North American Arctic, and are seen as an important source of current and future economic development. Social and environmental impacts have been both positive and negative, and the people living in this part of the world are familiar with the difficulty of balancing the pros and cons of development for their communities.

For the Indigenous Peoples who rely on subsistence hunting, fishing and gathering, these activities are significant to their health, culture and economy. The ecosystem services and benefits associated with these activities are viewed holistically and are best assessed as bundles. Important provisioning services include food and other goods from hunting, fishing and gathering a wide range of animal and plant species, with harvest of migratory tundra caribou being particularly important. Subsistence activities are also important, both for food and for cultural services, for many non-indigenous residents. Cultural services include ecotourism, outdoor recreation, sport hunting and fishing, and also include important benefits for personal and community health and well-being, spirituality, identity and education. Regulating services in the context of this policy example include natural regulation of floods and control of erosion provided by aquatic and riparian ecosystems.

Industrial activities, especially in combination with climate change, have the potential for widespread, major impacts on terrestrial and freshwater ecosystems in the NA Arctic. The major impacts of concern for the terrestrial environment are associated with cumulative effects of exploration activities, infrastructure development and extractive industry operation, including legacy effects from past operations. Aquatic ecosystems are also particularly vulnerable to broad-scale impacts from point sources, such as release of contaminants from abandoned mines, or catastrophic events such as spills or breaching of tailings dams.

The NA Arctic is characterized by multiple jurisdictions that often overlap: the multi-level jurisdictions associated with federal forms of government, plus jurisdictions based on traditional homelands of Indigenous Peoples and on land claim agreements and interim measures established for land tenure, governance and economic development. There is a strong culture of grass roots involvement in decision making, with a range of consultative and co-management systems in place in many areas and operating at the community/village and regional levels. However, with small populations and changing socio-economic conditions, communities often have insufficient resources and capacity to participate fully in important reviews and decision-making processes.

Some governance jurisdictions coincide well with the scale and distribution of resources associated with ecosystem services – especially as land claims are based on traditional hunting territories. Often, however, the fit is not so good, and policy affecting key ecosystem components may be spread over multiple jurisdictions and further complicated by overlapping traditional hunting territories and ongoing negotiations for rights. In addition to hydrologic and other ecological features that do not correspond to institutional boundaries, there are many migratory species with different ranges and seasons. Migratory tundra caribou, for example, migrate seasonally over ranges that include calving grounds on the tundra and wintering areas in northern forests. Caribou management boards have been established for many of the NA Arctic's migratory tundra caribou herds as a way to bring together managers (from different government levels across the jurisdictions within the herd's range) and Indigenous Peoples who hold or are negotiating land and harvest rights and benefit from the many ecosystem services associated with caribou.

The following policy shortfalls and alternative policy approaches (Table 5.2) were identified and suggested for follow-up in a TEEB Arctic assessment:

Table 5.2. Terrestrial NA Arctic policy example: identified policy shortfalls and alternative policy approaches

Policy shortfall	
Cumulative effects assessments are undertaken on a case-by-case basis and do not, in general, have comprehensive, strategic plans and assessments that look at a broader scale. This means that incremental ('nibbling') effects are difficult to take into account.	1. Making wider use of spatial planning and strategic environmental assessment approaches at the scale of ecologically meaningful regions, such as for caribou herd ranges
Ecosystem services are not explicitly or systematically included in environmental and socio-economic assessments or reasons for decisions for projects. Food security aspects of traditional (country) foods are not given adequate attention by many decision-makers.	2. Incorporation of the full spectrum of ecosystem services into environmental impact assessment through guidelines, procedures, methodologies and regulations at all levels for all activities subject to EIA in the Arctic
Although policy and processes for consultation related to industrial development are well established over much of the region, they are not always effective.	3. Improvement of participatory processes
Government subsidies and financial incentives are not (or are infrequently) assessed for unintended consequences on ecosystems and biodiversity.	4. Ecosystem value accounting: making use of financial policy instruments that capture the values of ecosystem services

In addition, the following policy shortfall was identified:
▶ Climate change is not consistently and adequately incorporated into assessment and planning for development.

This is cross-cutting and an important consideration for all alternative policies.

Policy instruments for planning and assessment depend on participatory processes that recognize the many ways in which bundles of ecosystem services are important to Indigenous Peoples and others, and that address concerns that arise. The NA Arctic has many effective governance mechanisms in place, based on various forms of co-management, most of which have a formal advisory role. Challenges, though, remain in the areas of effective public participation, meaningful incorporation of Traditional Knowledge, and planning and decision-making across jurisdictions.

Consideration of food security is a promising approach for analysis of the values of and risks to important ecosystem services, especially when a holistic approach is taken that incorporates the many cultural services associated with traditional foods. Using the framework of food security also makes the concepts of sustainability of ecosystem services associated with harvesting, preparation, and consumption of traditional foods more understandable at the local level. Ecosystem services and TEEB terminology can be difficult and misleading.

The types of policy and governance mechanisms discussed in this policy example are within national and sub-national jurisdiction. Action at the international level could include action through multilateral environmental agreements, but would mainly be through Arctic Council initiatives that shape policies and provide forums for building and sharing information, tools and methodologies – in particular through work on mainstreaming biodiversity that is ongoing and planned through implementation of the recommendations of the Arctic Biodiversity Assessment (CAFF 2015).

Chapter 6. Stakeholder analysis

J. Eamer

6.1. Identifying stakeholders and setting priorities

The objective of this section is to identify the major stakeholder groups for a TEEB Arctic assessment, and to provide initial analysis on roles, expectations from engagement, and stakeholder priorities. Input for this section includes the scoping study process, including initial development through the project partners and review through the CAFF Board, input through the project workshop and the online questionnaire, engagement of steering group and contributors; plus reviews of the draft versions of this report. Methodology for this section follows the Guidance Manual for TEEB Country Studies (TEEB – The Economics of Ecosystems and Biodiversity 2013).

Stakeholders[8] are persons or groups (e.g., individuals, organizations, businesses, sectors, governments, communities) with a stake in the way a particular ecosystem is used, valued or managed. Stakeholders include knowledge holders and potential users of the results of the study – and most of the Arctic TEEB stakeholder groups are both of these.

Table 6.1 identifies major stakeholder groups for a TEEB Arctic study, rationale for their involvement, recommended roles and initial contact points.

Within each stakeholder group, priorities will need to be set. Some priorities will be clear, as specific regional and local stakeholders will need to be involved when working on specific focal points of the assessment. Other criteria for setting priorities include achieving a good geographic representation of participation for issues that cover a broad scale, involving stakeholder organizations that provide the best likelihood of meaningful engagement, and gender balance of the core group and participants.

Another consideration when setting priorities is the value of building on current engagement in TEEB Arctic at the scoping study phase. This can be achieved by providing updates on findings and progress and continuing the dialogue with groups and individuals who were involved in this scoping study, including the respondents to the online questionnaire.

Participation for some stakeholder groups requires project funding, and many stakeholders will need to know the amounts and types of funding available before they can consider participation. In particular, an investment will be needed to cover costs for meaningful engagement for Indigenous Peoples, local communities, and possibly for some forms of sub-national government – as well as for input throughout the study by science-based researchers and Traditional Knowledge holders.

Table 6.1. Anticipated stakeholder groups to engage in the context a TEEB Arctic study

Stakeholder	Engagement mode	Why they need to be involved and what they bring to a TEEB Arctic study	Recommended/potential access points
Arctic Council	Core	• Shapes policy, and policy-makers directly involved; coordinates/oversees related initiatives; key information provider • Provides a coordinating/ consultative mechanism for many stakeholders	• CAFF, SDWG and PAME working groups
UNEP, TEEB programme, related initiatives	Core / Participants	• Expertise and experience, methodology, global perspectives • Learn from others' experiences and contribute to TEEB global initiative • Endorsement as a TEEB study	• UNEP TEEB office • Researchers and other experts with related experience (other TEEB studies and related work on natural capital and valuing ecosystems and biodiversity)

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8   It is recognized that "stakeholder" can mean different things in different contexts, in particular where distinctions are made between stakeholders ("communities of interest") and rights holders (e.g. Indigenous Peoples in Canada). This report uses the definition of "stakeholder" in an inclusive way, as defined by TEEB (TEEB – The Economics of Ecosystems and Biodiversity n.d.).

Stakeholder	Engagement mode	Why they need to be involved and what they bring to a TEEB Arctic study	Recommended/potential access points
National governments	Core / Participant	• Key policy-makers and information providers • Important to involve more than just departments of environment if TEEB is to be successful in promoting improved policy integration and decision making	• Primary access through Arctic council working groups • As needed involve multiple departments: e.g., dealing with finance, commerce and economic development, health, emergency response, marine navigation and safety, climate change mitigation, heritage resources
Indigenous organizations	Core / Participant	• Understanding of traditional management systems; Traditional Knowledge, world views, and perspectives on issues • Reliance on ecosystem services: at risk from loss of services; benefit from viable ecosystems and biodiversity • Key policy-makers and information providers	• Permanent Participants at Arctic Council • - -Potentially other indigenous institutions and governments
NGOs	Core / Keep informed	• Interests and expertise in nature conservation, social equity, participatory processes • Outreach capacity • Often have capacity and mandate to think outside the box and examine new models of policy and governance	• WWF (scoping study lead) • Potentially national, sub-national NGOs
Sub-national governance institutions	Core/ Participant	• Decision-makers and knowledge-holders for many issues at ecologically relevant scales	• Variable, and as relevant • Include some representation of co-management bodies
Business	Participant	• Knowledge about feasible mitigation and business economics • Interest re compliance with environmental assessment and regulatory regimes • Interest re social license to operate • Potential for industry-led initiatives that are pro-active	• Sectorial approach: business associations and engaged single companies. • Arctic Economic Council
Arctic researchers	Participant	• Multi-disciplinary approach is essential, involving environmental and ecosystem scientists, social scientists, and economists	• International Arctic Science Committee (IASC); • International Arctic Social Sciences Association (IASSA)
Indigenous Knowledge holders	Participant	• Important source of knowledge on Arctic • Opportunity to make Traditional Knowledge more visible in decision making	• Arctic Council Permanent Participants
Regional governance institutions	Participant / Keep informed	• Shape or produce policy for large Arctic regions	• European Union • Institutions managing regional agreements, such as for the Barents Sea
Local communities	Keep informed / Participant	• Affected by policy decisions due to direct dependence on natural resources • Significant source of knowledge that can help to frame policy options and methods of valuing ecosystem services	• Municipal or village organizations in some places
Non-Arctic nations	Keep informed / Participant	• Arctic interests or potential interests, e.g., in fisheries, oil, shipbuilding and transport • Provide global economic perspectives	• Arctic Council Observer states

Modes of engagement defined as:

Core: *Full involvement at all stages*

Participant: *Committed to active participation on specific aspects of the study*

Keep informed: *Two modes, with ability to move between; both provided with periodic updates.*

- *Active: work to keep channels of communication open (e.g., through soliciting feedback, making presentations at stakeholder events)*
- *Passive: with an open invitation that encourages feedback and participation as desired*

Where two modes of engagement are listed, this reflects the expectation that different parts of the stakeholder group would engage with the study in different way

6.2.   Basis for engagement

From the outset, what is expected from stakeholders during the TEEB Arctic study needs to be clearly communicated. Figure 6.1 shows a first-cut mapping of main roles and objectives of engagement of the major stakeholder groups identified in Table 6.1. This model illustrates the central role of Arctic Council in creating the basis for mutual understanding, the potential diversity and strength of stakeholder contribution to designing feasible alternatives, and the range of opportunities, at different scales, for creating ownership of solutions. TEEB studies follow an open architecture model of engagement, structured so that those who wish to contribute can do so through a range of avenues, such as through workshops, written submissions, and as authors and reviewers (TEEB – The Economics of Ecosystems and Biodiversity 2013).

Figure 6.1. Mapping roles of stakeholders and objectives of engagement
Based on categories in the Communication, Education and Public Awareness (CEPA) Toolkit (IUCN and CBD n.d.) (J. Eamer)
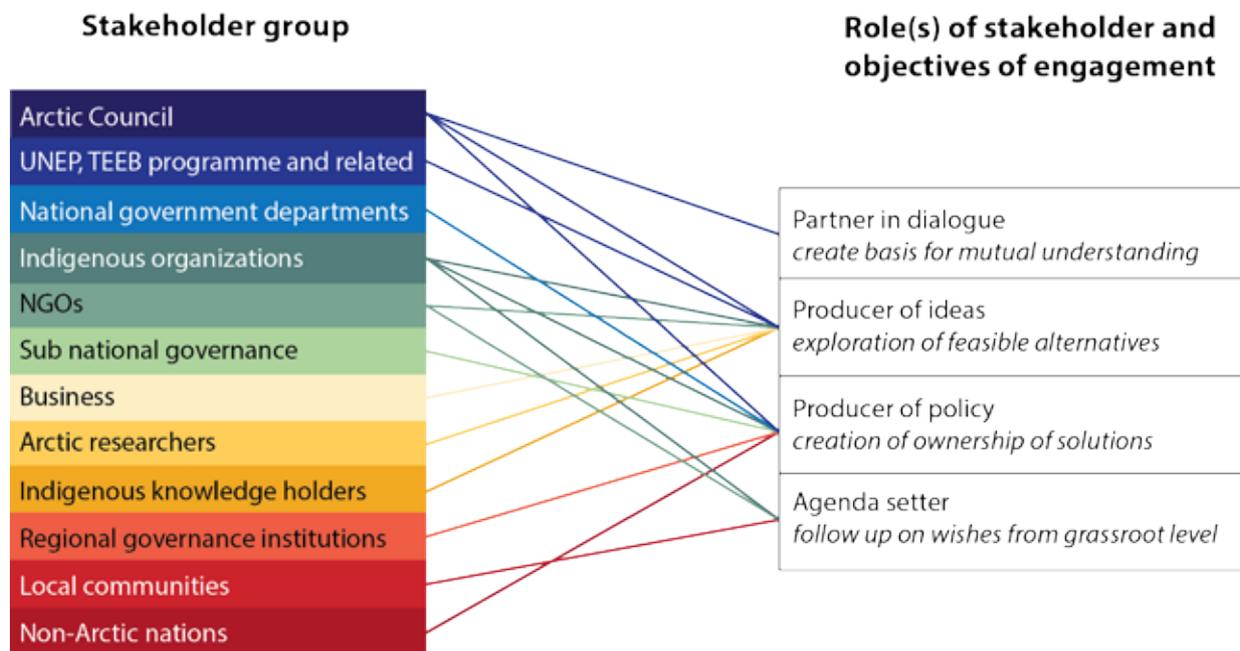
Table 6.2 shows some priorities of relevance to the management of Arctic natural wealth for the same set of stakeholder groups, along with notes on likely areas of agreement and disagreement. Stakeholder groups would need to be broken down into sub-groups (e.g., individual countries, types and regions of sub-national government, specific business sectors) to take this analysis further, and to identify which ecosystem services are of most concern for each stakeholder group, as recommended in the Guidance Manual for TEEB Country Studies (TEEB – The Economics of Ecosystems and Biodiversity 2013). Further stakeholder analysis would also incorporate recognition that views are not the same within groups (Bright et al. 2003)

Table 6.2. Some stakeholder priorities related to the management of natural wealth

Stakeholder priorities	Arctic Council	UNEP, TEEB programme and related	National government departments	Indigenous organizations	NGOs	Sub national governance	Business	Regional governance institutions	Local communities	Non-Arctic nations	Sources of agreement and disagreement
Development of Arctic cash economy (including jobs, generation of income)	X		X	X		X	X	X	X		Wide geographic variation: potential to overrule concerns about natural capital; disagreement between stakeholder priorities at different scales.
Protection of specific sites of high ecological and/or cultural value			X	X	X	X			X		Broad agreement in principle; disagreements in implementation of spatial planning; potential for disagreement where sites have oil, mineral potential.
Conservation of ecosystems and biodiversity	X	X	X	X	X	X		X	X		Broad agreement in principle, but disagreements on if and how to make explicit (e.g. natural capital accounting seen as blocking economic development).
Protection of wilderness, landscapes, seascapes and iconic species			X	X	X	X	X		X		Conflicts arise between this priority and priorities of developers; can also conflict with priorities of Indigenous Peoples & local communities/ businesses.
Access to non-renewable resources (oil, gas, minerals) & shipping access			X	X	X	X	X		X	X	Likely largest overall source of disagreement among stakeholders. Multi-faceted: most stakeholder groups cannot be typecast as "pro" or "con".
Access to renewable resources (e.g. fisheries, hunting)			X	X		X	X		X	X	Some stakeholders' priorities are to gain access; some to protect access; some to limit access
Well-being of Arctic residents, including health, culture, & spirituality	X		X	X	X	X			X		Broad agreement in principle. Likely most difficult to link to natural wealth in a way that convinces decision-makers.
Indigenous Peoples' rights, and fate control			X	X		X			X		Conflicts between Indigenous use/occupancy of lands/waters and other users and potential users. Some aspects are legal and not economy-related.
Food and water security			X	X		X			X		Conflicts around trade-offs to 1) conserve provisioning services 2) have affordable market foods.

Notes:
Priorities are flagged for stakeholders where there is a direct mandate, clear self-interest, or established advocacy. The two knowledge holder categories (Arctic researchers and Traditional Knowledge holders) are not included in this analysis.

'Business' includes major oil companies, mining, transportation, tourism, fisheries, and diverse local enterprises; priorities identified may apply to specific business types (for example, the priority for wilderness applies to ecotourism.)

Chapter 7. The way forward

J. Eamer and M. Sommerkorn

7.1.   Policy context

Although it is often stated that ecosystems and food webs are simpler in the Arctic than in many other parts of the world, no one has ever said this about the Arctic policy environment. Policy regimes include those of eight diverse nations, many Indigenous Peoples, sub-national governance, as well as cross-sectorial and cross-scalar policy and governance arrangements among diverse parties (e.g., co-management systems and impacts and benefits agreements). At the international level, relevant policies and regulations are rooted in bi-lateral, Arctic regional and circumpolar agreements and institutions (including the Arctic Council), as well as in commitments and regulations under global-scale multi-lateral agreements, notably those pertaining to Arctic Ocean areas beyond national jurisdiction. This means that there are many opportunities to introduce TEEB approaches into policies, but that care must be taken in identifying the types and levels of policy options that have the most potential for positive change.

At the circumpolar scale, the Arctic Council is the key forum for development of policy directions and for the development and dissemination of tools and methods for policy change. This is the primary policy context envisaged for a TEEB Arctic study. National-level TEEB studies aim to develop specific, place-based policy options for consideration by decision-makers. Local or other grass-roots efforts can develop, exemplify, and test policies that are relevant for TEEB. Critical needs and synergies for TEEB studies are linked to connecting policies across these scales. The TEEB Arctic study would provide vertical integration across these governance scales, as well as horizontal links, particularly among TEEB and ecosystem services initiatives in the eight Arctic countries.

The way forward options presented below aim at providing rationale, recommendations, supporting information, tools and methods that enable and encourage incorporation of the values of ecosystem services into decision making. The coordination for the study would be at the Arctic Council level. Stakeholder involvement and assessment of policy options would be at the scales of operation of specific policies, their impacts, risks, costs and benefits to priority ecosystem services and their beneficiaries.

This section presents a suite of options for follow-up to the scoping study, including a full TEEB Arctic study. The overall objective of this suite of options is to reduce the pressures and threats on Arctic ecosystems by mainstreaming the many and diverse values of biodiversity and ecosystem services into decision making.

 "My strongest recommendation is to avoid as much as possible "branding" a TEEB for Arctic as an environmental exercise. In our current governance model, economic policy trumps environmental policy with few exceptions. A TEEB for Arctic (as all TEEBs) should be identified as efforts that support a transition to a new economic reality full of opportunities our current model ignores." (TEEB questionnaire input)

7.2.   Objectives

These draft objectives would be reviewed and refined during the first stage of the study.

Overall objective

Reduce the pressures and threats on Arctic ecosystems by mainstreaming the many and diverse values of biodiversity and ecosystem services into policy making.

Specific objectives

1.   Provide rationale, recommendations, supporting information, tools and methods that enable and encourage incorporation of the values of ecosystem services into decision making.
2.   Provide guidance for integrating the diverse values of ecosystems and biodiversity into policy related to industrial development (including cumulative and interacting effects) potentially affecting Arctic marine, terrestrial and freshwater ecosystems, with a focus on the following economic sectors: oil and gas development, mining and international shipping.
3.   Provide options and tools to support decision-makers in setting priorities and investing in regional ecosystem conservation and sustainable use (such as ecosystem-based management and protected area establishment), including through identification of and knowledge about places and ecosystems that provide services of particular local and regional significance.

7.3. Suite of options for the way forward

The presentation of this suite of options is in two parts:

1. A TEEB Arctic study, or set of studies, based on two to five policy areas.
2. A number of additional options, some of which address fundamental issues and challenges to the application of the TEEB approach in the Arctic context. Some options would be done in collaboration with and enhance ongoing Arctic Council initiatives; all of them would complement the TEEB Arctic study. These options are aimed at increasing the visibility of the values of ecosystem services in policy through improving the knowledge base, raising awareness of the value of ecosystem services, and development of tools, guidance, methodologies and information products.

Part 1. TEEB Arctic study

Policy is the starting point for a TEEB study. Chapter 5 'Policy focus for a TEEB Arctic study' provides a list of potential policy areas for assessment through a TEEB Arctic study, based on input received during the scoping study. Two broad policy areas were selected from this list for scoping-level TEEB assessment. Types of policy measures that can be instrumental in formulating policy questions and scenarios in an Arctic TEEB assessment, based on these two examples, are presented in Box 7.1.

Box 7.1. Scoping of policy areas: Examples of types of policies that could be assessed in a TEEB study

Policy Area 1: Expansion of marine oil and gas activities and marine shipping

1. Governance mechanisms that cross scales and address distributional impacts, bringing the interests and voice of local actors (Indigenous Peoples, coastal communities) to complex multilateral governance arrangements
2. Inclusion of multiple knowledge and value systems in policy making from local to international scales
3. Positioning of ecosystem services as priority, using the precautionary approach: first, securing Arctic biodiversity as the guiding principle (e.g. through implementing of marine spatial planning, ecosystem-based management, marine protected area networks) and, second, managing the opportunities of shipping and oil and gas development

Policy Area 2: Development activity in terrestrial ecosystems, with a focus on mineral exploration and development, and cumulative effects (North American Arctic)

4. Making wider use of spatial planning and strategic environmental assessment approaches at the scale of ecologically meaningful regions, such as for caribou herd ranges
5. Incorporation of the full spectrum of ecosystem services into environmental impact assessment through guidelines, procedures, methodologies and regulations at all levels for all activities subject to EIA in the Arctic
6. Improvement of participatory processes
7. Ecosystem value accounting: Making use of financial policy instruments that incorporate the values of ecosystem services

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Methodology

The TEEB methodology includes the use of policy scenario analysis to make the case for policy change. Within each policy context, a TEEB Arctic study would conduct biophysical and economic valuation exercises on the change of ecosystem service provisioning under alternative scenarios compared to 'business as usual'. This will provide policy evidence on the important role of Arctic ecosystems and biodiversity for local and global well-being, with the aim of incorporating these values into decision making. The use of scenarios promotes looking ahead: What are the consequences for ecosystem services and their beneficiaries if we continue along the path we are following (a 'business as usual' policy scenario), and what difference would recognizing, demonstrating and/or capturing the values of nature in policy make (an alternative policy scenario)?

Great care has to be applied when choosing different scenarios. The focus is 'marginal change': how much difference would the alternative policy make, relative to a 'business as usual' baseline, as well as identifying and estimating any distributional impacts. Ecosystem models – models that describe and quantify the relationships between physical and biological elements of Arctic ecosystems – are particularly important as a supporting tool because they can help make forecasts about the future of resources when considering impacts from development, climate change, and other drivers of change. They thus

provide a scientific basis for scenarios and help stakeholders better understand status and trends of natural resources and the relationships between them.

These are the six steps recommended for a TEEB study (see Section 1.5 and Annex 2):
1. Refine the objectives of a TEEB study by specifying and agreeing on the key policy issues with stakeholders (see Table 6.1).
2. Identify the most relevant ecosystem services.
3. Define information needs and select appropriate methods.
4. Assess and value ecosystem services.
5. Identify and outline the pros and cons of policy options.
6. Review, refine and report.

TEEB studies need input from a wide range of interests and disciplines. The approach is cross-sectorial and participatory, and can only work with active participation of, and consultation with, a broad range of experts and stakeholders. Institutional capacities and governance have to be taken into account to develop viable and realistic policy options. For the Arctic, with its multiple governance jurisdictions, this means that the relevant regions and scales of the policy areas being assessed are very important.

Process and governance

The study would be phased over a four-year period, from its approval to proceed, to its presentation at an Arctic Ministerial Meeting. The bulk of the analytical work, however, would take place over a two-year time period (years 2 and 3). Initial time is needed for start-up, including resource mobilization and engagement of stakeholders. Time is also needed in the latter phase of the study to allow for adequate time to synthesize and discuss results with stakeholders, and to develop and review policy recommendations through the Arctic Council.

Part 2. Options for improving capacity to understand Arctic ecosystem services and their values, and to apply this knowledge to policy

These options are organized in categories, with examples of actions. The actions would be reviewed and refined through a collaborative process.

1. **Guidance, methods, tools and information to support policy**
   1.1. Raise awareness of the roles and value of ecosystem services among Arctic communities with the aim of empowering communities, grass roots organizations and local administrations for better discussions/negotiations with sub-national/federal governments and corporations on policy related to Arctic development.
   1.2. Through collaborative processes, raise awareness of the ways that Arctic Indigenous Peoples value nature. For example, facilitate partnerships between Indigenous Peoples, economists, and other relevant science experts, aimed at informing ways to accommodate indigenous values in economic policies and practices.
   1.3. Make the role of natural capital and ecosystem services explicit in relation to adaptation and adaptive capacity. This is best done through bringing results from this scoping study into, and working in collaboration with, Arctic Council initiatives, for example, by
      a) considering adaptation options for policy-makers that include the non-monetary and economic aspects of biodiversity, through the Adaptation Actions for a Changing Arctic (AACA); and
      b) creating resilience indicators that would encompass ecosystem processes (building on the human development indicators) through the Arctic Resilience Report.
   1.4. Make visible the societal and long-term economic values of Arctic biodiversity conservation and sustainable biodiversity use schemes, and identify opportunities for financing such schemes that are based on recognition of ecosystem services.
   1.5. Apply economic analysis with the goal of
      a) accommodating the multiple value systems underpinning mixed and livelihood economies in the Arctic, such as reindeer herding and community economies based, or partly based, on subsistence hunting, fishing and gathering;
      b) capturing Arctic social and ecological resilience in economic information and valuation; and
      c) facilitating investment in the insurance value of Arctic natural capital.

   The application of economic analysis does not exclude or replace the use of other methods of valuation, based on, for example, Traditional Knowledge, or ecological or socio-cultural theories and methods. Such valuation methods complement or help refine economic analysis, or contribute separate analysis.

2. **Knowledge base**

Adopting ecosystem-based approaches in policy and practice brings with it a set of knowledge needs. Some of these needs can be met with existing knowledge that is spread through the academic literature and through knowledge held by agencies and other places, often partially reported on in grey literature. Knowledge is also held within indigenous organizations and documentation of Arctic indigenous management schemes. Knowledge is rarely articulated as pertaining to ecosystem services, or as benefits of biodiversity and ecosystems to humans, or as relevant to ecosystem-services-based decision making.

Options for actions to address knowledge gaps related to Arctic ecosystem services:

2.1. Complete and maintain the Arctic Ecosystem Services Inventory. A draft ecosystem services inventory was prepared as part of the scoping study (as discussed in Chapter 2). The inventory is a start on a structured and synthesized literature review of Arctic ecosystem services, the ecosystems they are derived from, their associated benefits, status, trends, threats, uncertainty, knowledge gaps, and what work has been done on valuation. To be a useful source of synthesized information, and a basis for further information tools, the inventory requires further work. The inventory could

      a) be a ready resource for information and overviews of available information on ecosystem services and what is known about them in relation to beneficiaries, threats, trends and valuation, both to raise awareness and to provide an entry point for policy-related assessment work;

      b) serve as a metadata center and service through CAFF's Arctic Biodiversity Data Service; and

      c) provide input to research and monitoring plans and agendas, and potentially also to industry monitoring and research planning

2.2. Take steps to capture or present new research results in ways that make them useful to ecosystem-services-based policy development. This could be awareness raising through research meetings of the need to make this connection, increased expert networking, such as through a community of practice on ecosystem services, and/or through changes to funding mechanisms for research.

2.3. Clearly identify knowledge gaps (both at the broad underpinning and methodological scale, and for specific geographic scales) and develop mechanisms to bring them into discussion of research agendas.

2.4. Facilitate and coordinate monitoring of the social and economic importance of ecosystems (through the Circumpolar Biodiversity Monitoring Program).

3. **Synthesis, analysis and information products**

3.1. Analyze linkages over scale, time and actors that affect when, where and to whom the costs and benefits of industrial development in the Arctic on biodiversity and ecosystems occur, considering also current and future use and spatial subsidies, to demonstrate the value and help frame the distributive impacts of decisions.

3.2. Prepare ecosystem services inventories with regular status reporting. Include interdisciplinary valuation of ecosystem services at the level of LMEs and national scales, but also initiate a regular review and assessment process at the pan-Arctic scale. Review and assessment would be in collaboration with existing Arctic Council processes, including the framework for assessment of biodiversity status and trends established through the CBMP.

3.3. Develop indicators to help describe the status of Arctic biodiversity and ecosystems. Include indicators that convey the proximity to potential thresholds or tipping points and attach confidence metrics to all indicators reflecting the level of knowledge and understanding. Development of such indicators needs to be done through a collaboration of Traditional Knowledge holders and scientists. (Indicator development is underway through the Circumpolar Biodiversity Monitoring Program.)

3.4. Develop resilience indicators that make explicit the role of natural capital and ecosystem services in building of adaptive capacity. These would have similar use for policy making but be more encompassing of ecosystem processes than human development indicators.

3.5. Develop and test tools to evaluate Arctic ecosystem services in local and sub-national EBM, marine spatial planning, land-use planning and management, and in co-management schemes where they can directly contribute to co-producing knowledge and adaptive governance.

7.4. Outputs (preliminary list)

1. Evaluation of types of policy instruments (e.g., policies on EIA, oil and gas leasing, marine vessel traffic and financial instruments) on the basis of their effectiveness in addressing distributional, economic, social and environmental impacts and cost-effectiveness

2. Recommendations for changes to existing policies and recommendations for new policies if warranted (the scope and scale will need to be defined)

3. Tools and methodologies for making the benefits of nature more visible in decision making

4. Information products on ecosystem services and natural capital, their beneficiaries, status and trends, threats and values – to support decision-makers

5. Integration of ecosystem service values into key Arctic Council initiatives on ecosystem-based management, adaptation and resilience

7.5.   Stakeholder engagement

"Significant work has been done in recent decades to integrate indigenous and scientific knowledge. These efforts need to be stepped-up and knowledge holders meaningfully engaged in policy work. Dialogue and involvement in various forums. It is all about relationships (as are ecosystem services themselves)." (TEEB questionnaire input)

Input through the questionnaire and the workshop highlighted the critical, central role of engagement for a successful TEEB Arctic study. Policy-makers need to be consulted early on so that they can help to design the most effective approaches and opportunities for policy change. This includes policy-makers at the international and national level, and includes those working on policy not directly related to environmental management, such as trade, business and fiscal policy). Engagement takes time, so contact and a two-way flow of information needs to be established with all stakeholder groups as an early step.

With the size and diversity of the circumpolar Arctic and the complexity of policy regimes, a range of participatory approaches will be needed (Figure 7.1).

Figure 7.1. A range of types of engagement will be needed across the participation spectrum
(J. Eamer, based on categories from IAP2's Public Participation Spectrum (IAP2 2006))
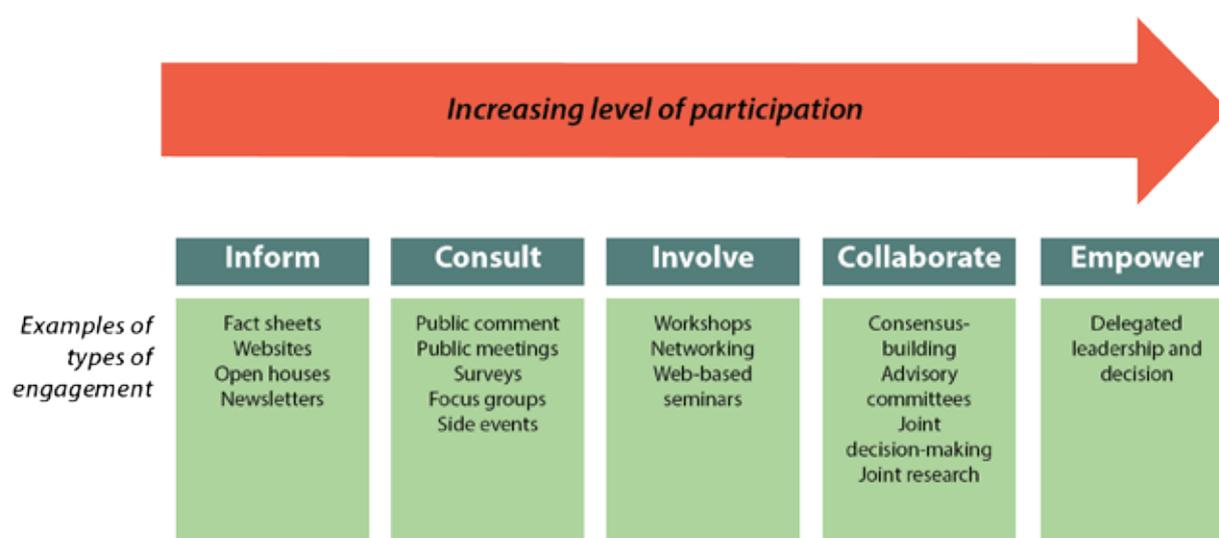
Stakeholder groups that would potentially be involved were identified in the stakeholder analysis (Chapter 6). These groups would be represented in and involved with the TEEB Arctic in various capacities and roles. Chapter 6 also contains information related to engagement of stakeholders, including preliminary identification of roles.

Key aspects of engagement for a TEEB study are (TEEB – The Economics of Ecosystems and Biodiversity 2013):

▶ **Credibility, legitimacy and relevance** of TEEB assessments requires having a balanced and independent assessment process, with involvement of a range of experts and stakeholders, and with ongoing advice from those with hands-on experience in public policy implementation. Building good assessment teams takes time and a clearly defined policy focus: this was a lesson learned from the scoping study, as the short timeline and broad focus inherent to a scoping study made it difficult to form expert author teams.

▶ **TEEB studies follow an open architecture design**, meaning that people who want to contribute are afforded the opportunity via a number of different means, such as calls for input (like the online questionnaire format used in this scoping study). For the TEEB Arctic study, there are opportunities for broad engagement through the Arctic Council, in conjunction with meetings, open houses, and other events. Techniques such as web seminars can also be considered.

▶ **Transparency in governance and engagement** is important throughout the process. The TEEB web site can provide a role in maintaining transparency, as can regular reporting on project development and engagement through Arctic Council and through briefings and newsletters.

7.6. Governance

Follow-up work to this scoping study would be coordinated through the Arctic Council. Leadership could be through CAFF, but it is important to involve other Arctic Council working groups and major initiatives. Because of the cross-cutting nature of the work, an effective approach would be to set up a task group on ecosystem services. Involvement is important from

▶ Ecosystem-based management initiatives (currently spread among the working groups)
▶ SDWG: Human Development Report II and associated follow-up work
▶ AMAP: AACA, for relationship to climate change adaptation policy, and monitoring and assessment linkages
▶ Arctic Resilience Report, for relationship to insurance (resiliency) values
▶ Protection of the Arctic Marine Environment (PAME) (marine component)
▶ CAFF (including CBMP): engagement in relation to agenda-setting for biodiversity monitoring and trend reporting, and indicator development

A potential model for project governance, based on the preliminary analysis of stakeholder engagement (Chapter 6) is shown in Figure 7.2. This schematic, which was developed with a TEEB Arctic study in mind, could be a starting point for discussion and review by the Arctic Council and other stakeholders. Many of the way forward options outlined in Section 7.3 could be initiated by a more restricted set of players, within the framework of overall Arctic Council coordination of goals, participatory methods, and outcomes.

Figure 7.2. Example of a potential governance model for a TEEB Arctic study
(See Chapter 6 analysis for related information on the groups identified in this schematic) (J. Eamer)
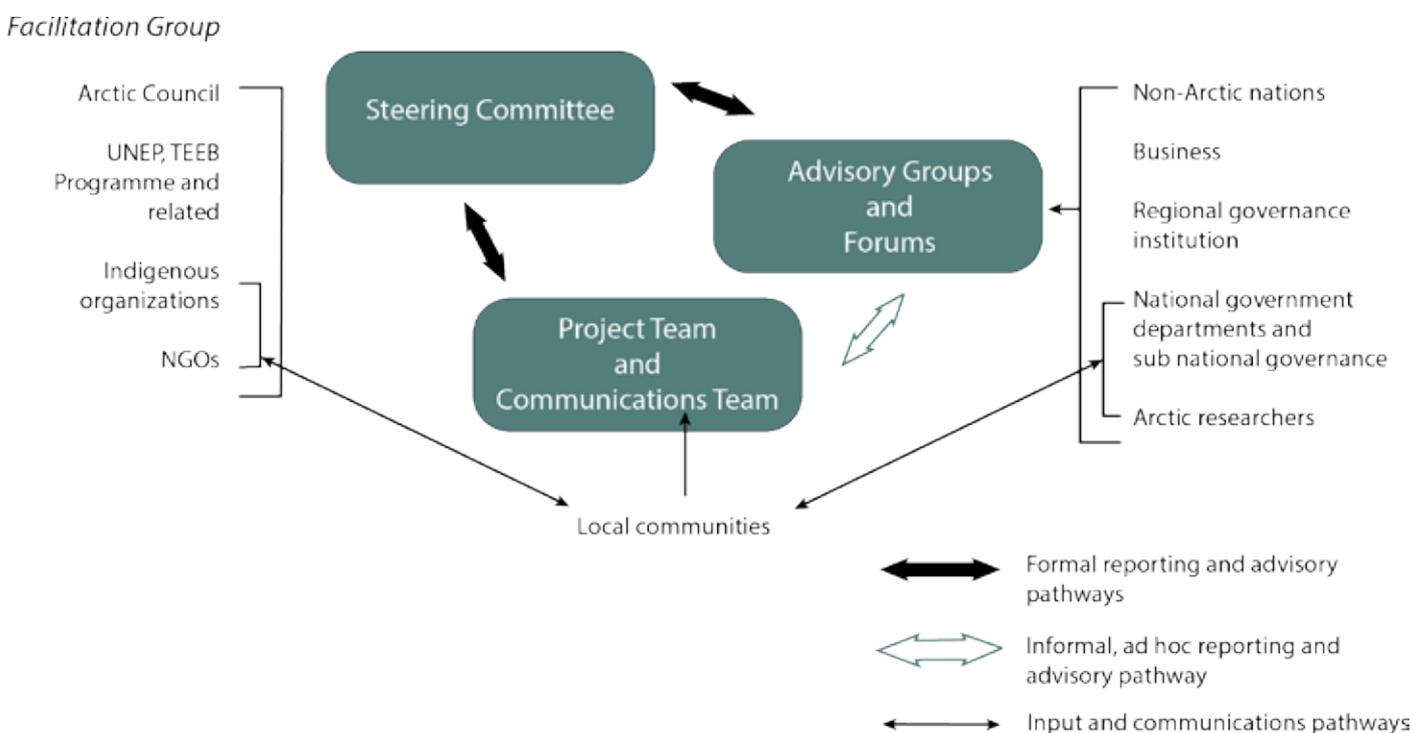
Whatever governance model is chosen, the decision-making process should be made explicit. Note that the TEEB programme recommends not adopting a consensus-based approach, but rather one that provides for minority opinion, dissent, and caveats and concerns to be presented within the framework (TEEB – The Economics of Ecosystems and Biodiversity 2013).

7.7. Work plan and milestones

As there is a suite of options put forward through this scoping study, the first step is to evaluate and make decisions on the options. The next steps are to develop coordination and governance structures, then secure resources.

7.7.1. Work plan for a TEEB Arctic study

The TEEB Arctic study (Part 1 in the suite of options, Section 7.3) could be phased over a four-year period, from its approval to proceed, to its presentation at an Arctic Ministerial Meeting (Table 7.1). The bulk of the analytical work, however, would require a two-year time period (years 2 and 3). Initial time would be needed for start-up, including resource mobilization and engagement of stakeholders. Time would also be needed in the latter phase of the study to allow for synthesis and discussion of results with stakeholders, and to develop and review policy recommendations through the Arctic Council.

Table 7.1. Draft preliminary work plan for a TEEB Arctic study

Activities	Milestones	Timing			
Phase 1: Project start-up • Engage stakeholders • Mobilize resources • Establish project governance and teams • Develop and consult on options and plans (including making decisions about the scope, scale and areas of policy focus) • Begin background work for ecosystem services and policy assessments • Establish working group and linkages with key Arctic Council initiatives and plan collaborative work • Initiate communications activities	• Resources secured • Stakeholders engaged • Governance structure in place • Plans in place • Arctic Council TEEB working group established • Communications team and strategy in place	Year 1 ■	Year 2	Year 3	Year 4
Phase 2: Analytical work • Conduct the six-step assessment process for the TEEB studies • Maintain stakeholder engagement • Conduct awareness raising • Develop methods, tools and information products	• Intermediate products • Completed reviews • Finalized products from both TEEB studies and pan-Arctic initiatives • Communications products	Year 1	Year 2 ■	Year 3 ■	Year 4
Phase 3: Consolidation and reporting • Present, discuss and refine results, analysis of achievements • Develop policy recommendations, including options for policy change implementation and undertake review, including through Arctic Council and through the TEEB programme • Develop project report or report series and additional products geared to meet stakeholder needs • Conduct follow-up planning • Present results and recommendations to Arctic Council Ministerial meeting	• Consolidated, synthesized results, including reports and web presentations • Policy recommendations • Follow-up plans • Stakeholder assessment of project • Communications products • Study and recommendations accepted/endorsed by the TEEB review board and the Arctic Council Ministers	Year 1	Year 2	Year 3 ■	Year 4 ■

7.8.   Budget and resource mobilization

Implementation costs for the project are estimated to be US$1,368,000 over a four-year project period (Annex 5). As with other Arctic Council initiatives, it can be expected that a significant portion of the cost related to expert research and authorship would be in-kind contributions from Arctic countries. A draft budget is presented in Table A5.1.

Resource mobilization will include proposals submitted to the following potential funders: Arctic governments, Nordic Council of Ministers, UNEP, the European Commission and NGOs. Other funding opportunities, such as through research programs, will also be explored.

7.9. Communication strategy

"For subsistence harvesting I think there is already a great appreciation of the value at the local level, but this needs to be extended to the regional, state and federal decision-makers. It is a matter of effectively communicating this value to 'outsiders' or decision-makers." (TEEB questionnaire input)

[Ecosystem services approaches, to be successful,] "need more foothold outside the 'environment realm', and probably improvements in categorization and terminology to reach a broader audience; for the Arctic will also need alignment with Indigenous Peoples' approaches and sets of arguments, and need further development on linking to people who express and 'fight for' values" (TEEB questionnaire input)

Groundwork for communications has been laid, with establishment of a communications team for this scoping study, and a project web site (www.arcticteeb.net). Communications during the scoping study featured an online questionnaire and several communications events, including presentations and panel discussions in conjunction with Arctic Council and other international conferences and meetings.

The strategy developed by the communications team for the scoping study could be revisited and expanded for the follow-up options chosen. The current strategy includes communications objectives, identification of audiences, identification of approaches for communication with the range of audiences, and scoping out of communications deliverables (products and events).
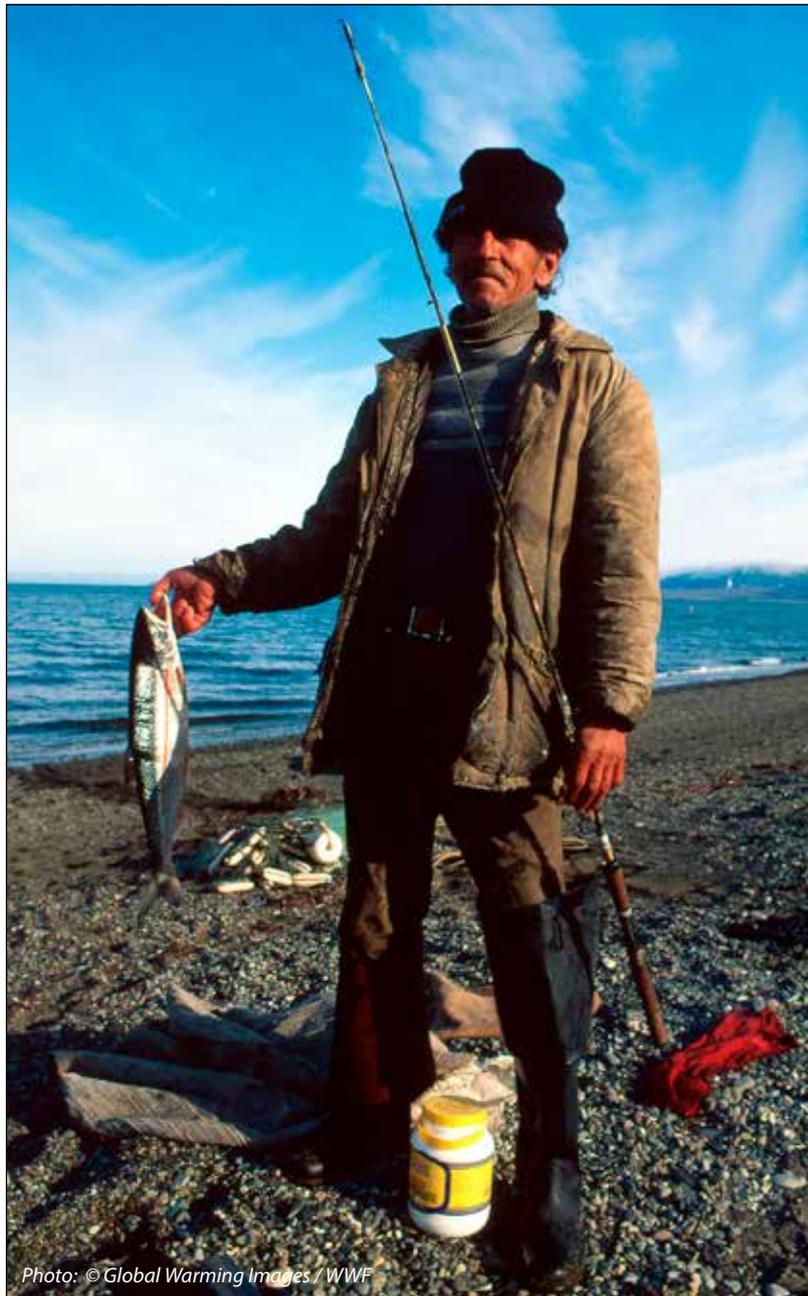
Photo: © Global Warming Images / WWF

Annex 1. Some major international initiatives related to ecosystem services and natural capital

Table A1.1. Major international initiatives related to ecosystem services

Initiative	Overview	Website
The Economics of Ecosystems and Biodiversity (TEEB) Initiated by a 2007 decision by environment ministers from the G8+5 countries meeting in Potsdam; multiple international partners; coordinated through UNEP.	TEEB draws attention to the economic benefits of biodiversity, including the costs of biodiversity loss and ecosystem degradation. TEEB aims to help decision-makers recognize, demonstrate and capture the values of ecosystem services and biodiversity. TEEB studies have been conducted at international, national, and regional scales, and for business and agriculture sectors.	www.teebweb.org
Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Established 2012 as an independent intergovernmental body open to all member countries of the United Nations.	IPBES is being developed as the leading intergovernmental body for assessing the state of the planet's biodiversity, its ecosystems and the essential services they provide to society. IPBES provides a mechanism to synthesize, review, assess and critically evaluate relevant information and knowledge generated worldwide. It aims to strengthen capacity for the effective use of science in decision making at all levels. The IPBES conceptual framework encompasses multiple value systems and knowledge systems and emphasizes the role of governance as the source of problems and solutions affecting nature (Figure A1-1).	www.ipbes.net
Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Broad coalition of UN agencies, governments, various institutions and nongovernmental organizations. Launched at the 2010 CBD meeting in Nagoya, Japan.	WAVES promotes sustainable development through mainstreaming of natural resources in development planning and national economic accounts. The partnership implements Natural Capital Accounting based on internationally agreed standards and develops approaches for other types of ecosystem service accounts.	www.wavespartnership.org
System of Environmental-Economic Accounting (SEEA) Programme under the UN Statistics Division, with handbooks published 1993, 2003 and 2012.	The SEEA is a system for linking of environmental and economic statistics. It organizes statistical data for deriving indicators and descriptive statistics to monitor the interactions between the economy and the environment, and the state of the environment, to better inform decision making. It contains standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics on the environment and its relationship with the economy.	unstats.un.org/unsd/envaccounting/seea.asp
Biodiversity Finance Initiative (BIOFIN) Global partnership launched in 2012 to increase financing to achieve the Aichi targets through the CBD. Managed by the UN Development Programme (UNDP).	The BIOFIN aims to develop and pilot a new approach and methodology for leveraging increased biodiversity investment at the national level. This involves building a sound business case for increased investment in the management of ecosystems and biodiversity at the national level, including developing methodology for quantifying the biodiversity finance gap, improving cost-effectiveness through mainstreaming of biodiversity, and developing resource mobilizing strategies.	www.biodiversityfinance.net

Based on respective website presentations of initiatives

Figure A1.1. IPBES conceptual framework
Boxes and arrows denote main elements of IPBES and their relationships. Black lettering denotes general descriptions; green lettering denotes categories from western science; blue lettering denotes examples of equivalent or similar categories in other knowledge systems. Solid arrows denote main influence; dotted arrows denote other acknowledged links. Colored arrows indicate interactions over scales of time and space. The lines on the right represent scales for IPBES assessments (Díaz et al. 2015b).
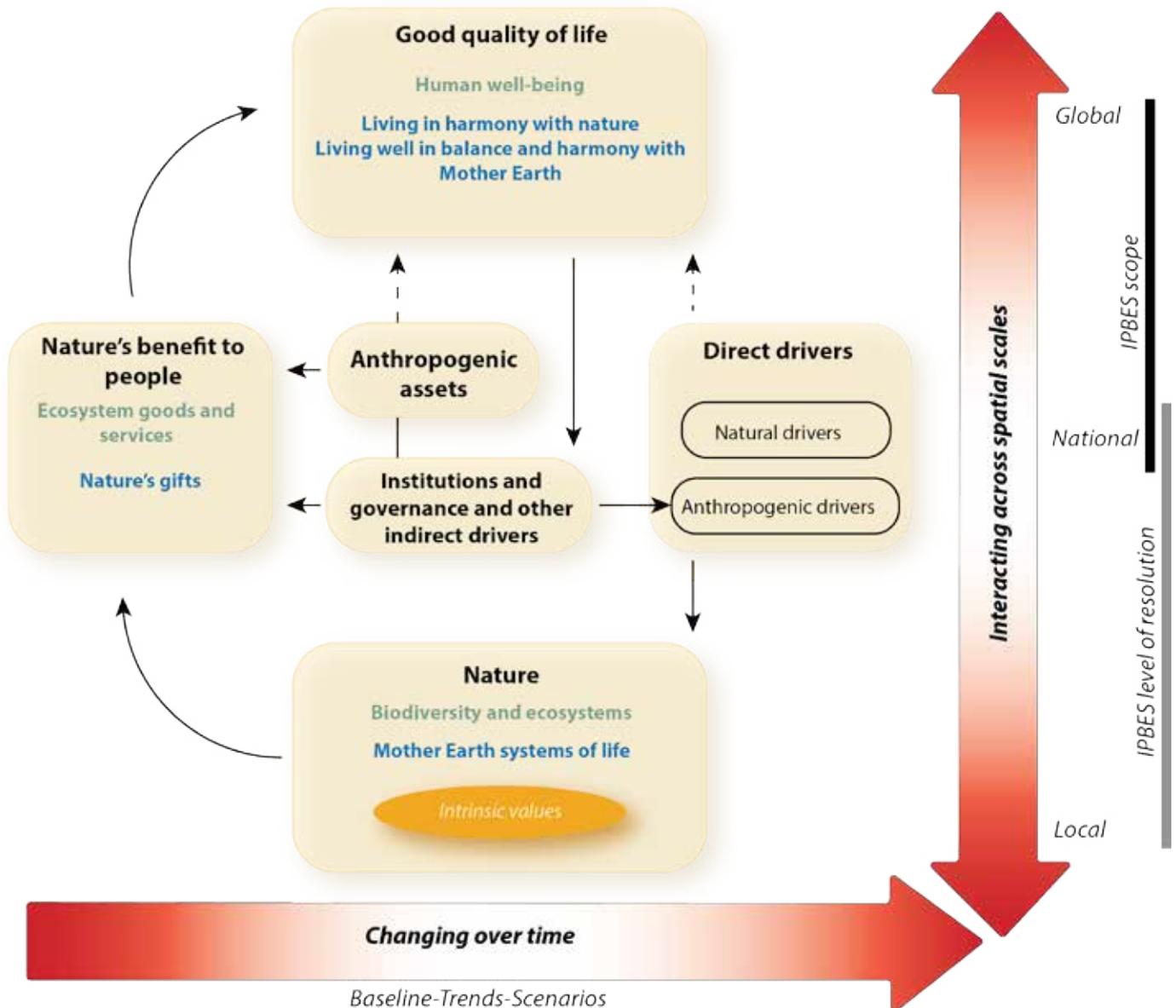
Annex 2. Overview of the TEEB six-step approach

Table A2.1. TEEB six-step approach

Steps	Step 1. Refine the objectives of the study by consultations on the key policy issues with stakeholders	Step 2. Identify the most relevant ecosystems and ecosystem services	Step 3. Define information needs and select appropriate methods	Step 4. Assess and value ecosystem services	Step 5. Identify and outline pros and cons of policy options, including distributional impacts	Step 6. Review, revise, and report study results
Key outputs	Clearly defined objectives and scope for the study, with the appropriate level of stakeholder involvement, especially from national and local policy-makers. Basic grasp of the differences in perspectives and potentially conflicting interests across different policy dependencies as well as impacts, including with a focus on gender analysis. Understanding of which institutions currently govern ecosystems and biodiversity and how decisions are made. Brief problem statement that can be referred to in order to guide the study	Basic understanding that can guide assessment of how different stakeholders value and prioritize ecosystem services. Key concerns identified with regard to ecosystem degradation or loss, the main drivers and trends, and related stakeholder groups. List of prioritized ecosystem services which are linked to the objectives of the study.	Clarity on what information needs to be generated and how this information will be used to further the overall objectives of the study. Decision made regarding methods to be used and desired output formats (e.g., maps, index, aggregate value, or number of people affected). Clarity on key data sources and matching of intended methods with data, time, capacity and resources available for conducting the analyses.	Assessment and possibly economic valuation of relevant ecosystem services according to Step 3, possibly including the trends in usage, degradation, ecosystem health, and resilience. Consideration of the key drivers of changes (what and by whom) in ecosystem service provision, and how stakeholders are affected by the changes. Understanding of how the benefits associated with ecosystem services and the costs associated with their degradation are distributed	Outline of currently existing policies and alternative policy options or measures, tested against consistent criteria including distributional implications. List and brief description of policy options or measures which show promise, giving a broad rationale. If relevant, assessment of ecosystem service provision under different policy scenarios or use options, including the trade-offs involved. Recommendations on how to best deal with un-avoidable negative distributional impacts that may arise, including with a focus on gender.	Ensure comments are adequately addressed. Final reporting adapted to the needs of decision-makers and target audiences. Statement of recommended criteria and indicators to be considered for impact analysis and monitoring, after recommended policy changes are implemented.

From Guidance Manual for TEEB Country Studies (TEEB – The Economics of Ecosystems and Biodiversity 2013)

Annex 3. Policy example: Expansion of marine oil and gas activities and marine shipping

Authors: G. Stetson, J. Eamer, M. Fidel and S. King
Contributing authors: C. Armstrong, T. Barry, M. Sommerkorn and R. Corell

Contents

1. Introduction

The purpose of this policy example is to prepare the groundwork for a full TEEB Arctic assessment on this topic. As such, overviews are presented of some important ecosystem services and the current policy and governance setting. Policy approaches that focus on sustainability of ecosystem services are presented and discussed in relation to the added benefits these policies may provide to selected important ecosystem services. The policy and governance setting is by definition transitional, as this example is about change: the current and projected expansion of industrial activity in a rapidly changing Arctic marine environment (see the 'Arctic issue scan', Section 1.7). Many of the challenges that this imposes are best addressed through strengthening and developing regulatory frameworks for environmental protection and safety. This policy example looks at where TEEB policy approaches will most benefit and find most accord with ongoing and emerging Arctic Council work.

This policy example builds on chapters 2 'Arctic ecosystem services', 3 'Governance of Arctic ecosystem services' and 4 'Valuing ecosystem services in the Arctic', including the input from respondents to the online questionnaire highlighted in those chapters and in Annex 3a. It also includes and draws material from the regional case study on the Aleutian Islands and the Unangax people, Annex 3b. This regional study raises many points that are broadly applicable. For example, there are similar issues in the Bering Strait, where people are concerned about how increased shipping traffic will impact their subsistence way of life (Fidel et al. 2012; Stetson 2014).

### Expansion of industrial activity in the Arctic marine environment

Climate change and globalization are leading to an expansion of oil and gas and marine shipping activities in the Arctic region. Although these activities bring potential economic benefits, if not carefully addressed, they also bring considerable risk, especially to users of ocean resources who depend on these resources for nutrition, income, and cultural identity (PAME 2013b).

Marine shipping activities consist of trans-Arctic and destination shipping, and includes bulk carriers, container ships, general cargo, government vessels, oil and gas service vessels, passenger ships, pleasure crafts, tankers, tugs/barges, and fishing vessels (Arctic Council 2009). Since 2008, vessel traffic has increased significantly in the Arctic region. The Northwest Passage (Figure 1.6) is not yet considered a viable ship route, although there has been an increase in cruise ships and adventure boats. However, if current warming conditions continue, destination traffic is expected to increase significantly, bringing natural resources (oil, zinc, gold, etc.) to global markets. The Northern Sea Route (NSR) is experiencing a significant increase in vessel traffic. A snapshot of vessel activity along the NSR in 2013 is shown in Figure A3-1 The NSR is primarily used as a domestic supply and export route for Russia and, to a lesser extent, as an international transportation corridor by countries in Europe or Asia. The export of Arctic hydrocarbon resources, primarily from Russia, and their transport along the NSR, is expected to grow.

However, this will not in itself establish the NSR as a trade route, but will increase one-directional traffic of ships laden with oil products from west to east (Humpert 2014).

Figure A3.1. Cargo transported and trips along the NSR, 2013
Total cargo was 1,350,000 tons from late June to late November. A further 22 vessels transited the NSR unladen, carrying 507,000 tons of ballast. Total number of trips was 71. Partial transits departed from or arrived at ports within the NSR. Traffic connected ports as far west as Ammassalik, Greenland, and as far east as Vancouver, Canada, in total calling in on 47 ports in 14 countries. Murmansk and Pevek (Russia) were the main ports for departures and arrivals (Humpert 2014).
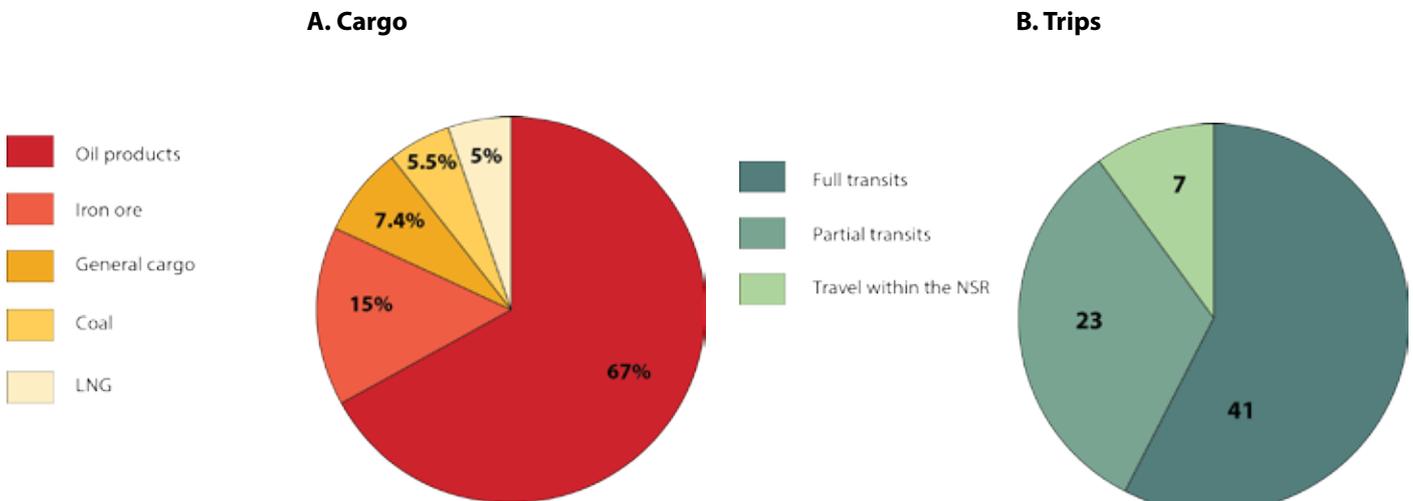
A. Cargo　　　　　　　　　　　　　　　　**B. Trips**

Humpert, M. 2014. Arctic Shipping: An Analysis of the 2013 Northern Sea Route Season. The Arctic Institute Center for Circumpolar Security Studies.

Oil and gas development, which leads to increased shipping and other maritime activities, is projected to expand significantly in the Arctic region. This would include tug and barge and tankers, seismic survey vessels, and other oil and gas related vessels such as mobile offshore drilling units. In 2010 and 2011 there were drilling operations off the west coast of Greenland, in the Norwegian Arctic and in the Chukchi and Beaufort Seas, and two shuttle systems are operating year round in the Barents Sea of the Russian Arctic (PAME 2013d).

Arctic transit shipping routes are shown in Figure 1.6 and oil and gas basins are shown in Figure A3.2. An overview of projected increases in marine industrial activity is in Section 1.7 ('Arctic issue scan').

Figure A3.2. Major oil and gas provinces and basins around the Arctic (AMAP 2010a)
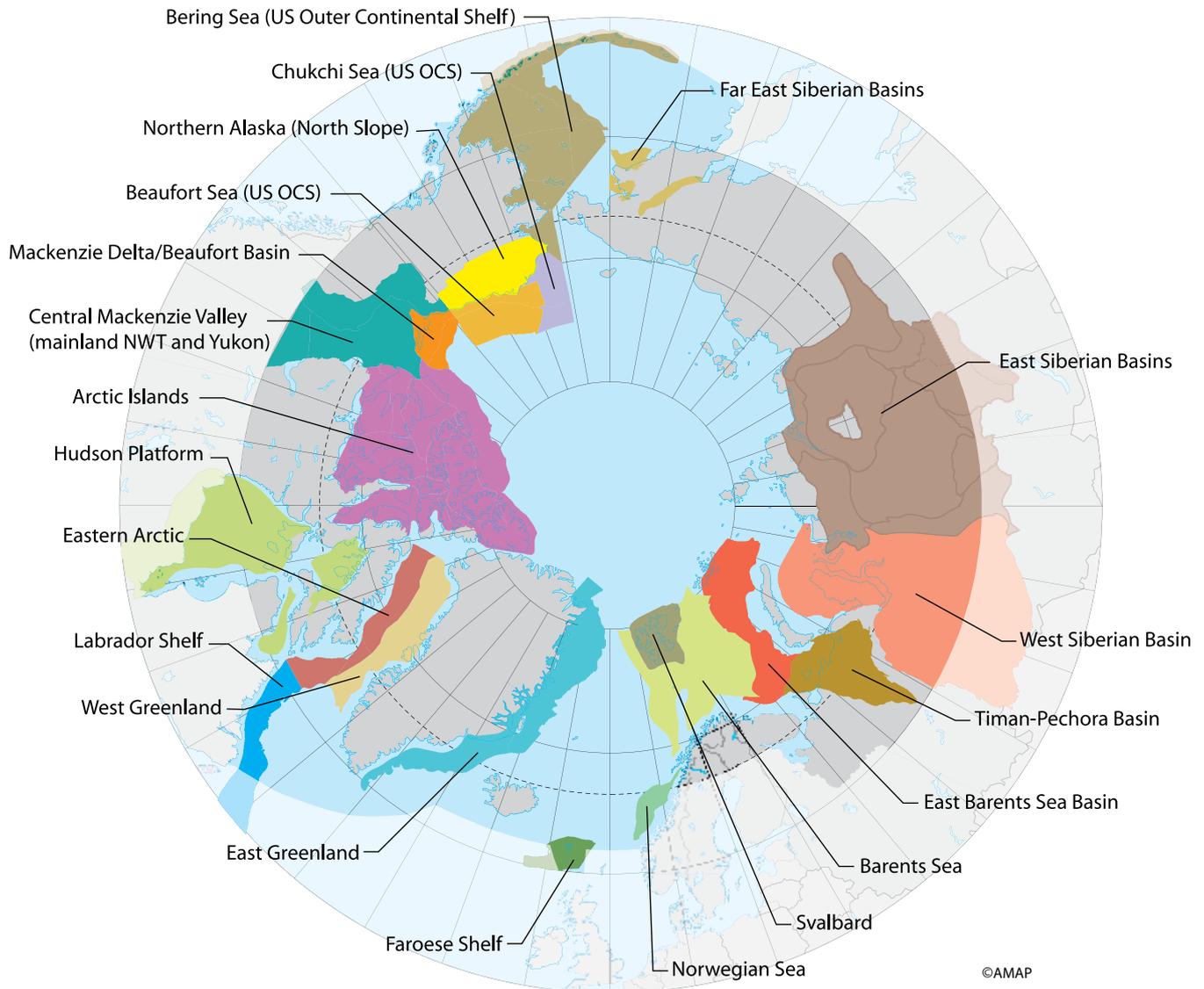
2. Ecosystem services

2.1 Overview of services

Arctic marine ecosystems provide subsistence, cultural, aesthetic, scientific, ecological and spiritual resources to communities throughout the Arctic region (see Chapter 2 'Arctic Ecosystem Services', and Annex 3b on the Aleutian Islands).

In many Arctic regions people are dependent upon these provisioning and cultural services. For coastal Indigenous Peoples, including the Inuit, coastal Saami, Aleut, Koryak, Chukchi and others, in addition to nutritional values, marine ecosystem services are closely connected to deep cultural and spiritual values.

Harvesting from the sea plays an important role in food security and traditional economies in many indigenous communities. The government of Nunavut, Canada estimates that the annual cost of substituting imported food for that obtained from subsistence hunting and harvesting would be C$35 million (Wenzel 2009). In many communities, marine resources provide a significant portion of this harvested food. For example, ringed seals provide over half the annual biomass captured by Inuit hunters in the Clyde River area of Canada (Wenzel 2009).

Ecosystem services also provide economic value to Arctic residents through commercial fishing and tourism.

Fisheries

Harvesting from Arctic seas plays an important role in food security at an international level. Arctic regions supply substantial provisioning services in the form of seafood, and thus potential trade-offs between oil/shipping expansion and seafood is a broader issue than purely in relation to the Arctic populace.

Commercial fisheries of global importance take place in the Bering Sea and the Aleutian Islands, the Northwest Atlantic between Canada and Greenland, the waters around Greenland and Iceland, the Norwegian Sea and the Barents Sea. These large-scale fisheries are also important to national and, in some areas, local economies (Huntington et al. 2013a). Commercial fisheries in Arctic seas account for over 10% of the global supply of commercially caught fish (Huntington et al. 2013a).

The importance of Arctic fisheries extends beyond these major commercial fisheries, but other commercial and subsistence fisheries are less well-documented, and their values may be less visible when decisions involving trade-offs are made (see Box A3.1).

Arctic commercial fisheries, like the shipping and oil and gas industries, are expected to change and to expand. Climate change is predicted to lead to a redistribution of global catch potential, one estimate being for a 30 to 70% increase in high latitude regions, and a drop of up to 40% in the tropics (Cheung et al. 2010). Arctic/subarctic Exclusive Economic Zone regions that are predicted to increase most in fisheries potential by 2055 in this analysis are Norway, Greenland, United States (Alaska) and Russia (Asia).

Anadromous fishes (spending part of their life cycle in the sea and part in fresh water) are also important to consider in relation to the ecosystem services they provide to inland communities. Arctic char and salmon and whitefish species are examples of fishes that are important as freshwater subsistence, commercial and sport fisheries in some Arctic areas (Christiansen et al. 2013). Impacts on anadromous fish stocks in the marine environment could affect ecosystem services relied on by people who live far from the coast.

Box A3.1. Estimating Arctic fisheries catches for Russia, US and Canada

Based on Zeller et al. (2011)

Most of the catches from small-scale operations are not reported to the FAO (United Nations Food and Agriculture Organization) for Fisheries Statistical Area 18, which covers about two-thirds of the Arctic marine environment. FAO Area 18 comprises the following Large Marine Ecosystems: the Beaufort, Chukchi, East Siberian, Laptev and Kara seas, the Arctic Archipelago, Hudson Bay and Arctic Ocean.

Total catch from commercial and subsistence fisheries in FAO Area 18 from 1950 to 2006 was estimated to be about 75 times higher than the sum of catches reported by FAO for this area over the same time period. Estimates were based on community-based reconstructions for Alaska and Canada, and government records for subsistence fishing from Alaska and commercial fishery catches for Alaska and Canada. A range of government and non-government sources was used to reconstruct catches for Siberia – with a high level of uncertainty.

Some conclusions from this study:

▶ The importance of Arctic fisheries is underestimated.
▶ Fisheries are widespread, mainly in estuaries and river deltas and other protected waters.
▶ Main fisheries, based on reconstructions, were:
- In Siberia, various whitefishes;
- In Alaska, various salmonids: chum salmon (in Kotzebue Sound) and whitefishes (in Colville Delta); whitefishes, chum salmon and Dolly Varden in subsistence fisheries (based on analysis of 15 communities);
- In Canada, whitefishes and inconnu (Stenodus leucichthys) in the Beaufort Sea, Arctic char in the Arctic Archipelago (based on analysis of 51 communities, 26 of which had small commercial fisheries over varying periods from 1950 to 2006.)
▶ The trend in estimated total catch from 1950 to 2006 declined from about 24,100 t/year in 1950 to about 10,200 t/year by the mid-2000s, influenced by various socio-economic drivers (e.g., increased availability of imported foods; reduction of subsidies in Siberia following the collapse of the Soviet Union; transition from sled-dogs to snowmobiles in Alaska and Canada in the 1960s to1970s.)

Tourism

Marine-based tourism represents the largest sector of the Arctic tourism industry (Arctic Council 2009). The industry is highly diversified in the Arctic , including: mass market tourism related to sight-seeing opportunities; sports fishing tourism; nature tourism related to wildlife watching and experiencing the beauty of natural areas; adventure based tourism; and, cultural tourism related to interactions with Indigenous Peoples. Cruise ship travel is expanding, with Arctic routes/destinations including Svalbard, Greenland, the Canadian Arctic, the Northern Sea Route, and the White and Barents seas (Huntington et al. 2013a). Most Alaskan cruises are still to destinations south of Arctic waters, but the number of cruise ships travelling north of the 66th parallel more than doubled from 2004 to 2012 (Conley et al. 2013). The cruise ship industry considers Arctic voyages to be a potentially lucrative market, with passengers prepared to pay between USD2,900 and USD55,000 per person (Arctic Council 2009). Visits to Arctic communities hosting cruise ships can also provide a source of additional income. For example, communities on Baffin Island in the East Canadian Arctic regularly host cruise passengers (Stewart et al. 2007). However, in many Canadian communities the economic benefits may not meet expectations due to infrequent visits, sea ice and weather forcing diversions and poor communication between the cruise operators and the communities (PAME 2014).

Status and trends of, and threats to, biodiversity and ecosystems that Arctic marine ecosystems depend on are described in ABA chapters on marine ecosystems (Michel et al. 2013), fish (Christiansen et al. 2013), birds (Ganter et al. 2013) and mammals (Reid et al. 2013), and in CAFF's report on sea-ice associated biodiversity (Eamer et al. 2013). The ABA chapter on provisioning and cultural services (Huntington et al. 2013a) features discussion of cultural and provisioning services related to marine subsistence activities and commercial fishing.

2.2 Impacts

The expansion of oil and gas and shipping presents formidable risks to Arctic peoples due to their close reliance on ecosystem services. One of the greatest concerns is the risk of a major accident (e.g., oil spill or ship grounding) that could do irreparable harm to marine ecosystems. The most serious problem may be related to the inability to respond effectively to a major accident, as response is limited in remote areas of the Arctic (Arctic Council 2009). Moreover, the biological degradation process of oil is slower in the Arctic than other regions because of extremely low temperatures, the presence of ice and permafrost, and extended periods of darkness (AMAP 2010a). For Arctic people who depend on a limited supply of marine resources, any disturbance to the ecosystem or diversion of animals away from contaminated areas places their immediate food security at risk.

Increased shipping and oil and gas development also brings the potential for chronic pollution problems that, if not effectively regulated, will impact marine ecosystems and their services. Environmental impacts typically include the release of black carbon and other air pollutants and greenhouse gases, ship discharges of oily bilge water, ballast water that carries potentially invasive species, and garbage and other debris from ships. Arctic people who live near coastal waters, especially subsistence hunters, are also concerned about noise pollution, ship strikes on marine mammals, and dangerous encounters with large vessels (Huntington et al. 2013a).

Effects and potential effects of oil and gas activities in the Arctic on biodiversity, ecosystems and ecosystem services highlighted in Arctic Council's assessments on oil and gas activities (AMAP 2010a) and shipping (Arctic Council 2009) include
  ▶ toxic effects of hydrocarbons, drilling fluids, or other toxic substances on aquatic organisms, from single-celled organisms at the base of the food change up to marine mammals. This includes both lethal effects (e.g., killing organisms outright after an oil spill or a ship strike) to sub-lethal effects (damage to the organism that affects its health or reproduction);
  ▶ habitat damage (from spills) and changes to food webs and balance of predator and prey organisms from many potential sources, including toxics and introduction of alien species, with long-term effects at the population level;
  ▶ tainting (causing undesirable tastes or odors) of fish from spilled or leaked hydrocarbons, affecting commercial and subsistence fisheries;
  ▶ noise in the marine environment, from seismic activity and shipping, affecting animal distribution and behavior, and accessibility to harvesters;
  ▶ cumulative toxicological effects – both on individual organisms (effects from several sources or types of stress) and on populations, through impairment of reproduction; and
  ▶ health and economic impacts on humans from tainting or contamination of food sources and/or changes in seaweed and animal abundance and distribution.

Other economic impacts may result from the perception of increased activity and potential pollution in the Arctic seas. For example, the perception of less clean waters may lower the market value of fish caught in the Arctic and species raised in aquaculture facilities in Arctic and subarctic waters, as well as reducing the attractiveness and economic value of Arctic seas as international tourism destinations.

Many of these potential impacts are identified based on studies in other parts of the world, with little Arctic-specific knowledge on their nature and scale. For example, ballast water is a major transport vector of aquatic non-indigenous species worldwide, but very few studies have examined the magnitude and significance of this vector in the Arctic (Chan et al. 2013).

Insufficient information specific to impacts on Arctic ecosystems can lead decision-makers and stakeholders to endorse oil and gas extraction activities based on information that may underestimate uncertainty and the extent of potential risk (Mcdowell and Ford 2014).

Cumulative effects

The cumulative effects from chronic pollution, general noise and seismic activity from increased gas, oil and shipping activities in the Arctic marine setting have the potential to disrupt marine mammal migratory routes and distribution. This could be exacerbated by potential invasions of non-indigenous species associated with increased ship movements in the region, which can negatively affect fish stocks with established fisheries, as well as other aquatic species. Increased shipping traffic could result in areas becoming unsafe for both commercial and subsistence fishing and possibly disrupt local trade routes. Furthermore, continued, piecemeal infrastructure development associated with extractive industries can make areas less attractive to tourism and impair cultural services.

When considering cumulative effects from industrial expansion, the combined and interacting stressors from other sources need to be taken into account (for example, Box A3.2).

Box A3.2. Overview of anthropogenic drivers of change for the Barents Sea ecosystem

Based on report on the joint Norwegian-Russian Barents Sea Ecosystem (Arneberg et al. 2009)

The anthropogenic driver with the largest effect is currently fisheries: overfishing of smaller stocks and damage to benthic communities from bottom trawling (especially effects on coral sponges and sea anemones). By-catch has declined but is still a problem, as is lost gear such as gillnets. Estimates of these impacts are not available. Climate change is another anthropogenic driver of change. Oil and gas and shipping thus far do not have significant direct impacts on the ecosystem, but this may change with the expected increased level of activity. Ocean acidification caused by anthropogenic emission of CO_2 is an emerging problem. The Arctic region has increased tourism, but little is known about the impact of this in the Barents Sea. Aquaculture may affect ecosystems (escaped fish, pathogens and pollution) but the overall scale of impacts is also not known. The largest documented drivers are fisheries and climate change – and there are strong interactions between these.snowmobiles in Alaska and Canada in the 1960s to1970s.)

Climate change

The provisioning and cultural services that are provided by marine ecosystems are also at risk from a range of climate change-related impacts on regulating and habitat/support services, as outlined in Section 2.3.1. These include changes in fish, bird and marine mammal habitats and seasonal timing related to sea ice loss, shifts in ranges of species, changing food webs, and effects of ocean acidification on marine life.

The combined effects of climate change and of marine industrial activities introduce additional uncertainties. For example, changes in Arctic sea ice may also result in increased interaction between migrating species and ships; black carbon emissions from ships operating in the Arctic may have regional impacts by accelerating ice melt; industrial facilities on the coast and off-shore may need to be stronger to withstand additional stresses from increased wave action resulting from more open water; and, increased potential for calving of icebergs driven by climate change presents a risk both to offshore platforms and shipping (Arctic Council 2009). The net result of these added risks and interactions is to increase uncertainty around projections of future ecosystem services.

2.3 Summary of ecosystem services and beneficiaries

Based on the Scoping Study findings, selected important services provided by the Arctic marine and coastal ecosystems and affected or potentially affected by oil and gas and by marine shipping activities are summarized in Table A3.1. Services found in the initial review to be most affected are provisioning, cultural and habitat/supporting. The outline of costs and benefits highlights the issue of externalities (see Chapter 3). Costs of impacts from global greenhouse gas emissions on Arctic ecosystems are not paid for by those who benefit (the global community of producers and users of fossil fuels). Costs of the impacts and risks to coastal communities from increases in shipping in the Arctic are not integrated into international policy instruments that govern the industries involved.

Table A3.1. Summary of selected marine ecosystem services affected by expansion of shipping and oil and gas activities

Ecosystem services (grouped)	Who benefits	Who stands to lose or incur costs from policy to maintain services	Main risks and impacts to services	Who affects the services*	Notes on linkages to other stressors
Marine mammal and bird harvest by Indigenous Peoples (diverse and interconnected **provisioning** and **cultural** services, including transmission of Traditional Knowledge)	Coastal Indigenous Peoples and other locals; cultural tourism, others through art, crafts and storytelling (both directly and indirectly, globally, e.g., through inspiration and education)	Oil and shipping industries (potential loss through restrictions on activities)	Damage, including food contamination, and/or loss of harvested species from spills, disruption of animal movements and behavior from activity and noise; disruption of hunters' and fishers' access; loss of cultural services	Shipping industry; oil industry; government (e.g., spill response capacity/ regulatory framework); Indigenous Peoples (harvest management); ecotourism industry (disturbance)	Climate change impacts on marine mammal, bird and fish abundance and distribution; socio-economic factors affecting traditional practices (e.g. affordability of fuel and equipment)
Commercial and main subsistence fisheries (**provisioning**)	Fishing industry; government revenue; international consumers; Regional/local residents through employment and business opportunities (in some areas)	Regional/local residents, Indigenous Peoples (e.g., through stock depletion, harm to other harvested species, and disruption of / competition with subsistence fishing)	Depletion of stocks from spills, chronic pollution, introduction of invasive species, including parasites and disease organisms, e.g., through ballast water; fish tainting; perception of less clean waters affecting market values	Fishing industry itself (through overfishing, effects of bycatch, bottom trawling); government (through regulatory framework); oil and shipping industries (risk of spills); market forces	Changing fish stocks related to climate change (both increases and decreases; changed distributions, with species moving north)
Ecotourism, cultural tourism and recreation (**cultural** services)	Tourism industry (international, e.g. cruise ships, to local); all local residents (from recreation)	Oil industry (potential restriction of operational areas); Indigenous Peoples (e.g. user conflicts with sport fishing)	Loss of marine and coastal wilderness and loss of wildlife viewing due to industrial development	Oil industry; Indigenous Peoples and other local residents (through restrictions or support); governments (e.g., through protected areas)	Economic climate affects tourism opportunities; climate change opens new areas to ship passage
Marine habitat/supporting services (especially food web services that contribute to food web maintenance and services maintenance, e.g. nutrient cycling)	Coastal Indigenous Peoples and other locals through cultural and provisioning services; fishing industry; global benefits (e.g., inspiration for art and culture)	Industry (potential losses from restrictions or requirements)	Alteration of food webs (e.g. through invasive species introduced in ballast water or through aquaculture; effects on forage fish of bycatch); damage to habitat from spills, pollution or physical alteration	Oil and shipping industries; fishing industry; governments (through regulations)	Diverse climate change impacts on marine ecosystem function, including through warmer waters, ocean acidification, loss of sea ice. Gamut of effects from changes in primary productivity to loss of habitat for marine mammals

Ecosystem services (grouped)	Who benefits	Who stands to lose or incur costs from policy to maintain services	Main risks and impacts to services	Who affects the services*	Notes on linkages to other stressors
Climate change regulation (regulating service)	All, globally	--	Greenhouse gas emissions; positive feedbacks in Arctic (e.g., from loss of sea ice) enhancing global climate change	Multiple sources of impacts are mainly external to region; Arctic oil and shipping industries (sources of greenhouse gas emissions and black carbon)	Major threat to Arctic biodiversity; interacting with other sources of impacts

* Impacts are not necessarily negative – e.g. good spill response capacity is a positive impact, and local people might have potential for both positive and negative impacts on an ecosystem service

3. Current governance and policy settings

3.1 Overview

The current governance framework related to oil and gas and shipping in the Arctic is based on a combination of regional and international agreements that include some national, sub-national, and supranational legislation, but is generally based on a soft law approach that focuses on scientific advice and policy recommendations. Although the Arctic marine region crosses national and international jurisdictional spaces, it is largely up to coastal states to implement national and international regulations and standards to protect Arctic ecosystems. Aside from the newly approved Polar Code (IMO 2014), there are virtually no international legally binding regulations that are specific to the Arctic marine area, which arguably leaves the region underprepared for any significant increases in oil and gas and shipping activities in the region (see Best et al. 2009, p. 2).

There has been significant recent progress on policies and governance regimes to address the impacts of oil and gas and shipping in the Arctic at the international level. For example, the Arctic Council's Arctic Marine Shipping Assessment (AMSA) (Arctic Council 2009) provides a framework of recommendations around three key themes: 1) enhancing Arctic marine safety, (2) protecting Arctic people and the environment, and (3) building Arctic infrastructure. There have been several initiatives directed towards these ends. Two of the most important are the Agreement of Cooperation and Aeronautical and Maritime Search and Rescue in the Arctic and the Agreement on Cooperation on Maritime Oil Pollution and Preparedness and Response in the Arctic. There has also been progress on the monitoring of ships, improved Arctic charting, and communication schemes. Importantly, these agreements set a precedence for collaboration at the international level between Arctic states on critical issues in the region (PAME 2013b).

There has also been important work that is closely related to oil and gas and shipping and will lead to continued policy collaboration between Arctic states and the International Maritime Organization (IMO). For example, recent annexes to International Convention for the Prevention of Pollution from Ships (MARPOL) include provisions on sewage, garbage, and emissions, and the IMO's work on the Polar Code is expected to go into effect in 2017 and 2018. The Polar Code includes a range of design, construction, equipment and training requirements relevant to ships operating in polar waters. The IMO is also working on initiatives on black carbon, heavy fuel oils, and ballast water, ship routing, and anti-fouling systems (PAME 2013b).

Oil and gas development, in contrast to international shipping, is subject to the jurisdiction of coastal states and to operational procedures that rely on industry standards. As a result, there are differences among national and subnational regulatory frameworks. However, operational procedures are largely defined by common industry standards and practices. Here international and regional agreements provide opportunities for collaboration between countries on policies and guidelines for safe and environmentally sound practices. To a certain extent, these policies have been based on a precautionary approach and a polluter pays principle, concepts that will be important for future policy work.

Global instruments such UNCLOS, MARPOL, the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), and the London Convention (1996 Protocol on oil pollution) address certain aspects of marine pollution, but do not provide a comprehensive regulatory regime for oil and gas or shipping. Regional mechanisms are more promising. As mentioned, the Arctic Council's agreements on search and rescue and oil pollution prevention facilitate regional collaboration. In addition, the OSPAR Convention on the Prevention of Marine Pollution from Land-based Sources is described as a 'robust regional convention' that could represent a model for Arctic-wide standards for environmental monitoring of oil and gas development (PAME 2013b). The agreement includes all five Nordic members of the Arctic Council and works closely with the Arctic Council's AMAP working group and the IMO. These governance arrangements and policies, however, do not necessarily address the diversity values of ecosystem services in the Arctic, especially from the perspective of Arctic Indigenous Peoples, for whom the stakes are especially high.

Overall, the current state of international and regional governance on shipping and oil and gas reflects coordination and goodwill at the international and regional levels, but relies heavily on the capacity of individual Arctic states to implement measures at the national or sub-national level, leaving a fragmented governance regime that will be hard pressed to respond to the rapidly changing Arctic environment, where biodiversity and ecosystems services are at risk.

3.2 Discussion

A TEEB approach requires that governance arrangements invite a diverse spectrum of knowledge and value holders to participate in and influence policy. In its current state, governance surrounding oil and gas and shipping, aside from a few innovative examples, is not sufficiently inclusive of a wide variety of knowledge and value holders.

The TEEB approach addresses this issue (inclusivity of values) in three distinct ways: 1) it highlights the importance of governance fit and scalability; 2) it explicitly incorporates multiple value and knowledge systems (and does not interpret all values and knowledge through an economic lens); and 3) it helps to structure governance and policy around precautionary principles of environmental governance (Iverson and Perrings 2011).

Governance fit and scalability

Identified policy shortfall: Governance and policy reflect cost, benefits, and risks according to the presence or absence of different stakeholders and rights holders, and the current governance approach in oil and gas and shipping has relied to a large extent on international and regional level agreements and venues that are not well represented by local stakeholders and rights holders.

One of the key challenges of Arctic governance relates to the issue of scalability. In order to design and implement policies that fully protect Arctic sustainability from an economic, ecological and cultural perspective it is important to consider the voice of those that depend on ecosystem services for survival. However, consideration of local voice requires governance arrangements that are able to scale up local input to international levels where key policy decisions are made that will impact local spaces. This is challenging. It requires an understanding of the small-scale uses of ocean resources and the values that local peoples give to ecosystems and the services they provide. Even more challenging, it also requires an understanding of the local governance modes that are used to express beliefs, opinions, and ideas in a public forum. Finally, it requires a sustainable governance process where local values are fully integrated into the decision-making process.

Oil and gas extraction and shipping are global industries that distribute costs, benefits, and risks differently across scales. A TEEB approach to policy would concentrate on the distribution of costs, benefits, and risks associated with a wide spectrum of knowledge and value holders of ecosystem services. The benefits of oil and gas development tend to accrue at the global scale (i.e., national energy prices, profitability for multinational companies, etc.), while the costs and risks are higher at the local scale. Local communities that depend on ecosystem services for subsistence would bear extraordinarily high costs in the event of a major oil spill, while oil companies, shipping companies, insurance companies, regional and national governments, and others might incur certain financial costs and risks, but these are lower relative to risks at a local scale. Some examples of how ongoing shipping activities impair ecosystem services are listed in Box A3.3. Local communities, of course, can also benefit marine industrial activities, but benefits tend to be localized to specific groups and areas. For example, some Iñupiat communities of the North Slope in Alaska, located close to oil and gas operations, may benefit economically from oil and gas development, while also encountering risks and costs. Other indigenous communities might only incur the risks and costs (see Annex 3b).

Box A3.3. Some costs and risks to Canadian Inuit from shipping

Based on "The sea ice is our highway: An Inuit perspective on transportation in the Arctic" (ICC - Canada 2008)

These examples of reported activities associated with shipping do not meet the Inuit standard of sustainability – the continuation of the Inuit way of life for thousands of years to come.

▶ Oil leaks from port facilities, leading to oil slicks on the bay, and "*You wouldn't see a seal up in the bay now. You wouldn't get one up there to save your soul*" (Makkovik, Nunatisavut).

▶ Ships break up the ice and the whale hunters cannot cross the ice safely. "…*because of the ice conditions that the ships left, there was almost like a disaster. We lost skidoos and equipment [when they fell through the ice].*" (Arctic Bay, Nunavut).

▶ When the big boats are off-loading, with lights on, that scares off some of the marine mammals and hunting is affected. "*There are less animals that come around our shores if there's a big boat off-loading, with its big lights and so on*" (Puvinituq, Nunavik)

▶ Ship traffic in and out of the harbor interferes with setting fishing nets in the channel in the fall. The ships pass back and forth over where the fishing nets are set. "*Usually with that kind of thing, we do have a say on whether the ships can use the area, but times are changing and every year we get applications to come into the harbor later and later.*" (Tuktoyaktuk, Beaufort Sea coast)

▶ Tourism brings some benefit and some loss. Cruise ships help the artists because the tourists buy carvings and craft work. "*But hunters have been complaining about those ships because they go all over Cumberland Sound, even to the campsites. People are saying they are scaring away the animals, the mammals and whales*" (Pangnirtung, Nunavut).

Consideration of distributional impacts is important at all phases of development, including the leasing and exploration phases, which are generally subject to either no review of impacts or less rigorous review and assessment than required for development phases. Seismic testing as part of oil exploration, of concern to Inuit communities because of potential impacts of noise on marine mammals, brings no local benefits and may involve little consultation with beneficiaries of the marine mammal-associated ecosystem services (e.g., conflicts over permitting of seismic testing in the Arctic Archipelago, CBC News 2014).

There has been progress in involving local actors in governance regimes and many decision-makers are aware of the need to involve them (see Box A3.4). However, bringing the interests and voice of local actors (including coastal Indigenous Peoples and coastal communities) to complex multilateral governance arrangements is challenging. It requires an understanding of the way governance works across scales, including small-scale village-level governance, sub-regional (state, territory, borough, district, municipal, etc.), national, regional and international levels of governance. Most importantly, it requires an understanding of how participation in governance can influence policies so that diverse perspectives on costs, benefits and risks are manifested in policy decisions and outcomes.

Box A3.4. Examples of multi-scalar governance mechanisms for Alaska

Open Water Season Conflict Avoidance Agreement (oil and gas)
This agreement between the Alaska Eskimo Whaling Commission and oil and gas operators such as BP, Royal Dutch Shell, ExxonMobile, ConocoPhillips, Statoil, Eni and other smaller operations, has worked to address potential conflicts between oil exploration operations and the bowhead whale hunt. The agreement forms a collaboration and negotiation process that has led to specific mitigation measures to avoid adverse impacts to bowhead whale habitat and the hunt. The agreement is a way to operate across scales: subsistence hunters from local communities meet with oil executives, scientists, and government observers to discuss mitigation measures. Since the mid-1980s, it has brought together scientific knowledge and Traditional Knowledge to improve the management of oil and gas development within the context of Alaska Native culture and the bowhead whale hunt. (Lefevre 2013)

Arctic Waterways Safety Committee (AWSC) (shipping)
The recently formed AWSC operates under the existing US Marine Transportation System as a Harbor Safety Committee whose function is to bring governance agencies, private organizations and the shipping industry together to develop mutually acceptable guidelines for managing ship traffic. The impetus behind this initiative is important to mention: given the long and complex process of getting initiatives through the IMO, the U.S. Coast Guard and subsistence hunter organizations, who are designated co-management organizations under the U.S. Marine Mammal Protection Act, came together to address the concerns of subsistence hunters in relation to increased shipping traffic in the Arctic region. The AWSC is a relatively flexible organization made up of key actors from different scales (local, regional, global) and a combination of government, private, and indigenous organizations, working to address practical concerns of all parties involved.

Multiple knowledge and value systems in policy making

Policy shortfall: Indigenous knowledge and value systems are not adequately integrated into policy making

A TEEB approach emphasizes the importance of bringing a wide variety of value-holders to the table. Yet, more than simply bringing actors together, assessing governance and policy capacity to protect biodiversity requires a thorough understanding and weighing of the relationship between values, knowledge, and policies. Values and knowledge inform policy and, as a result, it is important to understand how knowledge is produced, how values and knowledge are related, and how knowledge and values might be brought to any particular governance arrangement (or decision-making venue).

In the case of shipping and oil and gas development – industries that operate on a global scale – it is important to scale up knowledge and values from local, sub-national, and national levels to regional and international levels. The Conflict Avoidance Agreement and the AWSC (Box A3.4) are examples of how local hunters can be represented in global and regional level decision and policymaking venues, an important step in allowing a co-production of knowledge between holders of Traditional Knowledge and scientific knowledge in order to inform policy oil and gas and shipping.

However, while there are positive examples that suggest progress, the utilization of Traditional Knowledge to inform policy is complex and requires more than a simple presence of Traditional Knowledge holders. It requires an understanding of the way the Traditional Knowledge is produced and the appropriate governance structures that knowledge holders rely on to share knowledge with other governance entities. For example, if Traditional Knowledge holders share knowledge at the level of village governance, but then if this knowledge does not reach global decision-makers (indigenous and non-indigenous), key Arctic decisions on oil and gas exploration and production will likely suffer gaps in knowledge about specific ecosystem services that are potentially impacted by industry. Scaling up of results from local-based scientific research faces the same challenge.

Governance, precautionary principle, and Arctic uncertainty

Identified policy shortfall: the current approach to policy and governance is generally reactive, dealing with the immediate impacts of expanding oil and gas and shipping industries, rather than a comprehensive approach that is based on long-term sustainability of Arctic biodiversity and ecosystems.

The current governance approach is based on, first, taking advantage of emerging economic opportunities in oil and gas and shipping, and then dealing with or managing the impacts to Arctic biodiversity. To a large extent, this is a reactive approach that focuses on dealing with the immediate impacts of oil and gas and shipping (i.e., shipping accidents, oil spills, etc.), rather than a comprehensive approach that is based on protecting Arctic biodiversity from the impacts of industry.

The precautionary principle shifts the discussion of governance and policy to, first, securing Arctic biodiversity as *the* guiding principle and, second, managing the opportunities of shipping and oil and gas development. This does not mean that all economic opportunities are rejected in the name of conservation, but rather economic development takes places within a framework of Arctic biodiversity. In other words, economic activities take place only when policies and governance arrangements are in place to protect ecosystem services and biodiversity.

The precautionary principle is especially important given the uncertainty surrounding economic development and climate change in the Arctic. Climate change, as we know, is opening up the region to new economic opportunities in shipping and oil and gas development. However, the rapidly changing Arctic, while providing economic opportunities, is creating an especially unpredictable environment, from both a scientific and Traditional Knowledge perspective. A TEEB approach would make the benefits from ecosystems visible and provide the tools to weigh these benefits against the risks from irresponsible economic development in the midst of uncertain environmental conditions.

A TEEB approach, based on interdisciplinary analysis, makes visible (and explicit) the broad spectrum of values of ecosystem services, which can serve as a baseline assessment for policies and governance. In the case of oil and gas and shipping, this would mean that the potential impact on Arctic biodiversity, in relation to ecosystem service values, should play a predominant role in structuring both governance arrangements and policy decisions. This suggests that drawing specific attention to the value of ecosystem services from diverse perspectives will help decision-makers appreciate the risks, costs, and benefits of oil and gas and shipping, thus enabling a precautionary approach.

4. Possible pathway for future management of ecosystems and their services: What would adopting a TEEB approach contribute?

4.1 Alternative policies

Based on the discussion above, the following broad policy approaches have been identified and are suggested for follow-up in a full TEEB Arctic study. More in-depth discussion on governance issues discussed here can be found in Chapter 3.

A promising approach to improve policy decisions related to expanding oil and gas and shipping activity in the Arctic marine environment is to identify opportunities to introduce TEEB approaches to enhance ongoing and upcoming Arctic Council policy initiatives. This is best facilitated through a team with membership that crosses Arctic Council working groups and major initiatives (as discussed in Chapter 7 'The Way Forward'). Some examples of such Arctic Council opportunities are presented in the sections below.

Policy area 1: Governance mechanisms that cross scales and address distributional impacts

Policies to bring the interests and voice of local actors (indigenous groups, coastal communities) to complex multilateral governance arrangements

These policies make ecosystem services visible and address inequities inherent in distributional impacts from shipping and marine oil and gas development in the Arctic.

Examples of area-specific mechanisms that provide the forum and structure for cross-scalar governance are in Box A3.4, above. Other examples are proposed measures discussed in Annex 3b for the Aleutian Islands. Another approach, or a first step, is integrated ocean planning that is developed through multi-stakeholder partnerships, and that incorporates or leads to spatial plans and mechanisms that take into account costs and benefits across scales (e.g., Beaufort Sea Partnership 2009).

Assessment of current and developing policy frameworks

An ecosystem service-based approach, undertaken through a TEEB Arctic assessment, would examine the impact of oil and gas and shipping from the perspectives of beneficiaries of ecosystem services – at the local level – and evaluate the adequacy of current policy and governance regimes – at all scales – to conserve important ecosystem services potentially at risk. To be productive, this assessment requires involvement from a range of stakeholders and rights holders, including those dependent on the ecosystem services at risk, and policy-makers.

Identification of knowledge needs and development of tools and methodologies related to scalability and governance fit

See Section 7.3 'Suite of options for the way forward', Part B.

Many regions across the circumpolar north have relatively little experience with large-scale resource development, and there are often competing policy objectives and aspirations across scales, compounded by poor understanding of socio-ecological impacts. For example, authors of a study in the Disko Bay region in Greenland, an area of expanding oil and gas activity, concluded that the socio-ecological opportunities, risks and trade-offs associated with oil and gas development differed sharply depending on scale, and were not well understood and not well integrated into decision making (Mcdowell and Ford 2014).

An important aspect to build into alternative policies in this category is consideration of crossing not just geographic scales, but also scales of time. Many of the opportunities for economic development in the Arctic are available in the near term (involving high present value), providing benefits with greater certainty and easier measurability (market values). The risks are often further off in time (involving low present value), have greater uncertainty, and include substantial losses that are not so easily measured (non-market values).

Box A3.5. Arctic Marine Shipping Assessment recommendation AMSA II(B)

II. Protecting Arctic People and the Environment

    B. Engagement with Arctic Communities: That the Arctic states decide to determine if effective communication mechanisms exist to ensure engagement of their Arctic coastal communities and, where there are none, to develop their own mechanisms to engage and coordinate with the shipping industry, relevant economic activities and Arctic communities (in particular during the planning phase of a new marine activity) to increase benefits and help reduce the impacts from shipping. (Arctic Council 2009)

Windows of opportunity

Example of an Arctic Council opportunity to improve multi-scalar governance mechanisms and address distributional effects: implementation of the Arctic Marine Shipping Assessment recommendation II(B) (Box A3.5). Implementation of this recommendation would benefit from incorporation of an ecosystem services approach, making use of TEEB methodologies, in development of mechanisms of engagement with Arctic communities in relation to shipping, to help identify and overcome inequities from distributional impacts. Implementation of this recommendation is scheduled to begin in 2015–2016 through PAME.

National policy initiatives, including TEEB and other ecosystem services-related assessments (see Table 1.2 and Section 3.5), also provide opportunities for development of policies and governance mechanisms to address these issues of scalability and distributional impacts. As an example of relevant current policy discourse at the national level, see the Brookings Energy Security Initiative briefing on US policy role in offshore oil and gas governance in the Arctic (Ebinger et al. 2014). Focusing on building a suite of coordinated local, regional and bilateral governance approaches within existing legal frameworks, the authors stress the importance of involving industry and indigenous groups in decisions – from the start.

Policy area 2: Inclusion of multiple knowledge and value systems

A TEEB approach, based on an improved understanding of the relationships among knowledge, values, and governance, would highlight knowledge–values–governance linkages, emphasizing the importance of scaling up local knowledge and incorporating multiple value systems to international-scale decision making. However, more than just 'scaling up' knowledge, given the importance of sharing knowledge about ecosystems, the TEEB approach provides a framework for examining the complex relations across different scales of governance and knowledge.

Policies that facilitate the use of indigenous Traditional Knowledge and the consideration of indigenous value systems in decisions

This can include introduction of or improvement of governance mechanisms to achieve these policy goals, especially co-management systems, or can be through initiatives that provide direction to policy. For example, holistic consideration of policy options to improve Arctic food security requires a focus on Traditional Knowledge and values (see Section 1.7.5 on food security). Ongoing work by ICC-Alaska provides direction on how to assess food security from an Inuit perspective (Inuit Circumpolar Council Alaska 2014). Other policy initiatives on food security are also relevant in this respect, notably the Council of Canadian Academies report on Aboriginal food security in Canada (Council of Canadian Academies 2014).

Although there is a growing recognition, globally, of local and Traditional Knowledge as an important component of research, conservation and resource management in marine environments, comparatively few initiatives lead to truly collaborative, adaptive and resilient governance mechanisms for marine ecosystems (Thornton and Scheer 2012). In the context of this Arctic marine policy area, a study in Nunavut, Canada, where use of Traditional Knowledge is a management requirement, concluded that it was difficult to see how this Inuit knowledge had been used in decisions about shipping. Even when attempts are made to incorporate Inuit knowledge, decisions still seemed to be based more on scientific knowledge (Flynn 2013).

A promising approach is framed as knowledge co-production, the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systems-oriented understanding of that problem (for discusson in the Arcitc marine context, see Armitage et al. 2011; Dale and Armitage 2011). The emphasis is on creating collaborative processes that enable learning and adaptation, rather than on knowledge products.

Windows of opportunity

Opportunities in this policy area are for collaborating with (and adding an ecosystem services dimension to) work that has a focus on multiple knowledge and value systems. Examples:

▶ Explicit consideration of ecosystem services in Arctic Council and national Arctic food security studies, within the context of the impacts on these services from oil and gas and shipping activity.
▶ Initiatives related to integration of local and Traditional Knowledge in the work of the Arctic Council, as set out in the Kiruna Declaration (Arctic Council 2013b).
▶ Knowledge co-production and collaborative monitoring initiatives in Arctic marine environments, such as the Bering Sea Sub-Network (Gofman and Smith 2009).

Policy area 3: Securing ecosystem services as priority: precautionary approach

An important focus for this policy area is accounting for externalities. Many of the policy instruments that invoke a precautionary approach entail higher costs to industry, and may be perceived as an unreasonable burden on industry – or on government to support these extra measures. This is because important externalities are not always included in the costs of doing business in the Arctic. A TEEB Arctic study would focus on making these external costs and the distribution of costs and impacts explicit. To fully account for externalities, assessments need to include consideration of supporting/habitat services (e.g., effects at the lower end of food webs) and regulating services (e.g., effects on climate regulation).

Types of policies to consider further in a TEEB assessment:

Policies that take a precautionary approach to securing important ecosystem services through protection of identified priority marine areas

Examples are establishment of marine protected areas, and spill prevention and preparedness. An ecosystem services approach can help to set priorities, both in terms of areas and in terms of policy measures. Examples drawn from the Aleutian Islands discussion (Annex 3b):

▶ Designation of the area as a particularly sensitive sea area (PSSA) which would include measures developed through a multi-party working group to designate areas to be avoided, and offshore distances and routes for shipping.
▶ Building of response infrastructure at strategic points in the Aleutian Islands. Training of locals to operate response/ clean up technologies, including organizing commercial fishing vessel coordinated response, as is done in Prince William Sound (Regional Citizens' Advisory Council 2014).

This policy approach underlies current and recent follow-up work from the Arctic Council's Arctic Marine Shipping Assessment, such as the identification of marine areas of heightened ecological and cultural significance, AMSA recommendation II(C) (AMAP et al. 2013).

Building assessment of ecosystem services approaches into ecosystem-based management

The related policy approaches of strategic environmental assessment, marine spatial planning and ecosystem-based management have become increasingly popular and important globally, but the ecosystem service concept is rarely applied in marine planning and management (Bohnke-Henrichs et al. 2013). Greater application of approaches that incorporate consideration of ecosystem services into marine spatial planning foster a precautionary approach.

Windows of opportunity

In recent years the Arctic Council has made a range of recommendations and undertaken a range of activities that emphasize a need for more integrated policy incorporating social, economic and environmental aspects of specific issues. While the council has been moving towards this interdisciplinary approach, progress has been slow and without formal leadership, coordination or integration at the reporting stage. There are several initiatives operating independently: e.g., the Adaptation Actions for a Changing-C initiative, the economic expert group that has been formed within SDWG, and the various EBM initiatives underway. The option of a cross-working group team to set priorities and provide coordination and oversight to further TEEB work is discussed in Chapter 7. One policy option would be to explicitly link a TEEB Arctic marine assessment to the evolving EBM work within the Arctic Council. Arctic EBM initiatives have focused mostly on the marine environment and this presents an opportunity to propose adoption of TEEB methodologies as one of the set of tools to be used when considering integrated assessments.

There are also opportunities to work with national initiatives on integrating TEEB approaches into EBM for marine ecosystems. At the national policy level, ecosystem-based ocean management initiatives are well advanced in Arctic nations, with implementation to varying degrees and at various stages in Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia and US (Hoel 2009).

Financial instruments that could foster a precautionary approach

Examples of options that could be evaluated:

▶ Requirement for full appraisal of the project's environmental impacts in the decision-making processes for marine oil and gas extraction development. Such appraisal should include not only impacts to ecosystem services at local scales, but also to the global commons from greater warming, pollution, loss of culture, wilderness, etc. A number of options for project appraisal exist in this regard. Given the range and nature of Arctic ecosystem services (and their beneficiaries), reducing appraisal to monetary cost benefit analysis is likely to limit decision making by offering narrow mono-criterion information. Multi Criteria Analysis (MCA) provides a potentially more appropriate alternative. MCA is predicated on establishing a sound set of criteria for evaluating options, often supplemented by a weighting system (see Dodgson et al. 2009 for MCA approaches) Thus, MCA can capture broad information from a range of stakeholders on their preferences for both evaluation criteria and the relative importance of these criteria. As such the approach lends itself to the Arctic setting, where many ecosystem services, and preferences for these services, are difficult to represent with monetary values.

▶ Off-setting, employed where specific areas are developed for gas and oil extraction or shipping infrastructure. This could take the form of funding for Arctic marine conservation and establishment of Arctic marine protected areas.

▶ Financial mechanisms by which shipping and oil and gas businesses fund risk mitigation operations and infrastructure at the regional level. For example, following the Exxon Valdez oil spill in the Straits of Valdez the US Coast Guard established a system of 'escort tugs' (Carson 2012). Shortly after the Exxon Valdez oil spill, another supertanker lost power in the in the Straits of Valdez, drifted towards a reef and was rescued by escort tugs before hitting the reef. Since the establishment of the programme, escort tugs have taken control of a further three tankers in the Prince William Sound.

4.2 Summary of impacts of alternative policies on ecosystem services

Table A3.2 presents an initial scoping of the potential for impact on selected bundles of services under policy approaches discussed above. As with all projections of trends in the Arctic, impacts and uncertainty related to climate change need to be taken into account.

Because this scoping looks at marginal change, it compares alternative policies to a 'business as usual' scenario. In this case, where the topic is expansion of activities and the regulatory regime is in transition, the business as usual policies are, in a general sense, considered as the current state of multi-level regulatory regimes with improved international standards, guidelines and regulation that are 'in the works', and are to some extent based on precautionary approaches, countered by strong national policy directions favoring opening of areas to oil and gas development. A more rigorous analysis undertaken through a TEEB assessment would make these scenarios more explicit

Table A3.2. Summary of projected ecosystem service change under policy scenarios (examples, in relation to expansion of Arctic marine oil and gas and shipping activities)

Example 1. Ecosystem services related to marine mammal, fish and bird harvest by Indigenous Peoples (diverse and interconnected **provisioning** and **cultural** services, and related **habitat/supporting** services)
(examples, in relation to expansion of Arctic marine oil and gas and shipping activities)

Alternative policy areas	Projected marginal change on ecosystem services, comparing scenarios of 'business as usual' policies with policies that foster sustainable ecosystem services	Projected distribution of benefits and losses (marginal changes)
1. Governance mechanisms that cross scales and address distributional impacts	+ Improved protection of ecosystems and biodiversity through regulatory regimes responding to local priorities at national/international scales, e.g., on industry operational requirements such as for noise levels (protecting whales), ballast water regulation (reducing risk of invasive species), drilling waste discharge (reducing toxic impacts)	+ Indigenous Peoples (positive impact on food/cultural security) + Others benefitting from healthy ecosystems and biodiversity (e.g., fishing industry, tourism, global cultural enrichment) − ? Industry (potential added costs)
2. Inclusion of multiple knowledge and value systems	++ Improved protection of ecosystems and biodiversity and harvest (e.g., improved access/reduced conflicts with ship activities) at local level, because what is valued is given priority and Traditional Knowledge is used in setting measures to protect ecosystem services	++ Indigenous Peoples at local levels (needs are better met) + Industry (improved social license to operate) − Industry and government (potential for added restrictions, e.g., closure periods, and costs) + Eco and cultural tourism + Global cultural enrichment from preserving traditional cultures
3. Securing ecosystem services as priority: precautionary approach	++ Reduction of risks of spills and accidents (and related damage to ecosystems and biodiversity) through precautionary approach to permitting and regulation, including through financial mechanisms; and protection of intact ecosystems, e.g., through marine spatial planning and marine protected areas	++ Indigenous Peoples (food/cultural security) + Industry (increased certainty) − Industry / government (potential added costs and loss of opportunities)

Example 2. Commercial and main subsistence fisheries (**provisioning**) and related habitat/supporting services

(examples, in relation to expansion of Arctic marine oil and gas and shipping activities)

Alternative policy areas	Projected marginal change on ecosystem services, comparing scenarios of 'business as usual' policies with policies that foster sustainable ecosystem services	Projected distribution of benefits and losses (marginal changes)
1. Governance mechanisms that cross scales and address distributional impacts	+ ? Sustainability of major stocks through better conservation of habitat/supporting services (e.g. protection of spawning from disturbance or damage)	+ Small-scale subsistence and commercial fisheries (by higher visibility of need to protect stocks) + Local communities (perhaps enhanced economic benefits,
2. Inclusion of multiple knowledge and value systems	+ Conservation of stocks of local importance (e.g. whitefishes) and related habitat/supporting services	++ Indigenous Peoples and other subsistence fisheries (through higher visibility of values of these fisheries) including inland fisheries of anadromous fishes
3. Securing ecosystem services as priority: precautionary approach	++ Commercial stocks ++ Smaller scale commercial and subsistence stocks (through greater protection from damage by, e.g., spills) and related habitat/supporting services	++ Commercial fisheries industry and consumers, globally, Indigenous Peoples and others − ? Oil and shipping industries, through added costs − ? Government, through added costs (perhaps more upfront costs, but offset by lower clean-up, rehabilitation costs)

There is some overlap in fisheries between the first and second set of related services.

5. Conclusions

Making the values of ecosystem services more visible may contribute to the adoption of a precautionary approach in Arctic marine governance (an approach that is at least partly applied now in regulation development). The contribution of TEEB assessment would be in highlighting the importance of marine ecosystem services that are less visible but at risk, including habitat/supporting services, and provisioning and cultural services that are not well-known at the international level. It may also be in assessing potential for improving approaches to trade-offs through economic policy instruments, such as removal of subsidies with unintended consequences to biodiversity, or introduction or adjustment of financial incentives.

We focus in this report on the promising role for TEEB assessment in addressing identified policy shortfalls related to scalability and governance fit and the incorporation of multiple knowledge and value systems into decision making. The TEEB approach would focus on working from the local scale outwards to the multiple scales at which decisions are made – making visible the many interrelated benefits from Arctic marine ecosystems and biodiversity at local scales. This goes beyond saying that "these services are important" to saying in what way they are valued, who benefits from them and who stands to lose if they are damaged, what biodiversity, ecosystem and socio-economic attributes they depend on, and how and where they can most effectively be conserved. Bringing this locally grounded value-based and knowledge-based analysis into policy directions and governance mechanisms will not only ameliorate the ongoing provision of services, but make the distribution of benefits from and risks to these services more equitable.

This scoping study identifies next steps in implementing a TEEB approach in Arctic marine policy development:
- ▶ Build on this scoping study, through a collaborative process, with a cross-disciplinary (and cross-Arctic Council working group) approach, and with strong leadership from Indigenous Peoples. Consider how best to set priorities for regions and topics most likely to benefit from application of an ecosystem services approach.
- ▶ Identify options for ecosystem services approaches (including TEEB methodology) through ongoing and emerging Arctic Council initiatives and through policy initiatives at national and regional scales. Some windows of opportunity were identified in this scoping study, including EBM work in the marine environment and follow-up on recommendations from the Arctic Marine Shipping Assessment.

A TEEB Arctic study would further scope out the current policy situation and a range of alternative policies in relation to their effects on important marine ecosystem services that are potentially damaged by shipping and marine oil and gas development following the methodology outlined in Section 1.5 'Introduction to the TEEB approach'.

Annex 3a. Selected online questionnaire input related to marine oil and gas and shipping activity and marine ecosystem services

"It is very important to show that sustainable use of marine living renewable resources in a long term perspective provide more to human being than mineral extraction, being subsidized by governments. It is also very important to show non-Arctic countries that they should take part in protection of the Arctic marine ecosystems, since they provide them with healthy food and raw materials for medicine, recreation, etc." (Russia)

"To experience the Arctic nature (flora and fauna) and culture such as local cultures, history and/or cultural remains through for example an Arctic expedition cruise can be a great way to create 'Arctic ambassadors' or proponents of the future preservation of these Arctic assets." (Norway)

Major issue: *"Commercial ships going through the Arctic are not going through an empty ocean, but may have widespread effects on species and cultures. Recognizing what is at stake can help justify regulatory measures that allow shipping, but also protect nature and communities from disturbance, accidents, etc."* Windows of opportunity: *"National regulations/guidelines where they exist, and any actions by the International Maritime Organization (IMO), such as the development of its Polar Code."* (US)

Major issue: *"There are a number of issues around offshore oil and gas development, but a big one is the risk of an oil spill, and our limited ability to clean it up. If this study could somehow put a monetary value on the cost of a major oil spill perhaps decision-makers could allocate more funds to oil spill response infrastructure."* Window of opportunity: *"In the USA before development takes place on federal or state land an Environmental Impact Statement (EIS) needs to be completed. A study like this could submit information to contribute to an EIS, which would then need to be considered by decision-makers."* (US)

Relationship to stewardship: *"If there will be concrete results of assessment of TEEB, this could help to protect structure and productivity of marine ecosystems, especially in the fishery field and relations between different industries."* (Russia)

Aspects of governance that enhance a TEEB approach:
- *"Explicit requirements for cost benefit analysis"* and that work against a TEEB approach: *"Assuming more hydrocarbons is a social benefit. Need to include costs of warming, pollution, to culture, wilderness etc. against what is a private benefit to private petro companies in some cases."* (US)
- *"Introduction of ecosystem-based management, spatial planning, protection of essential habitats, ocean integrated management, best practices of fishery development. We should be able to assess ecosystem services and use it for decision-making process, raising its profile."* (Russia)

"Petroleum development in the Arctic is a negative economy …. All oil extracted contributes to an acceleration of climate change that significantly impacts on other ecosystem services….Exploration for petroleum incurs costs to other ecosystem services with no guaranteed reward. Seismic surveys divert whale migrations and have been documented as a cause of ice entrapment in whales – these species that represent food and charismatic tourism icons are harmed with no guaranteed profit to anyone." (Non-Arctic country)

Subsidies that may be harmful to ecosystem services:

- *"Arctic countries still tend to subsidize the building of industry and its infrastructure that continue harming the Arctic life and habitats in different ways. Typical are the mining, and oil and gas industries to support energy production. Subsidies should be changed to support development and construction of new and environmental friendly energy production."* (Norway)
- *"The perverse incentives are likely to be associated with fishing and oil/gas extraction. Also think about how taxes and royalties would be assessed if they were to reflect the true environmental costs (as measured in lost ecosystem services)."* (US)

Annex 3b. Regional focus on Aleutian Islands and the Unangax people

M. Fidel and P. R. Oleyer, Aleut International Association

This regional example, based on input from the Aleut International Association, provides context for the policy focus area of increased Arctic marine shipping. It illustrates the themes of this policy area: the high risks to local people from business activities that benefit others; and, proposed policy options that work across scales, recognizing the local values, perspectives and knowledge of ecosystems and biodiversity in national and international scale governance.

Contents

1. Aleut perspective

(By Piama R. Oleyer)

Our ancestors have continually inhabited the Aleutian region for nearly ten thousand years. We raised our children to eat from our land and sea, not by necessity but by preference. Every spring I took a big bowl out and we created salads of such variety to feast on. All summer I taught my children to know which plants, roots, seeds and berries were edible. Sadly, when it came time to harvest some of the products of the sea, we couldn't eat them due either to toxicity or regulations about who could take products out of our waters. The natural and manmade disasters have already been happening with ultimate consequences; we have already lost so much. People can no longer eat food from our beaches due to risk of illness and actual death. Unalaska has been declared a 'dead bay' due to industrial activity.

It's no longer 'a matter of time', it's a matter of not allowing the continuance of the degradation of our natural environment. To what extent must we keep accepting unbalanced policies that weigh heavy on the value of extracted resources? These policies aren't designed to benefit the people who've lived here for thousands and thousands of years. Policies are designed to benefit the few companies who now 'own' our resources. Grandma can't afford to lease the land where her basket weaving grass grows so businesses (even our own) trade traditional harvest areas for leases to industry.

Cultural losses can't be quantified with a dollar value. When you take away our fish you take away more than just our food. So much in life revolves around gathering it, preparing it, sharing it. With the demise of certain activities, entire concepts are lost and the gaps are obvious when trying to teach the language. Our traditional cultural knowledge is altered. My mother spoke about the Great Depression when the world seemed to have lost the will to live when they lost their money. "We were poor but we didn't know it because we had everything we needed," she would say. When all your needs are met, people are not poor even if they don't have money.

It is our duty to take care of our place on this planet. We Unangan are the stewards of this area. Our oceans provide an abundance of wealth. We should all be living at our maximum level rather than subsisting to exist. Much in our culture is based on sharing our wealth; this was our way of life. In the Aleutians, we live by an ocean harvest in the most bountiful waters in the world. We are told who can fish, what to fish, where, when, how and how much, and who we can or can't give or sell our catch to. Today in our region, a continuous stream of gigantic ships carry our resources away and regulations are written based on who uses the most money. These policy-makers are the same ones who allowed bottom trawlers to drag their massive ground level nets right up to our front doors destroying the habitat of the ocean floor. Subsistence users have a near zero by-catch which means, they do not accidentally catch and kill anything they aren't supposed to.

Super-cargo ships and industrial trawlers bear down on a collision course with the local fishermen in the area around Unimak Bight where these monstrous ships regularly plough through their fishing grounds. These enormous ships don't even see the fishermen. Is it because of their size or the value of their payload that they believe they have the right-of-way? Perhaps they just don't understand; a lot of them are foreign ships so there's a communication gap. According to the 'Risk of Vessel Accidents and Spills in the Aleutian Islands', during the past 15 years there have been 3,400 oil spills. Most of these are small but they estimate 1 to 5 large 'damaging' spills occur every year. I don't know how they define damaging and why they don't consider the other 3000+ 'small' spills damaging. I have personally witnessed catastrophic maritime events over the years such as the Kuroshima and the Selendang Ayu; both ran aground and oiled Unalaska's shores.

As indigenous people in the region, we need to call the shots on the methodology of the cleanup. With the increase in value of organic foods, how can we say our Alaskan waters are pristine, after chemicals are dumped in the water to disperse crude oil, when – not if – there is an oil spill? Tom Robinson, President of the Qawalangin Tribe of Unalaska where Dutch Harbor

acts as a maritime gateway to the world, says "There needs to be an efficient, ecologically friendly oil spill response at a mechanical level, not using dispersant. We do not condone or approve of the use of oil-dispersant chemicals in our waters." We acknowledge that these events are going to happen multiple times and of varying magnitude in our very near future. We want to be prepared. We need to guarantee that the ecosystem will continue to produce as it has for thousands of years. We need to ensure that our communities can sustain a local economy where children won't have to move away to have a better life.

Time and time again, our resources have been obliterated by outside merchants, yet our people have adapted as they always have. Our culture remains; our place in the world remains. In spite of the countless regulations placed upon us, we still find ways to harvest our foods. We still manage our own territory, though our voice is not always heard.

2. Shipping in the Aleutian Islands

The Aleutian Islands area is rich in wildlife: millions of seabirds seasonally, thousands of marine mammals, rich in commercial fish species, including crab. Frequent fierce storms characterize the area. It is home to the Unangax, or Aleut people. About 8,000 people live in the 17 communities, in Alaska USA and the Russian Federation, on an island chain of more than 300 islands stretching 1,900 km (1,200 miles).

Shipping is increasing on the North Pacific's Great Circle Route (NPGCR) (Annex 3a, Figure), the shortest and most economical route for large vessels traveling between northern ports of western North America and Asia. A 2006 report (Nuka Research and Planning Group LLC and Cape International Inc. 2006) estimated traffic at 3,100 vessels annually, with over a third being container ships with fuel capacity of 1.6 million gallons. In 2012, 4,615 vessels transited the route (Burn and Poe 2014). Traffic on the NPGCR is expected to increase in the next 20 years due to proposed and pending marine transportation projects (Aleutian Islands Risk Assessment and Nuka Research and Planning Group 2014). For example the Northern Gateway Pipeline project in Canada, currently working its way through the permitting process, would increase traffic through the Aleutians by about 220 super tankers per year carrying natural gas condensate and bitumen. People in the Aleutian Islands will not gain any economic benefit from this project but will bear the costs of any accident.

3. Key ecosystem services at risk

▶ **Commercial fishing**. This is part of the most productive fishery in the world, the Bering Sea, with nearly all Aleutian Island communities taking part in the commercial fishing. Commercial species include salmon, halibut, cod, king crab, rockfish, sable fish, and Atka mackerel. In 2009, the total value for the Aleutian Island commercial fishery was US$159.7 million (ADFandG 2011).

▶ **Subsistence hunting, fishing and gathering**. Subsistence is a deeply engrained part of culture in the Aleutian Islands where people harvest all types of fish, shellfish, marine mammals and seaweeds. In most small communities store-bought food is extremely expensive, and less preferred than fresh subsistence food. Subsistence also supports a handicraft industry, where only Alaska Natives may sell marine mammal products as handicrafts. It also supports cultural transmission, and social cohesion

The marine ecosystems of the Aleutian region are at risk from oil spills given the limited response infrastructure and planning in the area and the increasing vessel traffic. Oil spills occur every year on the Great Circle Route, with 43 significant oil spill events occurring from 1981 to 2006. These events total almost one million gallons of oil (Nuka Research and Planning Group LLC and Cape International Inc. 2006). It is just a matter of time before a devastating oil spill occurs, then effects to local communities would likely be similar to after the Exxon Valdez oil spill. Effects to communities affected by the oil spill included a decimation of the commercial fishing for many years, increased suicide, increased domestic violence, an interruption of cultural practices, a reduction of subsistence activities because of contamination, increase in substance abuse, people forced to move to the city for work, and feelings of frustration, grief, fear and anger (Braund et al. 1995; Braund and Kruse 2009)There were also devastating effects to ecosystems, which 25 years later have still not fully recovered. Additional risks are effects to marine mammals from a gradual increase of noise and increased probability of collision. There is evidence that marine mammals avoid noise sources, and may even alter migration routes to avoid noise (Fay et al. 1984; Richardson et al. 1995; Jansen et al. 2010). As vessel traffic increases, so does the probability for collision of big boats with whales (Reeves et al. 2012). There are also concerns about increases in air and water pollution, and potential for introduction of invasive species.

4. Current regulations and proposed policy options

The majority of these ships are international innocent passage and do not require a state oil spill contingency plan or certificate of financial responsibility. The U.S. Coast Guard is the managing authority in the area and would be responsible for coordinating oil spill and emergency response, unless the accident occurred in Russian waters.

Figure A3.3. North Pacific Great Circle Route through the Aleutian Islands

A recommendation of the Aleutian Island Risk Assessment (Aleutian Islands Risk Assessment and Nuka Research and Planning Group 2014) was to have the US Government petition the IMO to designate the Aleutian Island region as a Particularly Sensitive Sea Area (PSSA) and a work group was established to develop protective measures. Identified measures include the designation of areas to be avoided, and of offshore distances and routes. Another policy option is the building of response infrastructure at strategic points in the Aleutian Islands, along with training of locals to operate response/clean up technologies.

Annex 4. Policy example: Industrial development activity in terrestrial ecosystems, with a focus on cumulative effects (North American Arctic)

Authors: J. Eamer, L. Wakelyn and S. King
Contributing authors: G. Bussidor, A. Gunn and A. Medeiros

Contents

1. Introduction

The purpose of this policy example is to prepare the groundwork for a possible full TEEB Arctic assessment on this topic. As such, overviews are presented of important ecosystem services and the current policy and governance setting. Policy approaches that focus on sustainability of ecosystem services are presented and discussed in relation to the added benefits these policies may provide to selected important ecosystem services. This policy example builds on chapters 2 'Arctic ecosystem services', 3 'Governance of Arctic ecosystem services' and 4 'Valuing ecosystem services in the Arctic', including the input from respondents to the online questionnaire highlighted in those chapters and in Annex 4a. It also includes and draws material from the regional case study on co-management for the Beverly and Qamanirjuaq caribou herds, Annex 4b.

Human population in the North American (NA) Arctic (Figure A4.1) is sparse: Canada's three northern territories cover 40% of the area of Canada, but, with a combined population of 107,000 (2011 census), make up only 0.3% of the nation's total population. The population of Arctic Alaska, based on the 2013 census (including four census areas fully or partly within Arctic Alaska) is over 30,000 (Hillmer-Pegram 2014). The percent of the people who are indigenous (native) in the Alaska census areas ranges from 53% to 80% (Hillmer-Pegram 2014). In Canada the percentages of people reporting indigenous (A aboriginal) identity in the 2011 census were: Yukon 23%; Northwest Territories 52%; Nunavut 86% (Statistics Canada 2012). Residents of northern parts of Canada's provinces that also form part of this broad Arctic region are predominantly indigenous.

Figure A4.1. Map of North American Arctic
The North American Arctic (north of the red line), following the definition used by the Conservation of Arctic Flora and Fauna (CAFF) working group of Arctic Council, extends well south of the treeline in Canada and includes both tundra and taiga ecosystems in both countries. The region includes the northern segments of major river systems, extensive deltas, and large areas of wetlands that are underlain by permafrost in the northern areas. Taiga ecozones are underlain by continuous or discontinuous permafrost, and are characterized by open forest dominated by small conifers, thinning to shrub land and tundra as latitude increases (CAFF).
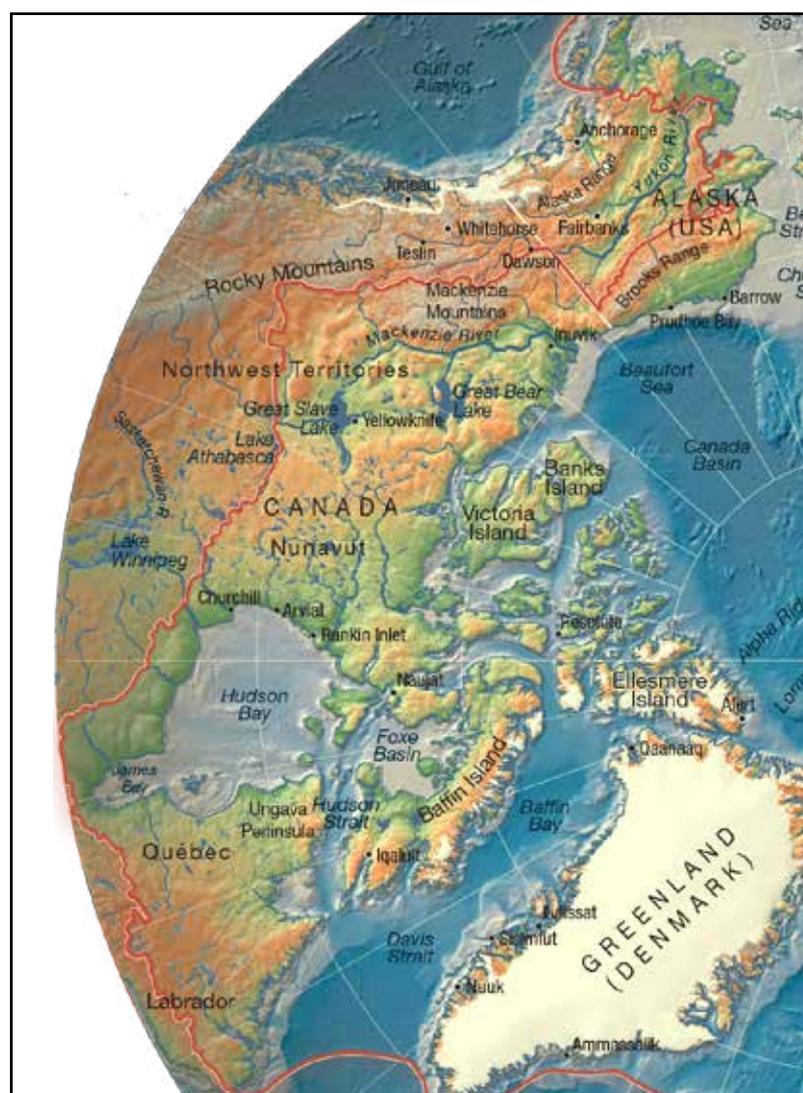
Mineral, diamonds, and oil and gas extraction industries are major economic drivers for the North American Arctic, and are seen as a major source of current and future economic development (Box A4.1) (Statistics Norway 2009; The Conference Board of Canada 2013; Hillmer-Pegram 2014). Social and environmental impacts have been both positive and negative, and the people living in this part of the world are familiar with the difficulty of balancing the pros and cons of development for their communities.

Industrial development of the NA Arctic has impacts on the sustainable and equitable use of the region's terrestrial and freshwater ecosystems and their services, in particular in relation to food security and social cohesion. For the Indigenous Peoples who rely on subsistence hunting, fishing and gathering, these activities are important for calories and nutrition, and are significant to their health, culture and economy, especially outside of the larger towns. The benefits associated with these activities are also important for many non-indigenous residents. Migratory tundra caribou are a focus of this policy example because of the importance of the ecosystem services associated with caribou, including for food security, and because caribou, as the major herbivore throughout most of the NA Arctic, are important to ecosystem functioning.

Box A4.1. Industrial development in the North American Arctic

Existing and planned development activities are related to mining and oil and gas development, with oil and gas being further developed in Alaska than in Canada; mining (including exploration) is the dominant extractive resource industry in northern Canada.

- ▶ In the NWT and Nunavut, about 14 mines are operational or undergoing environmental assessment; over 1,000 km of all-weather roads have been constructed since 2001 or are proposed (MVEIRB 2015; NIRB 2015).
- ▶ The Red Dog Mine, one of the largest zinc mines in the world, was developed through an operating agreement between a mining company and an Alaska Native corporation owned by Iñupiat of Northwest Alaska (Red Dog Mine 2009).
- ▶ While exploration activities are relatively short-lived, developed mines typically have projected lives of 15 to 30 years. Infrastructure developed for both phases, though, may remain in place and may be adapted and expanded.
- ▶ In Arctic Alaska, planned, relatively modest infrastructure development for oil and gas is mainly expansion of existing infrastructure.

Table A4.1. Summary of existing, planned and proposed infrastructure related to oil and gas development in Arctic Alaska.

This table excludes offshore development, but includes coastal infrastructure. 'Planned' are active at the exploration and development phases. 'Proposed' are at various stages, including feasibility stage, on hold, or being actively pursued.

	Existing	Planned	Proposed
Structures	460	7	321
Wells	6,185	57	860
Road	1,831 km	34 km	2,197 km
Pipeline	1,450 km	53 km	2,446 km
Footprint	7,469 ha	82 ha	3,400 ha

(Hillmer-Pegram 2014, table 10.1)

2. Ecosystem services

2.1 Overview of services

Provisioning services include food and other goods (including medicines, firewood, and animal skins) from hunting, fishing and gathering a wide range of animal and plant species, with caribou harvest being particularly important. Trapping, while not a major economic driver now as it was in the past in this region, provides materials for clothing and crafts, as well as a source of income. Figure is an example of a measure of the widespread use of subsistence activities in the NA Arctic. Other important provisioning services include water supplies, for household and industrial use.

Cultural services include ecotourism, recreation in the form of outdoor activities such as boating and hiking, as well as recreational hunting and fishing. Cultural services also include a range of vitally important, less tangible benefits for personal and community health and well-being, spirituality, identity, maintenance of indigenous languages, and education.

Some important **regulating** services in the context of this policy example include natural regulation of floods, water purification and control of erosion provided by aquatic and riparian ecosystems.

Supporting/habitat

Bird nesting areas, caribou calving grounds and fish spawning areas are habitat services with obvious linkages to the provisioning and cultural services described above. Migratory tundra caribou calving grounds require special attention, as they are fairly restricted locations, herd-specific, and with specific characteristics that maximize reproductive success (Reid et al. 2013).

Herbivores play a role in nutrient cycling and changes in their abundance and distribution affect this important supporting service. Caribou shape the NA Arctic terrestrial ecosystems by their numbers (Gaston and Fuller 2008). Arctic food webs have relatively few links and are nutrient-limited because so much carbon is inaccessible, with only a shallow active layer of the soil thawing each year. Migratory caribou transport nutrients and energy, cycling nutrients on land and in water through their faecal pellets (Gunn et al. 2011b).

Inputs from the terrestrial environment to aquatic systems strongly govern biogeochemical processes that can define aquatic biological communities and maintain the freshwater food webs that include fish species that directly benefit people (Medeiros et al. 2012).The transition from the terrestrial to aquatic environment is key for ecosystem function, with characteristics such as topography, underlying geology, permafrost and catchment vegetation strongly influencing the chemical composition of northern surface waters (Lim et al. 2005).

Figure A4.2. Inuit participation in subsistence activities by region, based on the Survey of Living Conditions in the Arctic
Percent is of respondents who engaged in the subsistence activity in the 12 month period before the interview (2001). Sample size was 4,700 for Canada.
Data from Poppel et al. (2007)
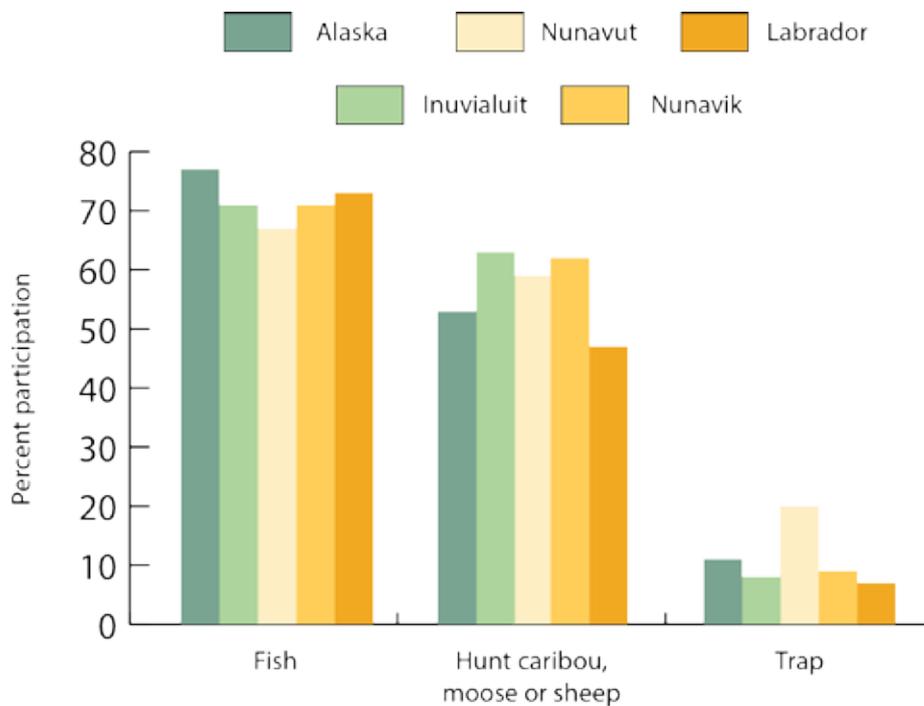
2.2 Impacts, status and trends

Industrial activities, especially in combination with climate change, have the potential for widespread, major impacts on terrestrial and freshwater ecosystems in the NA Arctic (Schindler and Smol 2006). Some of these impacts lead to localized or short-term deterioration in ecosystem services, such as loss of berry quality from road or mine site dust (see Figure 2.2), while others are potentially more widespread and longer lasting, for example, impacts resulting from habitat fragmentation.

While cultural and provisioning services are the ecosystem services most visibly and directly threatened by industrial development, regulating and habitat/supporting services are also of concern. Loss of streamside vegetation, disruption of permafrost and addition of silt to streams are examples of common impacts from land-based development that affect water regimes and can impair fish habitat and regulating services such as natural flood protection – services that also provide benefits to industry.

Caribou

Migratory tundra caribou herds in Canada and Alaska have fluctuated in numbers over time, resulting in periods of caribou abundance and other periods with low numbers of caribou. Peak overall abundance was 1.7 million caribou in 1994; since then, most herds have declined 70-98%. Some herds have stabilized in numbers in recent years or show signs that the numbers are rebuilding (Gunn et al. 2011b; Reid et al. 2013).

At the landscape scale, habitat is still largely intact. In 2010, 94% of the Canadian northern boreal region (which includes much of migratory tundra caribou winter range) was rated as intact (Federal Provincial and Territorial Governments of Canada 2010). Calving grounds of most herds however, are not protected and several are in areas slated for development. Impacts from development on calving grounds include displacement to less favorable habitats and disruption of calf suckling behavior due to disturbance (Festa-Bianchet et al. 2011; Reid et al. 2013).

To look at trends that are meaningful in terms of securing ecosystem services, it is important to consider abundance, distribution and the health of the caribou at the scale of individual herds and harvesting areas accessible to the communities. Both abundance, at the herd level, and distribution, may be affected by development infrastructure, associated activities and secondary impacts like changes in patterns of human settlement (Reid et al. 2013).

Cumulative effects include those resulting from disturbance and habitat fragmentation from incremental increases in exploration and development activities across the caribou ranges. Other types of stressors on the ecosystem services also need to be taken into account, for example, habitat alteration from increasing wildfires on the winter ranges, increased harvest resulting from changes in hunting patterns or accessibility, and changes in technology (such as more powerful snow machines and guns, communication using social media about recent locations of animals, and sale of caribou between regions in some jurisdictions). Small-scale changes in feeding patterns as well as large-scale changes in caribou migratory behavior and seasonal range use patterns can affect productivity and long-term population levels, as well as the availability of caribou to specific communities.

Aquatic ecosystems and services

Increased industrial and municipal development may result in impacts on aquatic ecosystems that lead to loss or reduction of freshwater ecosystem services. Sources of impacts include run-off and leaching from industrial operations, landfills and sewage containment areas; hydrocarbon and chemical spills; waste disposal; stream channel crossings and diversions (often accompanying road construction); and, increased sedimentation from gravel haul operations (Medeiros et al. 2011). Impacts on aquatic environments from these sources can affect fish directly, affect the habitat or the food sources of fish, affect water supplies, and affect the ecosystem's natural capacity to regulate water flows and flooding, purify water and control erosion.

The disposal of mining wastes and tailings is a significant threat to surface and groundwater systems across northern regions unless adequately controlled during and following the operational period. For example the North Rankin Inlet nickel mine, which operated from 1957-1962 managed waste and tailings poorly, discharging into ponds below sea level that leached into Hudson Bay and contaminated shorelines (Erickson 1995; WESA Inc. 2010). Many mineral deposits in the NA Arctic have the potential to generate acid, which dissolves metals that are toxic to algae, benthic invertebrates and fish, posing a threat to ecosystem services associated with fishing and with unpolluted river systems – and in some cases also threatening drinking water supplies (The Conference Board of Canada 2013).

Decommissioning of mines has been problematic across the NA Arctic (Alaska Department of Natural Resources 2011; The Conference Board of Canada 2013). Mines abandoned prior to complete remediation frequently have persistent effects, especially on aquatic resources, with major and increasing economic costs to government. An audit published in 2002 estimated the costs to government for cleaning up and closing 17 abandoned mines in Canada's North at C$555 million, with additional costs for long-term management of impacts at some sites (Office of the Auditor General of Canada 2002). The 2014 remediation plan for the Giant Mine, Yellowknife (a gold mine that operated from 1948-2004), however, is estimated to cost nearly one billion dollars (CIM 2014).

Climate change: an additional and interacting stressor

Climate change adds another layer of consideration to all impacts from development on ecosystem services – and an added degree of uncertainty about the combined impacts from the two types of stressors (Section 2.1.2). For example, changes in temperature and precipitation patterns are associated with the observed increases in the area of boreal forest that is burned annually by wildfire, as well as with changes in nitrogen dynamics and increases in plant growth. These impacts affect the plants and lichen that caribou feed on, which affects the distribution of caribou and their availability to harvesters (Gunn et al. 2011a). Current and projected changes in permafrost, streamflow and groundwater regimes interact with impacts from industrial development (Schindler and Smol 2006) with, for example, potentially increased risk of failure of tailings dams and other in-stream structures from higher amplitude extreme precipitation events or permafrost thaw. Failure of dams and instream structures scours stream channels, removes riparian vegetation, destroys or damages downstream fish habitat and releases sediment and potentially toxic substances into water, affecting all aquatic ecosystem services.

2.3 Socio-economic importance of ecosystem services affected by industrial development in NA Arctic terrestrial environments: selected topics

Caribou

A holistic perspective on the socio-economic importance of caribou is presented in Annex 4b. Regional focus on Beverly and Qamanirjuaq caribou herds and co-management. Below is a discussion of services, based on work of the Beverly and Qamanirjuaq Caribou Management Board (BQCMB), but that is generally applicable across the NA Arctic, with regional variability in importance of caribou as a staple food and extent of local business opportunities (tourism and recreational hunting).

▶ **Provisioning services**. Provisioning services are directly linked to food security, a serious issue receiving increasing attention for small northern communities. Loss of caribou as traditional food source has already had impacts on the traditional economy, culture, and sustainability of some northern communities where caribou are no longer available. Reduced availability or loss of this food source could become more widespread and lead to increasing poverty and replacement with less healthy, non-traditional foods in many northern communities.

▶ **Spiritual and cultural values of caribou for Indigenous Peoples**. The harvest of caribou includes key cultural and spiritual components including time spent on the land involved in traditional activities; opportunities to teach youth about respect for the land, wildlife and people; teaching young people about traditions, practical tasks and survival techniques; and healing time for those recovering from trauma. Caribou harvest is essential for maintaining cultural identity and maintaining or regaining self-respect and respect for others.

▶ **Recreational hunting**. Resident (non-indigenous) hunters, as well as benefiting from provisioning services, derive enjoyment and benefits to health and well-being from participating in outdoor recreational activities. Local people and others benefit by running outfitting businesses and providing and obtaining employment. This benefits the local cash economy, the well-being of people employed as guides, and can also benefit locals by provision of food (from non-resident hunters to communities).

▶ **Wildlife viewing as a focus or component of tourism and recreation**. Governments and local people benefit by running businesses based on or incorporating wildlife viewing, providing employment for communities; local people benefit through employment and access to markets for arts and crafts and tourism services.

The economic value of the provisioning services from the Beverly and Qamanirjuaq caribou herds was estimated in a study based on 2005/06 statistics (Box A4.2).

Aquatic ecosystems

Harvesting of freshwater and anadromous fish provides a food source for many communities. In addition, commercial harvesting of fish can provide an important source of local income, often supporting subsistence economies, and may also provide local employment opportunities from recreational sports finishing. For example, the total value of Arctic char in Nunavut in 2007 for subsistence use was estimated at C$4.4 million/year replacement value, with commercial sales valued at C$1.4 million/year (Christiansen et al. 2013). Sport fishing for char, though lower in actual amount harvested, provided the highest economic return per fish caught – with a relative value of C$55/kg fish in comparison with C$3.30/kg fish for commercial fisheries. Cultural services associated with fishing, both for Indigenous Peoples and through sport fishing, are important throughout the Arctic (Huntington et al. 2013a).

The supply of clean, safe water is an essential and highly valued ecosystem service, both for domestic water use and for the role of water quality in supporting fish and wildlife. Concerns about degradation of water quality, including risk of contamination of fish and wildlife through water contamination, are high on the agenda for NA Arctic communities, partly related to past problems with poor practices of waste disposal and industrial decommissioning (for example, Governments of NWT and Canada 2010; see also Annex 4b).

2.4 Summary of ecosystem services and beneficiaries

Based on the scoping study findings, a selection of important services provided by the Arctic terrestrial and freshwater ecosystems affected or potentially affected by development activities are summarized in Table A4.2. Services found in the initial review to be most affected are provisioning, cultural and habitat/supporting, both terrestrial and freshwater. These services are generally at risk over broad scales due to cumulative impacts potential. The regulating services of flood protection, erosion control and natural water purification are also potentially affected at more local scales. The important role of added and interacting impacts from climate change highlights the issue of externalities (see Chapter 3) related to costs of the globally generated greenhouse gases that cause climate change.

Box A4.2. Dollar value of the Beverly and Qamanirjuaq caribou harvest: reflections on the utility of this valuation

A study commissioned by the BQCMB (InterGroup Consultants Ltd. 2013) estimated the net annual economic value of caribou harvested from the Beverly and Qamanirjuaq caribou herds at about C$20 million, based on harvest estimates for 2005-2006. About 84% of the total harvest was domestic: subsistence use by about 13,000 people (mainly indigenous) living on or near the caribou ranges. Domestic harvest was valued at C$14.8 million, outfitting harvest at C$4.1 million, commercial harvest at C$0.59 million and harvest by licensed resident hunters at C$0.47 million.

Because there are so few monetary valuations of traditional (country) foods, this total value of C$20 million has been cited regionally and nationally in science-based reporting (e.g., Federal Provincial and Territorial Governments of Canada 2010; Kendrick 2013) and in the media (e.g., CBC News 2008) and has likely served to highlight the significance of caribou in northern economies to audiences beyond the region.

Potential utility of this type of valuation study for decision-makers comes in breaking down the different components of the values to aid in decisions about management, including harvest management and management of development on the herds' ranges, and decisions about allocation of resources for research and monitoring. But use in this manner has been limited, perhaps because the data are not presented in a way that makes them readily accessible (for example, by herd and jurisdiction, by herd and harvest class, or by herd and jurisdiction and harvest class). Trends over time in values in different areas would allow decision-makers to assess the loss to local economies where caribou have become less available, and to look more broadly at linkages to economies and policies in the context of change (i.e., to look at marginal values, see Chapter 4). In this case, as comparable harvest data for recent years are not available for the herds, the study cannot be updated.

There are time lags and costs involved in bringing new types of information into decision making. This includes the monitoring and data collection programs to provide the information for valuation, as well as working with decision-makers to develop the most useful measures. An additional important concern is that values with relatively easily attached dollar figures are cited and used – but there is no comparable way to combine and highlight the values of caribou for personal and community health, culture and spirituality. This leads to an over-emphasis of the monetary values and an under-emphasis of the values that cannot be quantified.

Table A4.2. Summary of selected NA Arctic terrestrial and freshwater ecosystem services affected by industrial development

Ecosystem services (grouped)	Who benefits	Who stands to lose or incur costs from policy to maintain services	Main risks and impacts to services	Who affects the services*	Important linkages to other stressors
Caribou harvest by Indigenous Peoples, and by other subsistence hunters and sport hunters (diverse and interconnected provisioning and cultural services)	Indigenous Peoples over the ranges of the caribou herds (extending south of the Arctic); local and regional populace; outfitters in some jurisdictions; cultural tourism; others through art, crafts and storytelling (directly and indirectly, globally, e.g. through inspiration and education)	Conflicts between user groups can result in compromises and losses; mining/oil and gas industry (potential loss of opportunity or added costs through restrictions on activities)	Direct effects on caribou abundance and distribution (and hence availability to hunters) from industrial development (e.g., through displacement from calving grounds or reduced body condition, or increased access for hunting); overharvesting at low points in population cycles	Extractive industrial development; Indigenous Peoples (e.g, through harvest practices, sharing, management at the local level); government and co-management through policy, land-use planning and designation, and regulation (including financial incentives and disincentives)	Climate change impacts on caribou abundance and distribution; socio-economic factors affecting traditional practices (e.g. affordability of fuel and equipment)
Hunting, trapping and gathering (including berries, medicines, birds, and mammals other than caribou) by Indigenous Peoples and other local residents (diverse and interconnected provisioning and cultural services)	Indigenous Peoples; local and regional populace; cultural tourism; others through art, crafts and storytelling (directly and indirectly, globally, e.g. through inspiration and education)	Conflicts between user groups can result in compromises and losses; mining/oil and gas industry (potential loss of opportunity or added costs through restrictions on activities)	Direct effects on species abundance and distribution from industrial development (e.g., through displacement of fur-bearers); overharvesting; Damage to quality of services (e.g., dust on berries near roads)	Industrial development; Indigenous Peoples (e.g., through harvest practices, sharing, management at the local level); government and co-management policy and regulatory frameworks (including financial incentives and disincentives)	Climate change impacts on species abundance and distribution; socio-economic factors affecting traditional practices (e.g., affordability of fuel and equipment)
Ecotourism, cultural tourism and recreation in terrestrial ecosystems and rivers (cultural services)	Tourism businesses (generally local/regional); local and regional populace (from recreation)	Conflicts between competing interests can lead to losses (e.g., losses to local business and to industry from exclusion of areas from development)	Loss of wilderness values through cumulative effects; noise and disturbance from activities and roads; changed access patterns	Industrial development; government regulatory framework	Market forces

Ecosystem services (grouped)	Who benefits	Who stands to lose or incur costs from policy to maintain services	Main risks and impacts to services	Who affects the services*	Important linkages to other stressors
Terrestrial habitat/ supporting services	Those who benefit from the provisioning and cultural services supported	Industry (added costs and time of dealing effectively with cumulative effects; potential loss of business opportunities); Government (some added short-term costs to broader protection of ecosystems and biodiversity, offset by longer-term benefits	Cumulative effects from industrial activity (e.g., habitat fragmentation, loss of calving, nesting and staging habitats, noise, toxics, disturbance)	Mining/oil and gas industries (from exploration to post-decommissioning)	Diverse and poorly understood impacts on habitat and food webs from climate change (including from warming, snowpack changes, permafrost thaw) plus indirect effects such as northward spread of predators, parasites and diseases
Fishing (provisioning and cultural services)	Indigenous Peoples, other subsistence users; local and regional people for sport fishing; local businesses (fishing lodges, limited commercial fisheries)	Conflicts between competing interests can lead to losses (e.g., losses to local business and to industry from exclusion of areas from development)	Cumulative and project-specific effects from land-based contamination from industrial sources; risks from catastrophic events (e.g. tailings dam breach)	Industry; governments, co-management bodies (through regulatory framework, including fishing regulation)	Climate change, including effects from warmer temperatures and changes in surface and groundwater regimes, and changes in distribution ranges of fishes
Clean water supply (provisioning and cultural services)	Indigenous and other local people (both through water supply and through cultural values associated with natural, pure water); industry; municipalities	Industry (maintenance of high quality water at regional scale might add costs to doing business)	Cumulative and project-specific effects from land-based contamination, including from decommissioned mines; spills; tailings dam failures	Industry; governments through regulatory regime; communities through waste and sewage disposal	Climate change (including water supply shortages in some areas, such as Baffin Island)
Freshwater habitat/ supporting services	Those who benefit from the provisioning and cultural services supported	Industry (added costs to deal with cumulative effects; potential loss of business opportunities); government (some added short-term costs to broader protection of ecosystems, offset by longer-term benefits	Land-based contamination entering aquatic environments and affecting habitat and food webs; sedimentation, erosion, loss of instream and riparian habitat quality; loss or degradation of spawning areas	Industry; governments through regulatory regimes	Climate change (including changes affecting habitat through alteration of surface and groundwater regimes and permafrost change, and changes to food webs from species distribution change

Ecosystem services (grouped)	Who benefits	Who stands to lose or incur costs from policy to maintain services	Main risks and impacts to services	Who affects the services*	Important linkages to other stressors
Regulating services (freshwater and riparian ecosystems), e.g. erosion control, natural purification of waters; flood control	Industry Local people Government (e.g., cost benefit from flood control)	Industry (potential added costs to ensure downstream services maintenance)	Industrial activities including infrastructure (e.g., stream crossings, vegetation removal): risks and impacts include disruption to permafrost, erosion, silting up of wetlands	Industry Government (e.g., through infrastructure development, but also through regulation)	Climate change (e.g., permafrost thawing)

* Impacts are not necessarily negative – e.g. good spill response capacity is a positive impact, and local people might have potential for both positive and negative impacts on an ecosystem service.

3. Current governance and policy settings

3.1 Introduction

The NA Arctic is characterized by multiple jurisdictions that often overlap: the multi-level jurisdictions associated with federal forms of government, plus jurisdictions based on traditional homelands of Indigenous Peoples and on land claim agreements and interim measures established for land tenure, governance and economic development.

There is a strong culture of grass roots involvement in decision making, with a range of consultative and co-management systems in place in many areas and operating at the village and regional level. However, with small populations and changing socio-economic conditions, communities often have insufficient resources and capacity to participate fully in important reviews and decision-making processes.

3.2 Canada overview

Provinces are stewards of natural resources, and this authority has recently been devolved from the federal government to the Yukon (2003) and the NWT (2013), and is under negotiation in Nunavut (AANDC 2014). The federal government regulates natural resources on Indian reserves and federal lands, as well as aspects of industrial development that relate to federal jurisdiction (including fish habitat, migratory birds and species at risk). Environmental impact assessment processes vary with jurisdiction. Both EIA processes and regulations are a mix of federal and provincial/territorial policy and governance mechanisms.

Settled land claims result in additional planning, assessment and regulatory regimes, including for all four Inuit regions (the Inuvialuit region (NWT), Nunavut, Nunavik (Quebec) and Nunatsiavut (Labrador). Land claims agreements create public boards of governance that have various mechanisms for joint decision making (co-management); many land claims agreements also include self-government agreements. Significant regions of the NWT, Yukon and the northern provinces do not have settled claims. The Yukon has one coordinated EIA process that applies to all levels of government. Environmental assessments may also be undertaken through the federal system (*Canadian Environmental Assessment Act*). Canadian Aboriginal people have constitutionally protected rights to traditional harvesting activities on their traditional lands.

3.3 Alaska overview

Assessment and permitting requirements in Alaska are also complex and cross-jurisdictional. The State of Alaska requires permits, such as for waste disposal and protection of cultural resources, generally with requirements for consultation with local people, especially subsistence users. Development proposals must meet the requirements of the National Environmental Protection Act (NEPA), which is triggered by federal interests, including federal lands, federal funding, or requirements for federal permits. The NEPA process is an environmental assessment, the outcome of which can be an Environmental Impact Statement, which is broadly based, including ecological, cultural, economic, social and cumulative impacts that were identified in the review process (UAF 2011).

Indigenous Peoples in Alaska have additional rights on Tribal lands under the *Alaska Native Claims Settlement Act*, and they retain their rights as sovereign governments. The *Alaska National Interest Lands Conservation Act* (ANILCA) gives all people living in rural areas a priority to hunt and fish on public lands for subsistence purposes and contains provisions for protection of Native subsistence rights (Alaska Department of Natural Resources 2010).

3.4 Discussion'

Regional variance is too great to present a 'business as usual" scenario, but some general points can be made and policy shortfalls identified.

Scale

Some governance jurisdictions coincide well with the scale and distribution of resources associated with ecosystem services – especially as land claims are based on traditional hunting territories. Often, however, the fit is not so good, and policy affecting key ecosystem components may be spread over multiple jurisdictions and further complicated by overlapping traditional hunting territories and ongoing negotiations for rights. Migratory tundra caribou, for example, migrate seasonally over ranges that include calving grounds on the tundra and wintering areas in northern forests. Caribou year-round ranges generally include portions of hunting territories of more than one Indigenous Peoples' group.

Caribou management boards have been established for many of the NA Arctic's migratory tundra caribou herds. These boards are generally inclusive and advisory, with representation of beneficiaries of the ecosystem services associated with the caribou and of management agencies. They work across the range of the herd, and thus cross jurisdictions and management regimes (Annex 4b). However, while there are clear incentives to working at the herd scale to manage a migratory resource

of importance to communities, effectiveness is often limited by lack of resources, lack of a legislated mandate, and/or lack of consistent commitment from governments.

In the context of the current policy and governance there are a range of general policy shortfalls that result in ecosystem services not being visible or adequately accounted for when major decisions are made about developments. While these policy shortfalls are identified in relation to the North American Arctic, and often in relation to specific areas looked at in this scoping study, there is wider applicability, and much of this policy discussion would also be applicable, for example, to the policy area of marine development and of development in areas important for reindeer herding. It should also be noted that these policy shortfalls are generalizations – innovative policy solutions that are in place or being developed would form a part of the further investigation through a TEEB Arctic study.

Policy shortfalls identified in the context of this policy study were:

1. Cumulative effects assessments, in the context of environmental impact assessment, are undertaken on a case-by-case basis and do not, in general, have comprehensive, strategic plans and assessments that look at a broader scale. This means that incremental ('nibbling') effects are difficult to take into account. Cumulative effects assessment is a requirement for environment impact assessments undertaken for large-scale proposed industrial development across the region. Assessments only consider effects of industrial activity that has already occurred or for which planning is underway.
2. Land use planning and land zoning processes that designate and protect key habitats are lacking or poorly implemented.
3. Ecosystem services are not often explicitly or systematically included in environmental and socio-economic assessments or reasons for decisions for projects.
4. Although policy and processes for consultation related to industrial development are well established over much of the region, they are not always implemented effectively.
5. Government subsidies and financial incentives are not (or are infrequently) assessed for unintended consequences on ecosystems and biodiversity.
6. Food security aspects of traditional foods are not given adequate attention by many decision-makers. Food security is discussed as an emerging policy issue in Section 1.7.5.
7. Climate change is not consistently and adequately incorporated into assessment and planning for development. The impacts of climate change on Arctic terrestrial and freshwater ecosystems are of increasing scope and significance (CAFF 2013b). Changes in supporting services such as primary production and nutrient cycling, and changes to regulating services such as moderation of extreme events and erosion prevention are happening at the same time as development-related impacts – and the outcome of this mix of impacts is hard to predict. Managing this uncertainty through good planning and adopting a precautionary approach is facilitated by consideration of climate change in all aspects of project planning and impact assessment. This policy shortfall has linkages to Arctic Council projects addressing policy to strengthen resilience and take action on adaptation (Arctic Council 2013c, 2014).

4. Possible pathway for future management of ecosystems and their services: What would adopting a TEEB approach contribute?

4.1 Alternative policies

This section presents, for consideration in future TEEB Arctic assessment, policies that, combined, implement a TEEB-approach, incorporate the values of ecosystem services and address policy shortfalls identified above. These are broad policy thrusts that include measures that are already partly implemented or are under consideration in at least some jurisdictions. The identified policies are considered complementary.

Policy 1: Strategic environmental assessment

Make wider use of spatial planning and strategic environmental assessment approaches at the scale of ecologically meaningful regions, such as for caribou herd ranges. Strategic environmental assessment encompasses a range of decision-support processes that aim to ensure that environmental and possibly other sustainability aspects are considered effectively in policy, plan and program making (Fischer 2010).

The predictability of development is relatively high at a broad geographic scale as it is dependent on underlying geology. However as resource extraction is typically driven by commodity price cycles, it is difficult to predict the scale and timeframe of actual developments. Spatial planning and strategic environmental assessments are preparation for the environmental, socio-economic and cumulative effects assessments at the individual project stage.

In addition to the scale of caribou herds, maintenance of ecosystem services can be facilitated through spatial planning at scales such as river catchment areas for the maintenance of water supplies and/or fisheries.

A regional approach to assessing the status of caribou and other associated and/or regionally relevant ecosystem services can yield recommendations or design measures to conserve bundles of ecosystem services (for example, the full spectrum of values associated with caribou). Withdrawal of calving areas from development, setting of thresholds for linear development, and specific mitigation measures to reduce impacts on a regional scale are examples of possible outcomes.

Examples of policy implementation

▶ The Peel Watershed Regional Land Use Plan (covering 64,000 km^2 of northern Yukon) is "*designed to maintain the wilderness characteristics and ecological integrity of this special region, while allowing for carefully managed economic activity*" (Yukon Government 2014: p. 1) creates zones that provide protection for wilderness and others that allow for economic development, as well as other measures, such as restricting access and life of industrial roads.

▶ Nunavut Planning Commission's draft land use plan for Nunavut. Includes policy (still under development) aimed at protection of caribou calving and post-calving areas: a) area protection that excludes industrial land use for areas "*that have not been identified for high mineral potential*" and b) special management areas that may require mitigation of impacts from some land uses for areas "*that overlap with high mineral potential*" (NPC 2014).

▶ Emerging directions for the Canadian Environmental Assessment Agency (Government of Canada), which lists regional planning and practical measures of limits to growth as an aspect of Canadian assessment processes requiring improvement (Canadian Environmental Assessment Agency 2014).

Policy 2: Ecosystem services in EIA

Incorporate consideration of the entire spectrum of ecosystem services into environmental impact assessment through guidelines, procedures, methodologies and regulations at all levels for all activities subject to EIA in the Arctic.

Although this lies within national regulatory responsibility, action can be taken at the international level through measures such as recommendations, guidelines and best practices.

Explicit incorporation of ecosystem services into EIA is a topic receiving current international attention: for example, through assessment of benefits and methodologies (Landsberg et al. 2013), consideration for incorporation into industry guidelines and financial policy instruments (IFC 2012).

Opportunities for policy implementation at the international scale include:
▶ Working through the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention);
▶ Updating EIA guidelines through Arctic Council (Arctic Environmental Protection Strategy 1997);
▶ Bringing EIA procedures and standards to the agenda of the new Arctic Economic Council.

Policy 3: Improved participatory processes

Allocation of resources by governments to review processes is often not adequate for beneficiaries of key ecosystem services to participate effectively in consultation processes. Indigenous organizations often lack both resources and capacity to fully participate. This is a multi-faceted problem, and would need a suite of policies to implement. Responsibility lies with various scales of jurisdictions, and international policy action may be in the form of analysis and guidance. Some directions that policy measures could take:
▶ Make consultation more strategic and efficient. Consultation on development plans is often done on a case-by-case basis, overwhelming communities with multiple requirements for review.
▶ Invest in training and support for all parties involved in co-management and other forms of collaborative decision making.
▶ Introduce measures that encourage or require consultation at very early stages of development and promote consistent communication and consultation throughout the lifetimes of projects. This is already recommended practice, but is applied unevenly. There are various ways this could be accomplished, including through promotion of best practices and guidelines, and through permitting requirements.

Policy 4: Ecosystem value accounting

Make use of financial policy instruments that capture the values of ecosystem services.

The full social and environmental cost of mining and hydrocarbon development in the Arctic is not borne by the respective producers and not accounted for in government decisions. The external costs of these developments may take various forms, from direct government subsidies to environmental degradation that, in turn, reduces ecosystem services provision. These external costs can be very large when mines are not properly decommissioned and incur high and potentially very long-term expenses by governments, along with risk of long-term damage to ecosystems.

While it will be possible to capture financial values for a number of Arctic ecosystem services, this will not be possible for all services. As such, any monetary assessments of environmental impacts arising from mining and hydrocarbon development should be acknowledged as incomplete and reflective of a lower bound. Accordingly, the scope of Ecosystem Value Accounting should also identify and document the additional 'valuable', but not monetized, ecosystem services in an appropriate format. This is may be particularly relevant for a number of cultural ecosystem services in the Arctic that do not readily lend themselves to monetary valuation approaches.

Examples of options that could be assessed for their potential to ameliorate negative impacts of mining and oil development on Arctic ecosystem services:

- ▶ **Financial mechanisms that relate to project and/or infrastructure financing**. These can include voluntary mechanisms to demonstrate no adverse effect on biodiversity and ecosystem services provision or effective mitigation of impacts. The updated International Finance Corporation (IFC) Performance Standard 6 on biodiversity (PS6) requires a systematic assessment of ecosystem services dependencies and impacts for associated projects. This standard has been adopted by over 60 equator principle banks and applied to major project finance investments (IFC 2012). If an international investment vehicle for sustainable development in the Arctic is established, as recommended by the World Economic Forum (WEF 2014), application of the PS6 would be a step in achieving the goal of sustainability. The effectiveness of this as a policy instrument would be highly dependent on the quality and independence of the underlying ecosystem services and biodiversity assessments, and the institutional structures for 'signing-off' on the assessment processes and associated mitigation measures.
- ▶ **Subsidy reform** for oil and mining exploration and extraction industries (or, at the international level, guidelines and best practices related to subsidies and incentives). Subsidies to extractive industries, such as the oil sector, have typically been predicated on increasing general exploration and development activity by reducing costs via tax breaks and royalty reductions (EnviroEconomics Inc. et al. 2010). This can incentivize adverse impacts on biodiversity, particularly in scenarios where activities are economically marginal. There are drivers for reforming incentives, including subsidies, which are harmful to ecosystems and biodiversity (e.g., the commitment to Aichi Target 3 under the Convention on Biological Diversity). Future subsidies to incentivize oil and mining activities in the Arctic region in a more positive direction could incorporate specific provisions that finance independent assessment of impacts on biodiversity and ecosystem services provision and the development of mitigation measures via stakeholder engagement. Studies such as Carson et al. (2003), Kotchen and Burger (2007) and Bostedt and Lundgren (2010) suggest funding this through public funds is likely to be supported by the general public.
- ▶ **Ecosystem service off-setting**: e.g., mechanisms for funding investments in remediation of other industrial legacy problem sites or associated infrastructure when new areas are developed for oil and mining.

4.2 Summary of impacts of alternative policies on ecosystem services

Table A4.3 presents an initial scoping of the potential for impact on selected bundles of services under policies discussed above. As with all projections of trends in the Arctic, impacts and uncertainty related to climate change need to be taken into account.

Table A4.3. Summary of projected ecosystem service change under policy scenarios (examples, in relation NA Arctic terrestrial and freshwater ecosystem services affected by industrial development)

Example 1. **Provisioning, cultural** and **habitat/supporting** services related to migratory tundra caribou (examples, in relation NA Arctic terrestrial and freshwater ecosystem services affected by industrial development)

Alternative policy	Projected marginal change on ecosystem services, comparing scenarios of 'business as usual' policies with policies that foster sustainable ecosystem services	Projected distribution of benefits and losses (marginal changes)
1. Strategic environmental assessment	++ Contribute to improved protection of calving grounds and reduction of habitat fragmentation and disturbance (general reduction of cumulative impacts), with benefits to caribou abundance and availability to harvesters	++ Indigenous people in caribou user communities at scale of herd ranges (positive impact on food security, cultural benefits) ++ Others benefiting from healthy caribou herds, including sport hunting, wildlife viewing, ecotourism, and global cultural enrichment. + Industry, local communities for employment and business opportunities (greater certainty for investment) − Potential for loss of development opportunities + Ecotourism and recreation (positive impact on wilderness protection and wildlife viewing opportunities through spatial planning)
2. Ecosystem services in EIA	+ Improved protection against loss of caribou-related ecosystem services from individual projects (reduction of impacts such as disturbance of caribou); potential enhancement of services from mitigation measures and benefit agreements	+ Caribou users at scale of potential impact from project (scales from the project's immediate zone of influence to the herd scale) − Industry (more onerous assessments)
3. Improved participatory processes	++ Improved or less loss of ecosystem services (from decisions taking into account knowledge, values and priorities of beneficiaries + Improved adaptive capacity due to incorporation of local and Traditional Knowledge in management decisions, resulting in improved chance of continuity of ecosystem services in changing conditions (e.g., in relation to climate change impacts on caribou)	++ All stand to benefit from improved decisions involving trade-offs, including, e.g., industry benefiting from enhanced social license to operate, communities benefiting if improved participatory processes better address their concerns and meet their needs − Added investment needed from government; added investment in time and expertise from communities − Potential for added costs and restrictions to industry
4. Ecosystem value accounting	+ Benefits to caribou and ecosystem services, including food safety, from improved post-development clean-up + Benefits to caribou and ecosystem services from better screening of lifetime project impacts prior to embarking on development	− Industry (potential added time to start-up phase and added costs) + Government and public (reduced financial burden for clean-up after industry) − Government (could reduce ability to boost local economies through incentives and subsidies to industry)

Example 2. Provisioning, cultural and habitat/supporting services related to fish and supply of clean water
(examples, in relation NA Arctic terrestrial and freshwater ecosystem services affected by industrial development)

Alternative policy	Projected marginal change on ecosystem services, comparing scenarios of 'business as usual' policies with policies that foster sustainable ecosystem services	Projected distribution of benefits and losses (marginal changes)
1. Strategic environmental assessment	+Watershed level protection of water quality and fish, including reduction of cumulative effects	+ Local people (ecosystem service benefits) + Ecotourism business, those engaging in outdoor recreational activities and associated businesses + Industry, local communities for employment and business opportunities (greater certainty for investment) + Industry (should streamline subsequent EIA processes) – Industry, government, local people. Potential for loss of development opportunities
2. Ecosystem services in EIA	+ Water, aquatic resources and fishery protection at scale of zone of influence of projects	+ Local people + Ecotourism business and those engaging in outdoor recreational activities (including, e.g. canoeing and sport fishing) + Industry: enhanced social license to operate – ? Industry: potential for added time and costs for EIA process (possibly not significant increases)
3. Improved participatory processes	+ Water, aquatic resources and fishery protection at scale of community/ traditional territory, through, e.g., identifying priorities and through use of local and Traditional Knowledge	+ Indigenous Peoples, other local people – greater confidence and opportunities for needs to be met, both for fish and clean water, and for economic benefits
4. Ecosystem value accounting	+ Reduced risk of damage to fish, water supply and supporting/habitat services, related to go/no go decisions and operational requirements for industrial activity ++ Reduced risk of damage to fish, water supply and supporting/habitat services from decommissioned/abandoned mines and related waste and infrastructure	+ Local people (through protection of fish, water supply and supporting/habitat services, overall aquatic ecosystem health) + Government (taxpayers) from less risk of large public expenditure for dealing with abandoned mines – Higher upfront funding needed by industry – Potential barrier to investing in mine exploration and development, with loss of economic opportunities (loss to government revenue and communities in terms of jobs and business opportunities)

5. Conclusions

The risks to ecosystem services from cumulative effects of industrial development in the NA Arctic can be reduced through a stronger emphasis on planning and assessment at ecologically meaningful scales, taking an ecosystem services approach in setting priorities and making decisions involving trade-offs. At the scale of individual projects, risk can be reduced through explicit, consistent incorporation of consideration of ecosystem services into assessments of the project's environmental and socio-economic impacts.

These policy instruments for planning and assessment depend on participatory processes that recognize the many ways in which bundles of ecosystem services are important to Indigenous Peoples and others, and that address concerns that arise. The NA Arctic has many effective governance mechanisms in place, based on various forms of co-management. Challenges, though, remain in the areas of effective public participation, meaningful incorporation of Traditional Knowledge, and planning and decision making across jurisdictions.

Consideration of food security is a promising approach for analysis of the values of and risks to important ecosystem services, especially when a holistic approach is taken that incorporates the many cultural services associated with traditional foods. Using the framework of food security also makes the concepts of sustainability of ecosystem services more understandable at the local level. Ecosystem services and TEEB terminology can be difficult and misleading.

The types of policy and governance mechanisms discussed in this policy example are within national and sub-national jurisdiction. Action at the international level could include through multilateral environmental agreements, but would mainly be through Arctic Council initiatives that shape policies and provide forums for building and sharing information, tools and methodologies – in particular through work on mainstreaming biodiversity that is ongoing and planned through implementation of the recommendations of the Arctic Biodiversity Assessment (CAFF 2015).

A TEEB Arctic study would further scope out the current policy situation and a range of alternative policies in relation to their effects on important ecosystem services that are potentially damaged by mining, oil and gas and infrastructure development following the methodology outlined in Section 1.5 'Introduction to the TEEB approach'.

Annex 4a. Selected online questionnaire input related to industrial development in North American Arctic terrestrial ecosystems

Improving decision making: *"Better decisions about where NOT to drill/mine, to make sure key areas are protected". Windows of opportunity: "In the US, there are several stages in the oil development process at which ecosystem services can be recognized, from determining which areas will be offered for leasing, to determining the conditions of the leases, to determining the conditions of infrastructure and other development, etc."*

Benefits of an ecosystem-services approach to land-use permitting decisions: *"Better certainty and less conflict between industry and local communities"*

Policy option: *"Arctic development strategy. This would provide guidance to decision-makers across Arctic Canada, including infrastructure requirements, funding challenges, training and retention issues, educational challenges, sustainable solutions and legislative/regulatory framework. Ensure that ecosystem services become entrenched in legislation/regulatory frameworks across Arctic Canada. There are some regulatory areas where this occurs but it is not consistent."*

Protection of fish-related services: *"For anadromous fish (e.g., Arctic char), the freshwater ecosystems are also crucial to their survival. Mining should be banned or at least heavily regulated in watersheds that sustain economically important anadromous fish populations."*

Climate change and industrial development: *"A larger planning exercise is dealing with the impacts from climate change such as more frequent, extreme events. The environmental assessment and approvals process must take into account these factors through improved design and engineering of structures and facilities. This is currently done on an ad hoc basis."*

Policy areas for application of a TEEB approach (Canada):
► *"Identifying conservation strategies. Incorporating ecosystem services information into development of conservation plans and protected areas planning. Looking at ecosystem services bundles and where areas of high ecosystem service provision may overlap with other landscape features the national government is trying to maximize."*
► *"Incorporating ecosystem services information into development of land use plans to protect ecosystem function and benefits."*
► *"Local planning. Details would depend on national context, but tools that include explicit ecosystem services accounting could be relevant as a way to encourage more long-term monitoring and evaluation than environmental impact assessments."*
► Windows of opportunity: *"Look at the development of national planning strategies in the different countries. Windows of opportunity are likely to be nation-specific."*

What elements of governance enhance consideration of ecosystem services in decision making?
- ▶ *"Participation by local people in management efforts, to make sure local voices, concerns, and perspectives are considered."*
- ▶ *"Co-management at an appropriate geographic scale with appropriate institutions in place."*
- ▶ *"Co-management boards that issue land-use permit and manage wildlife merge perspectives from Aboriginal people with those of industry and other governmental needs."*
- ▶ *"I think most Arctic countries have a form of an Environmental Impact Statement (EIS), which is a process of evaluating the costs and benefits of a development project to the environment and local people. Through this process much information is gathered, and study like this could contribute information to the process."*
- ▶ *"Public opinion is also a driver that can shape policy, so if the general public is more aware of the value of ecosystems they will elect like-minded people, and support decisions that take the value of ecosystem services into account."*
- ▶ *"A long-term planning horizon, so that the long-term impacts of development are considered, not just the short-term ones. Cumulative impacts assessment, so that a series of smaller actions do not wind up adding up to a major impact."*

What works against ecosystem services consideration?
- ▶ *"Short-term thinking. The idea that impacts must be demonstrated before projects are changed, rather than putting the burden on industry to show that they will NOT have impacts before they start their activities. More attention to money than to other aspects of ecosystem services."*
- ▶ *"How to include cumulative effects at regional levels are (still) not well developed and implemented in decision making. (Boards don't have all the data/information and the instrument to use the data/information for making decisions are lacking; they don't have GIS for example.)"*
- ▶ *"Decision making is a process of weighing costs and benefits, so anything where the benefits are considered great will outweigh the cost to the environment. The profits to be made from oil and gas development are considered a great benefit and as such oil and gas development is likely to occur regardless of the cost to the environment and the people that hunt and fish there. Also, many politicians don't represent the average rural Arctic resident. They are usually from big cities, wealthy backgrounds with much education so it is difficult for them to appreciate the benefit of a clean river to fish in."*
- ▶ *"Lack of human and financial capacity in local and regional governments and institutions. Complex governance systems with too many decision-making bodies that can hamper decisive action-taking."*

Relationship to stewardship: *"As the ecosystem services decline (less caribou), less people have access to its benefits, the people with less access begin to care less or know less about the service. More education on the values of the ecosystem service is important during times when the resource is limited so that difficult stewardship decisions are made and supported."*

Need for participatory processes: *"One-sided economic or engineering-specific consultation often does not take into account the unique northern ecosystem and ecosystem services in the north. For example, seemingly simple urban planning decisions are much more complicated in northern environments than local, regional, or even national governments realize. Consultation with Indigenous Peoples, scientists, and policy makers should be made for northern development projects."*

Board governance model: *"The Board style of governance across Northern Canada (YESAB [Yukon Environmental and Socio-economic Assessment Board], NIRB [Nunavut Impact Review Board], MVLWB [Mackenzie Valley Land and Water Board], MVEIRB [Mackenzie Valley Environmental Impact Review Board]) promotes consideration of ecosystems as their members are community based. Unfortunately these Boards are generally under-resourced, which fetters their ability for in-depth follow-up of issues in making decisions. Northern Boards report to the Minister of Aboriginal Affairs and Northern Development (with the exception of YESAB) with recommendations. The Minister can accept or reject decisions – this may impact consideration of ecosystem services across the North."*

Values: *"Regarding food, monetary and non-monetary values of country food tend to be understated/underrepresented. We have worked with replacement values (one kg of caribou being worth the equivalent of 1 kg beef at the local store, and so on.) But this still underestimates values, especially social/cultural ones such as sharing."*

Water supply: *"Growth and development in northern regions will require significant amounts of clean freshwater. Some northern communities are already faced with a limited supply of water (e.g., Iqaluit, Nunavut). Due to geographic constraints, and high cost of services, the need for sustainable water resources in northern regions is high. Thus, the associated monetary value of clean sustainable freshwater resources is also high. Likewise, the cost of purification and treatment of water is significant, and discharge of untreated wastewater places a heavy burden on the environment. Industrial development and resource extraction industries also utilize large amounts of fresh water, and create large amounts of wastewater. Legacy contamination of water resources (e.g., Giant Mine, NWT) are reminders of the monetary cost of water use (and misuse) in northern regions."*

Traditional Knowledge: *"It is critical that Traditional Ecological Knowledge be treated in the same manner as "western" ecological knowledge during an approvals process. However this is currently not the case due to a number of factors including: 1. availability of TEK to both Boards and proponents; 2. the "politics" of TEK; 3. the lack of acceptance of TEK in the commercial, scientific and engineering community; and, 4. the lack of credibility of TEK in both government and academic communities. There needs to be*

publically available TEK such that proponents and government have the ability to access this information during the design of projects. Government has a number of publicly available databases available for general use (e.g. water survey, geoscience, hazards, soils etc.). TEK at a high level should be no different."

Financial incentives: *"From the exploration and mining industry perspective, assessment credit should be granted for consultation programs and environmental programs that are undertaken in support of a project. This is currently not allowed. It has been documented that over 25 % of costs for a mineral exploration program can be dedicated to aboriginal consultation and environmental baseline programs at a very early stage in the process – this is very difficult for proponents."*

Annex 4b. Regional focus on Beverly and Qamanirjuaq caribou herds and co-management

Authors: L. Wakelyn and G. Bussidor (Beverly and Qamanirjuaq Caribou Management Board)

This regional example, based on input from the Beverly and Qamanirjuaq Caribou Management Board, provides context for the policy area of cumulative effects of industrial activity in Arctic terrestrial areas. Much of the material in this annex is drawn from the BQCMB management plan and related Board information (BQCMB 2014a, 2014b).

Contents
1. Caribou Harvester Perspective
2. Beverly and Qamanirjuaq Caribou Management Board
3. The many-faceted value of caribou
4. Mineral exploration and development

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1. Caribou harvester perspective

By Geoff Bussidor, northern Manitoba community BQCMB alternate

The North is vast, largely uninhabited, fresh and wild. Although the environment may seem extreme and rough, it is also fragile and very sensitive. Governments, companies and people who authorize or are authorized to work there should consider it a privilege, to be working and living up there. These folks should in turn treat the land and water systems and its inhabitants with utmost respect and responsibility.

The areas of work should be left as it basically was before work commenced. No sites should be abandoned and left without clean up (remediation) efforts, it is the responsible thing to do. Abandoned sites should be cleaned up before any other permits are released for these areas. Contaminants, debris and toxic materials should not be left on this precious land.

The North is our last great resource and should be treated with the extra care it deserves. The caribou in particular have their young up there. Efforts should be made to protect these areas from development.

Our people suffered much due to efforts to protect the caribou, by Government in the past, but, we moved back to an area where we would still have access to caribou. This issue has gone a complete circle now, we now need to speak up for the animals that we relied on in the past and still enjoy today.

2. Beverly and Qamanirjuaq Caribou Management Board

The BQCMB is a Canadian co-management board that provides planning and management advice in relation to two herds of migratory tundra caribou. The size of the combined ranges of these migratory herds (1940s–2012) is approximately 1.3 million km2 (larger than Norway, Sweden and Finland combined). About half of this area is in tundra ecosystems and half in taiga. Thousands of indigenous residents of 22 communities on or near the ranges of the two herds depend on the caribou to feed their families. The BQCMB is made up of representatives of Inuit, Dene, Cree and Métis governance bodies and communities, and representatives of five governments (Canadian federal government, two territories and two provinces.)

Figure A4.3. Map of Canada showing the Beverly and Qamanirjuaq caribou ranges, calving grounds and communities within the herds' ranges
(J. Eamer, based on data from BQCMB)
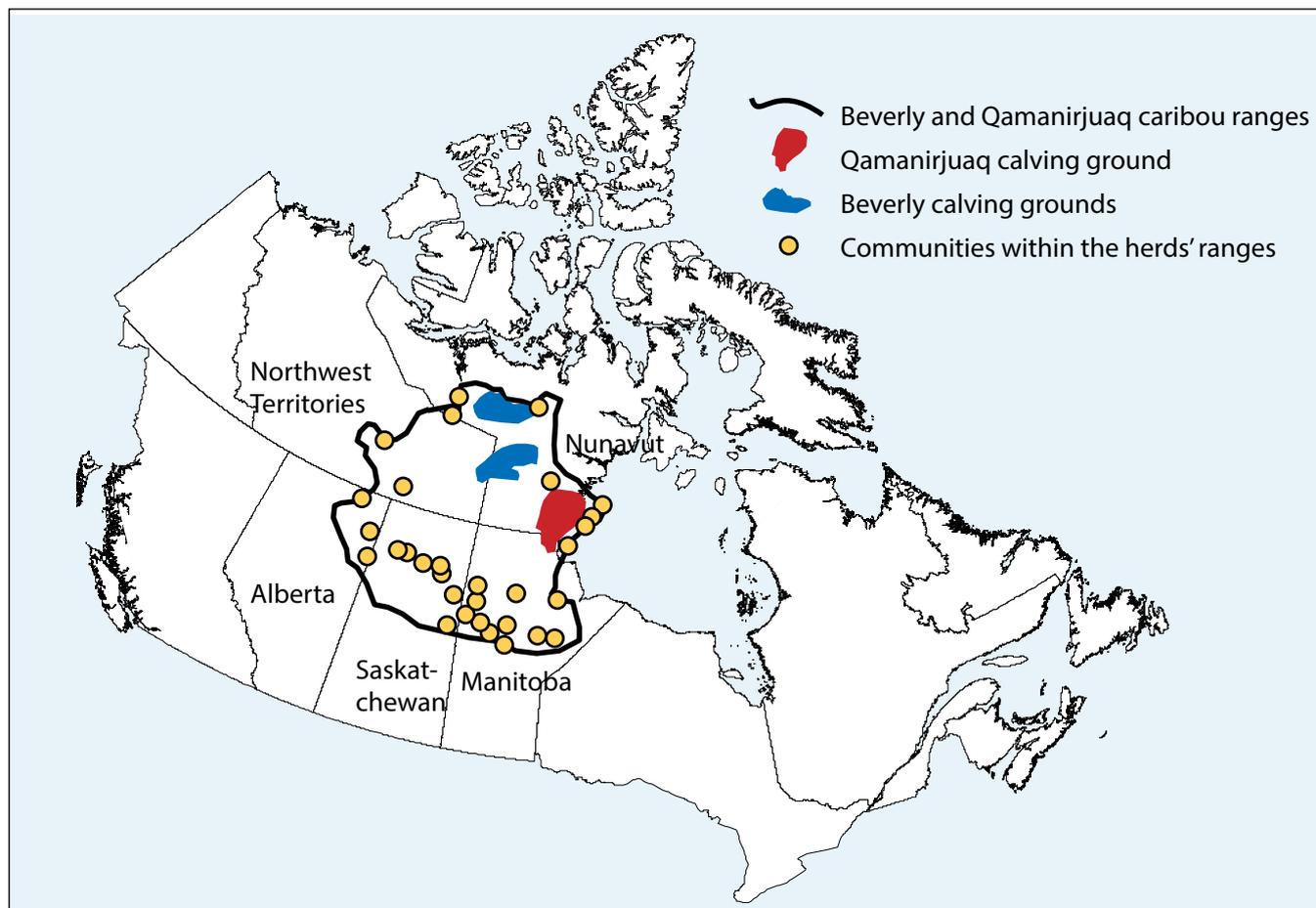
3. The many-faceted value of caribou

The relationship of people with caribou is a fundamental part of traditional harvesters' identities that has been passed down through many generations. Caribou provide a secure and reliable source of healthy and nutritious food for many people across the caribou ranges. Additional economic values are derived from the use of skins for clothing and bedding, and bones and antlers for handicrafts. However, harvesting caribou is not simply a means of providing food or income. The true value of caribou for indigenous people is reflected in the strong traditional, cultural and spiritual relationship that exists between the people and animals. Harvesting caribou and other activities associated with use of caribou (for example, ceremonies and community feasts) continue to have enormous social and cultural values for maintaining traditional cultures for present and future generations (adapted from BQCMB 2014b: p. 18). An economic study placed the value of the annual harvest at C$20 million, based on the 2005/2006 harvest, as discussed in Box A4.2.

4. Mineral exploration and development

Exploration and development on the Beverly and Qamanirjuaq caribou range has been a major concern of the BQCMB since its creation in 1982. Exploration and development have occurred on the historical winter range of the Beverly herd in northern Saskatchewan since the 1940s. Interest in extracting mineral resources from other parts of the caribou ranges and developing roads to access these resources has increased and expanded geographically over the past decade.

Observations by people from the caribou range communities show that roads have increased unregulated harvest of caribou, acted as barriers to caribou movement, resulted in frequent disturbance, and reduced habitat availability. There is a high potential for greater harvest levels resulting from increased access to caribou range that could be provided by new and proposed roads. Restrictions on use of roads built to support exploration and development are very difficult to establish and enforce.

5. Policies that may be damaging to caribou-related ecosystem services

This summary of policy issues illustrates the interrelationship of policies and their sometimes unintended impacts on ecosystem services.

▶ **Inadequate environmental assessment**

Case-by-case environmental assessment, with cumulative effects assessments limited to single projects in relation to others, rather than regional assessments with identification of thresholds. The BQCMB supports range-wide assessments.

▶ **Inadequate application and enforcement of existing policies and regulation**

For example, the repeated occurrence of mineral exploration sites and mines being abandoned prior to complete remediation and their persistent effects, especially local contamination, is of great concern to residents of northern communities. Community members of the BQCMB believe that governments and regulatory agencies are not doing enough to prevent these situations, and enforcement is not adequate. As well, people feel that the mining industry as a whole is generally not taking adequate responsibility for their role. Despite industry claims that things have improved and 'the bad old days' of irresponsible mining are over, people out on the land continue to encounter inadequately remediated sites that cause them great concern for their water, their land, and their wildlife resources.

▶ **Insufficient constraints on industrial uses of lands and waters**

For example, the adverse effects on caribou health of dust-contaminated forage resulting from open pit mining and access roads is of great concern to traditional caribou harvesters around the Beverly and Qamanirjuaq caribou ranges. The perception is that industry, regulatory boards and governments are not doing enough to seriously consider this issue, including in cumulative effects assessments, or to take action to address it.

▶ **Lack of land use planning** to provide certainty for land users and protection for wildlife, lands and waters

▶ **Inadequacy of protected areas and wildlife conservation areas**

For example, despite a BQCMB position against exploration and development on Beverly and Qamanirjuaq calving grounds, post-calving areas and key migration routes and concerns voiced by communities from across the caribou ranges about these activities, mineral exploration has continued on these key habitats.

▶ **Lack of finalized land claims**

Land use planning in the NWT and other regions is prevented in part because of outstanding land claim issues. This has also constrained efforts to protect important wildlife habitats in several regions.

▶ **Government incentives and subsidies with unintended consequences that are harmful to wildlife**

For example, subsidies for:

• Use of air charters to access caribou herds far from communities
• These subsidies are often provided by one government department without consultation with government departments with responsibility for wildlife management.
• Shipping traditional (country) foods (including caribou) between communities (instituted to provide traditional foods to communities where caribou are no longer accessible)
• This may have unintended consequences of increasing harvest in areas where caribou are close to communities, contributing to cumulative effects on caribou herds that could exacerbate population decline and result in reduced availability of caribou to all.

▶ **Lack of incentives for helping communities maintain healthy lifestyles** that include harvest of traditional (country) foods, including caribou, for example:

• Incentives for hunters to travel longer distances overland to harvest their own animals (rather than using subsidized air charters) in times of shortages
• Incentives to harvest other wildlife species (especially fur-bearers) that are not the main focus of their trips to help fund the cost of hunting trips away from communities

▶ **Shortfalls in collection of information essential for management**. The BQCMB has ongoing concerns regarding the continued sustainability of both the Beverly and Qamanirjuaq herds for harvesters (BQCMB 2014b) and has recommended acquisition of annual harvest estimates and minimum standards for the collection and reporting of harvest data.

Annex 5. Draft budget overview for the full TEEB Arctic study

The budget projection (Table A5.1) is based on the draft preliminary work plan for a TEEB Arctic study (Table 7.1 in Chapter 7 'The way forward'). The budget projection is based on the assumption that the project will be completed in four years (48 months, or 16 quarters) and includes in-kind contributions from Arctic countries for expert research and writing.

Table A5.1. Draft budget projection for the full TEEB Arctic study

Activities	Milestones	Timing (Q)	Budget (US$)
Phase 1: Project start-up (Q 1-4)			
Engage stakeholders	Three initial sub-regional workshops with key stakeholders	Q1-2	170
	Organization of the project website with questionnaire and other materials for the project	Q1	15
Mobilize resources	Staff cost for fundraising activities	Q1-3	20
Establish project governance and teams	Identification of partners to form steering group Identification of project leader and the key experts for the team	Q1	15
Develop and consult on options and plans (including making decisions about the scope, scale and areas of policy focus)	Develop full project plan Project steering group meeting	Q2 Q2	10 25
Begin background work for ecosystem services and policy assessments	Experts' work (4 for ecosystem, 4 for policies, 2 for TK)	Q3-4	70
Establish working group and linkages with key Arctic Council initiatives and plan collaborative work	Identify authors and experts to work with the key expert team	Q4	10
Initiate communications activities	Develop communication work plan Develop initial materials	Q4 Q4	5 10
TOTAL for Phase 1		**Q1-4**	**350**
Phase 2: Analytical work (Q5-12)			
Conduct the six-step assessment process for the TEEB studies	Work of key experts team and engaging other authors Authors workshop (experts, authors, PSG)	Q5-12 Q6	350 50
Maintain stakeholder engagement	Communicate to stakeholders through website and communications materials	Q8-12	25
Conduct awareness raising	Awareness raising activities	Q8-12	35
Develop methods, tools and information products	Models, tools	Q11-12	50
TOTAL for Phase 2		**Q5-12**	**510**
Phase 3: Consolidation and reporting (Q10-16)			
Present, discuss and refine results, analysis of achievements	Consolidation and synthesis of results Presentations at various venues	Q10-13	45 35
Develop policy recommendations, including options for policy change implementation and undertake review, including through Arctic Council and through the TEEB programme	Draft policy recommendations Workshop	Q12-14	50 50
Develop project report or report series and additional products geared to meet stakeholder needs	Full project report (editing, design)) Communications materials designed for various stakeholder groups	Q15-16	30 25
Conduct follow-up planning	Stakeholder assessment of project Develop follow-up plan	Q15-16	35 25
Present results and recommendations to Arctic Council Ministerial meeting	Preparation of published materials Organizing side event	Q16	20 15
TOTAL for Phase 3		**Q10-16**	**330**
Management cost (15%)		Q1-16	178
TOTAL for the Project		**Q1-16**	**1,368**

Glossary

Throughout the text, words defined in the glossary are **highlighted** where they first appear.

Sources: TEEB on-line glossary (TEEB – The Economics of Ecosystems and Biodiversity n.d.), Guidance manual for TEEB country studies (TEEB – The Economics of Ecosystems and Biodiversity 2013), CEPA toolkit glossary (CBD 2008); Millennium Ecosystem Assessment (MA 2005d) and as noted.

Biodiversity (a contraction of biological diversity): The variability among living organisms, including terrestrial, marine and other aquatic ecosystems. Biodiversity includes diversity within species, among species and among ecosystems.

Distributional impacts (effects): Economic valuation almost always entails value effects for different groups of people, including, for example, values for different generations. For considerations of social or intergenerational justice, and gender equity, for example, it is important to spell out these distributional effects

Ecosystem services: Direct and indirect contributions of ecosystems to human well-being.

Ecosystem functions: The biological, geochemical and physical processes and components that take place or occur within an ecosystem. Or more simply put, ecosystem functions relate to the structural components of an ecosystem (e.g., vegetation, water, soil, atmosphere and biota) and how they interact with each other, within ecosystems and across ecosystems. Sometimes, ecosystem functions are called ecological processes (Petter et al. 2012).

Externality: A consequence of an action that affects someone other than the agent undertaking that action and for which the agent is neither compensated nor penalized. Externalities can be positive or negative (TEEB – The Economics of Ecosystems and Biodiversity n.d.).

Governance (of ecosystems): the sum of many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative action taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest (Carlsson et al. 1995).

Human well-being: A context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience (MA 2005d).

Intrinsic values: The values inherent to nature, independent of human judgement, and therefore beyond the scope of anthropocentric valuation approaches (Díaz et al. 2015a).

Mainstreaming: Integrating or including actions related to conservation and sustainable use of biodiversity in strategies relating to production sectors, such as agriculture, fisheries, forestry, tourism and mining. Mainstreaming might also refer to including biodiversity considerations in poverty reduction plans and national sustainable development plans. By mainstreaming biodiversity into sectorial strategies, plans and programs, we recognize the crucial role that biodiversity has for human well-being (UNEP and CBD 2007). The Arctic Biodiversity Assessment recommends that "mainstreaming biodiversity" "require[s] the incorporation of biodiversity objectives and provisions into all Arctic Council work and encourage[s] the same for on-going and future international standards, agreements, plans, operations a/or other tools specific to development in the Arctic. This should include, but not be restricted to, oil and gas development, shipping, fishing, tourism and mining" (CAFF 2013a).

Marginal vs. average or total values: Marginal value refers to the change in value when some circumstance is altered. Value data that measures marginal changes, for instance to compare the economic value effects between different alternatives or scenarios (policies, land uses, management options, etc.), tend to be more meaningful and less open to misinterpretation than are estimates of total values. Average or total values, however, can be useful in conveying overall importance of specific ecosystem services (adapted from TEEB – The Economics of Ecosystems and Biodiversity 2013).

Natural capital: Natural assets in their role of providing natural resource inputs and ecosystem services for human-well-being.

Participatory valuation: A participatory approach to valuation recognizes stakeholders as active collaborators in a decision process. Participatory valuation is a tool to unlock stakeholder values, experiences and insights about the management of ecosystem services across the whole decision-making cycle (Fish et al. 2011).

Policy: A course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions. (Merriam-Webster dictionary). Public policy: The organizing framework of purposes and rationales for government programs that deal with specified societal problems (UNPA Glossary (DPADM n.d.).

Social-ecological system: An integrated system that includes human societies and ecosystems. The functions of such a system arise from the interactions and interdependence of the social and ecological subsystems. Its structure is characterized by reciprocal feedbacks (Arctic Council 2013c).

Strategic Environmental Assessment (SEA): A range of decision-support processes that aim to ensure that environmental and possibly other sustainability aspects are considered effectively in policy, plan and program making. Processes vary in the degree to which they are 1) systematic, 2) participatory, and 3) based on environmental impact assessment methodology (Fischer 2010).

Traditional Knowledge (working definition): A systematic way of thinking and knowing that is elaborated and applied to phenomena across biological, physical, cultural and linguistic systems. Traditional Knowledge is owned by the holders of that knowledge, often collectively, and is uniquely expressed and transmitted through indigenous languages. It is a body of knowledge generated through cultural practices, lived experiences including extensive and multigenerational observations, lessons and skills. It has been developed and verified over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation (Arctic Council Permanent Participants 2015).

Valuation: The process of expressing a value for a particular good or service in a certain context (e.g., of decision making) usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology, and so on).

Value: The contribution of an action or object to user-specified goals, objectives, or conditions.

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Acknowledgements

For further information and additional copies
contact:

CAFF INTERNATIONAL SECRETARIAT
Borgir
Nordurslod
600 Akureyri
ICELAND

Telephone: +354 462 3350
Fax: +354 462 3390
E-mail: caff@caff.is
Internet: http: //www.caff.is

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