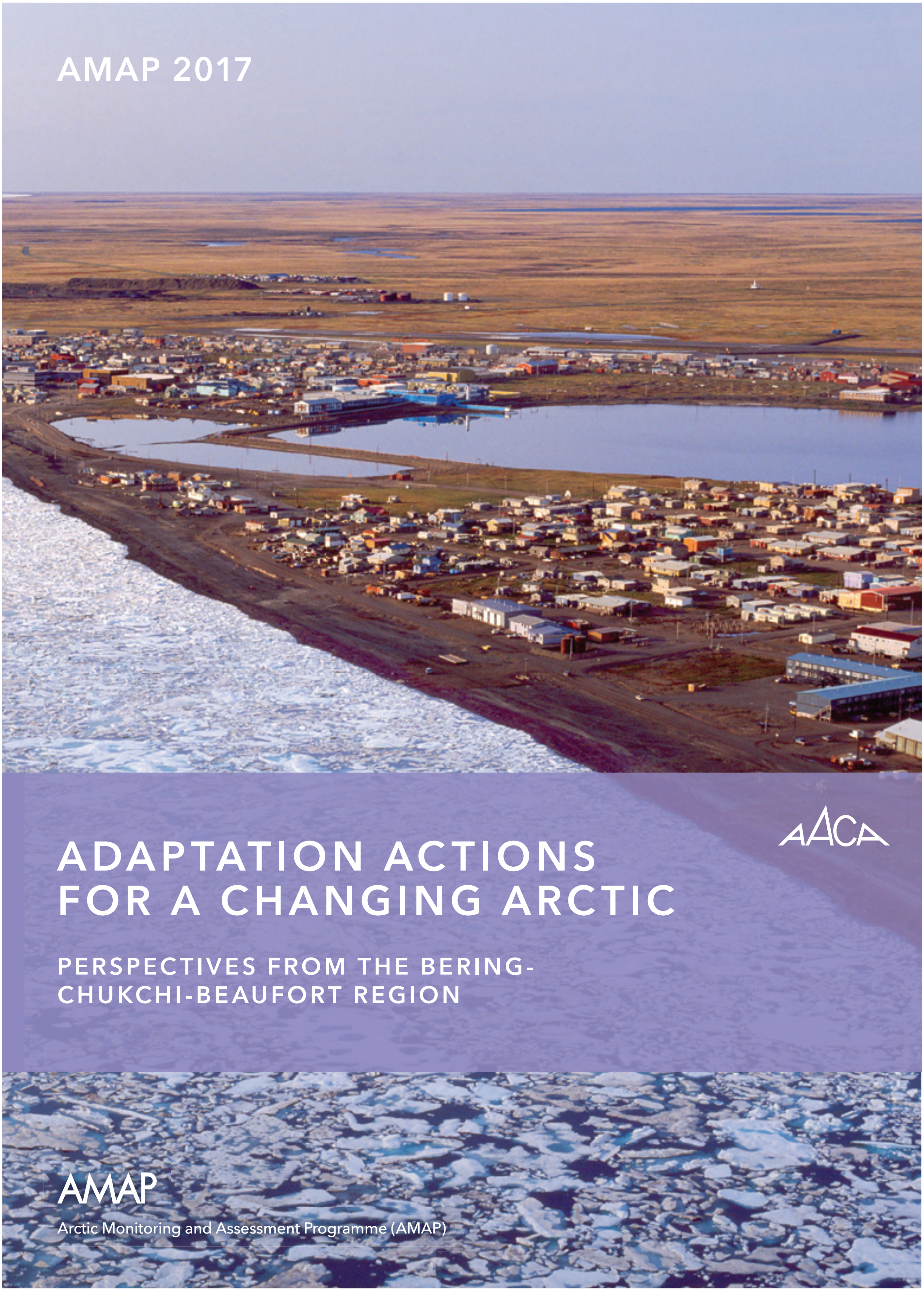

AMAP 2017

ADAPTATION ACTIONS FOR A CHANGING ARCTIC

PERSPECTIVES FROM THE BERING-CHUKCHI-BEAUFORT REGION

AACA

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AMAP 2017

Adaptation Actions for a Changing Arctic: Perspectives from the Bering-Chukchi-Beaufort Region

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8. Scenarios thinking for the Bering-Chukchi-Beaufort Region

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Key messages

- ***The future of the BCB region is one of significant socio-economic and climatic changes.*** *The consequences of climate change as well as the capacity of communities within the region to respond effectively will be contingent on the suite of social and environmental changes facing the circumpolar North. Over long timescales, such change is inherently uncertain. Scenarios provide a mechanism for representing that uncertainty, incorporating alternative socio-economic futures into climate change assessment, and identifying key opportunities for future investigations.*
- ***The evolution of governance systems as well as global demands for energy and the exploitation of Arctic resources are key uncertainties affecting future socio-economic pathways in the BCB region.*** *Global energy demand will affect future investments in the exploitation of Arctic energy resources. Meanwhile, the strength and level of cooperation among different government institutions and non-state actors will affect how well the BCB region addresses change and balances the benefits and costs. The potential for quite distinct futures across social, economic, and cultural dimensions also has implications for the adaptation experiences of communities and ecosystems in relation to the type and severity of climate change impacts.*
- ***Scenarios for different communities illustrate how the opportunities and challenges associated with climate change will vary significantly over time and place.*** *Different communities face different risks from a changing climate and have different perspectives regarding the implications of those risks and the most appropriate response options. As a result, it may be difficult to align decision-making at different levels, from local to international, to effectively address challenges across diverse communities, ecosystems, and stakeholders. Cross-scale research and collaboration in governance can mitigate disconnects. Participatory scenario processes can identify those aspects of human and natural systems that are most relevant to the sustainability of BCB communities.*
- ***Scenarios can be useful for navigating the interface between Arctic science and policy.*** *Thinking deliberately about the future can provide a vehicle for integrating multiple sources of knowledge into assessment and decision-making. This includes both technical and scientific knowledge, such as model projections of a changing climate, as well as the knowledge of Indigenous peoples. Scenario processes can reveal critical uncertainties that are directly relevant to stakeholder needs and livelihoods, which can then become targets for future research and monitoring of early warnings of change to enhance the social impact of science investments.*

8.1 Introduction

A number of biophysical and socio-economic drivers will have a significant influence on future vulnerability, risk, resilience, and adaptation planning in the Bering-Chuckchi-Beaufort (BCB) region (Chapters 4–7). The trajectories of some of those drivers are amenable to modeling, forecasting, or projection. However, the future is inherently uncertain, particularly over long time horizons. Scenarios have been used for over 50 years as a tool for exploring such uncertainty in order to identify key driving forces and critical unknowns, as well as to generate shared understanding among stakeholders regarding the potential for, and implications of, alternative futures (van Notten et al., 2003; Bishop et al., 2007; Avango et al., 2013).

This chapter provides a general overview of scenarios and their value for understanding the implications of a changing climate within the broader context of global change. The chapter includes a review of how scenarios have been used previously to understand climate change vulnerability, risk, and resilience, with a particular emphasis on the Arctic. It also introduces a new series of qualitative regional and subregional socio-economic scenarios for the BCB region, peering into the future to 2050, and discusses their implications for climate change impacts as well as adaptation planning and implementation.

8.2 Background on scenarios

8.2.1 What are scenarios?

For the purposes of this chapter, scenarios are narratives of plausible future worlds. Scenarios and methods for scenario development have been used for analysis and planning in a wide range of settings (Peterson et al., 2003; Kok et al., 2006a,b; Andrew, 2014). They have been successfully employed by governments, industry, researchers, and community-scale organizations (e.g., school systems, natural resource management groups), all of which face the common challenge of responding to uncertain futures during periods of rapid change.

> "*They [scenario development processes] introduce discontinuities so that conversations about strategy – which lie at the heart of any organization's capacity to adapt – can encompass something different from the present. Storytelling is key to making this process work.*" Wilkinson and Kupers (2013, p. 124) on Royal Dutch Shell's scenario process

> "*In addition, the process of scenario development offers a variety of ancillary benefits, notably raising awareness, learning from past experiences and reconsidering the validity of policy assumptions. Engaging stakeholders and policy-makers directly in development also boosts the validity and credibility of outputs.*" EEA (2009, p. 5)

Box. 8.1 Definitions of concepts used in exploring future states

Based on Andrew (2014) and Lindgren and Bandhold (2009).

Projection – A projection is a parametric description of a future time and possibly also the pathway to that time. For example, "the world's population in 2100 is projected to be 29 billion if fertility remains high".

Forecast – *"What do I predict will happen?"* A forecast is a projection that is considered most likely among other projections. While a projection can be simply a trajectory of a particular parameter (e.g., global population growth or decline), the process of forecasting additionally assigns some likelihood to various projections and highlights the most likely among them. For example, "the world's population in 2100 is likely to be 29 billion because fertility is expected to remain high".

Scenario – *"What would happen if?"* A scenario is a coherent narrative describing a future and often the pathway to that future and the drivers of changes along the way. Scenarios are often accompanied by projections, but not always. For example, "developed nations step up their ambition to eradicate common diseases in developing nations". This would be a valid scenario because the key drivers and their trajectories to create it are grounded in data that explain a trajectory to this outcome.

Visions – *"What do I want to happen?"* Visioning exercises address desired futures and specifically include values held by participants while purposefully discounting risks. They are usually qualitative, and often the goal is to trigger voluntary changes. Visioning may use projections, models, and forecasts, but only after determining the desired future state. For example, "we desire to have renewable energy widely available across the Arctic by 2040".

Sensitivity analysis – Some projections are presented as sensitivity analyses, where the uncertainty of the forecast is investigated by varying the assumed values of key parameters. Effectively this results in a number of additional projections with no change in the forecast (the most likely projection). This practice is particularly common in economic projections.

Models – Models formalize relationships between drivers and outcomes as a way to represent reality. Usually greatly simplified compared to the real world, models can be quantitative or qualitative, deterministic or stochastic (random), process-based or empirical, spatial and/or temporal. A model can be used to develop components of a scenario or assess the outcomes of a scenario.

Scenarios provide a flexible but informed perspective on a range of plausible socio-economic and environmental outcomes, which explains their wide use as a planning tool (Schwartz, 1996; Lindgren and Bandhold, 2009).

Although inherently forward-looking, scenarios are not explicit models of the future. While models can help inform scenario creation, scenarios are neither forecasts nor predictions (see Box 8.1 on definitions). Using scenarios is often a process of asking *what if?* This process can be implicit and informal, as individuals or organizations contemplate possible future events, consequences, and responses. In contrast, a range of formal scenario development processes have been designed to explicitly articulate alternative future development trajectories, states, and associated uncertainties. Scenario development processes can be used to bring together a wide variety of expert and lay perspectives to examine social, economic, and environmental processes. In general, participants identify drivers or key factors related to a question about the future (i.e., the 'focal question'), then examine current data, knowledge, and understanding around these drivers. Scenario participants can hypothesize how the most important drivers will interact in the future – typically over a time horizon of at least 20 years.

The long-term time horizon associated with scenarios hints at their key utility. Scenarios are used to explore possible futures that lie beyond forecasts or predictions where there is reasonable confidence about trajectories, outcomes, and uncertainties. Hence, scenarios are often described as plausible futures of unknown probability. For example, while demographic models are commonly used to develop population forecasts, the longer into the future those forecasts are made, the less reliable they are due to the accumulation of unforeseen and random events. Eventually, the forecasts become largely speculative. Thus, switching to a scenario mode of thinking can be helpful for exploring a range of alternative population trajectories and associated driving forces while explicitly acknowledging inherent uncertainties. Scenarios have also proven valuable as tools for exploring low-probability, high-consequence events that may not be readily identified or anticipated through management processes focused on the status quo, the foreseeable future, or the most likely trajectory (see Section 8.2.4).

Furthermore, because scenario exercises rest on an understanding of information pertinent to answering key questions tailored by those using the process, the data used can come from a variety of sources, such as climate change models, Indigenous knowledge, practitioner experience, or community values. In this sense, scenario development is based on science – established facts about how the world works – but the process of using science and values is flexible to the knowledge needs and expertise of participants. For example, a scenario process based on the question "What is needed to maintain subsistence hunting and gathering across the Arctic Slope of Alaska in 2050?" would rest on data that spans a variety of sources. A different question "How can infrastructure for cities in the High North be sustained in 2050?" would use different perspectives and information. The blend of imaginative thinking and tangible data is what makes scenarios such a powerful tool for society.

To the extent that scenarios engage a range of different experts and stakeholders, the scenario development process itself can significantly benefit those preparing for the future by enabling conversations among affected parties, introducing and sharing new information sources, and indicating the interconnected aspects of shared problems. Moreover, the identification and exploration of key uncertainties identified in the process can lead to the development of early indicators of challenges and opportunities. These indicators can be observed over time in order to track, at the community or regional level, a trajectory toward a desirable or undesirable future (see Section 8.6.3). The use of long time horizons also lets participants think outside their short-term budgetary, political, or research constraints, thus enabling participants to freely communicate and consider multiple options. Ultimately, the selection of experts and stakeholders for participation in the scenario process is contingent upon the goals of scenario development, the questions around which insights are being sought, and who is seeking those insights. As illustrated in this chapter, a range of approaches to the development and use of scenarios are evident in the BCB region, all of which have potential applications for the assessment of vulnerability, risk, resilience, and adaptation planning.

8.2.2 Scenario methods and objectives

A wide variety of methods have been used in scenario development processes (Bishop et al., 2007; Rounsevell and Metzger, 2010). Börjeson et al. (2006) and Rounsevell and Metzger (2010), for example, identified three general approaches to scenario development often used in environmental assessment, which vary with respect to the intended application:

- *Exploratory* scenarios describe plausible but alternative development pathways
- *Normative* scenarios represent series of events and causal relationships that lead to desirable or undesirable futures or outcomes
- *Business-as-usual* scenarios explore the consequences of relatively well-known, near-term changes, and thus are often associated with shorter time horizons.

Other authors have identified a range of distinguishing characteristics associated with scenarios, including whether they are oriented toward actors or problems, use qualitative or quantitative data, span short or long time horizons, or are local versus global (van Notten et al., 2003; Chaudhury et al., 2013).

This diversity in approaches to scenario development offers a rich toolkit that enables scenarios to be developed and used for a wide variety of purposes, with varying levels of investment and intended outcomes. Van Notten et al. (2003) suggested that this diversity can be organized around three primary themes: scenario goals, scenario design, and scenario content. This heterogeneity in scenario approaches is apparent in the different BCB region scenario activities described in Section 8.3.

8.2.3 Scenarios across different scales

Scale is highly important to the development of any scenario process and can be defined as "the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon" (Gibson et al., 2000, p. 5; Cash et al., 2006). In scenario processes, scale often refers to hierarchies of space and organization or time, each of which may encompass multiple levels (e.g., local to global, household to international institution, or near-term to long-term). The issue of scale matters in terms of which problems are considered, which participants are included, and what types of information are used. The scale of any scenario activity results from the questions and uncertainties around which insights are sought, as well as the manner in which scenarios will be used to achieve those insights.

One common scale dichotomy describes scenarios as being generated either from the 'bottom up' or the 'top down'. Top-down scenarios tend to be expert driven, developed at aggregate (e.g., global or national) scales for the purpose of generating a consistent set of driving forces for other applications. For example, investigating the key drivers of extractive industries in the Arctic to consider impacts on national economies would produce scenarios of production from sets of economic, demographic, geographic, and industrial data. Meanwhile, bottom-up scenarios tend to be developed at a local or regional level using participatory methods in order to target concerns of stakeholders at these local scales. For example, planning for the provision of clean water to a small rural community in the Arctic would require data from global and regional models of weather and climate, but one would desire for the majority of participants to be people involved in that provision. Although scenarios can be applied in subsequent analyses or planning, the scenarios themselves and the processes by which they are generated can be quite informative in their own right. The process of coming together with other experts, either from a technocratic or a citizen science perspective, learning from one another, and considering long-range uncertainty can prompt new thinking about problems and their policy components. It should be noted, however, that the dichotomy between top-down and bottom-up is subjective and not entirely clear-cut, and therefore the labels of 'top-down' and 'bottom-up' are simply convenient shorthand to describe different approaches to scenario development.

Top-down approaches are represented by the Millennium Ecosystem Assessment (Carpenter, 2005; Raskin, 2005), Global Environmental Outlook (Raskin and Kemp-Benedict, 2002), Foresight (DTI, 2002) and, more recently, the parallel scenario process (Moss et al., 2010), which is a key scenario framework currently supporting the climate change community. Within the parallel process, the representative concentration pathways (RCPs) used in modeling to support scientific assessments, such as those of the Intergovernmental Panel on Climate Change (IPCC), represent alternative global greenhouse gas trajectories and land use change projections over the 21st century. Because the objective of the RCPs was to generate scenarios to use in climate change projections rather than to describe alternative socio-economic states, the underlying socio-economic trends have not been extensively analyzed. Instead, the alternative socio-economic futures under the parallel scenario process have been represented by the Shared Socio-economic Pathways (SSPs), which describe alternative global development narratives framed around socio-economic challenges for mitigation and adaptation (O'Neill et al., 2017). In addition, a limited set of quantitative projections for population, gross domestic product (GDP), and urbanization have been developed for each of the SSPs at the national level. However, because the SSP narratives are at the global level, they lack detail regarding many aspects of future socio-economic systems that might be of interest to communities, decision-makers, and stakeholders in the BCB region. Hence, the SSP framework was developed with the intent of developing storyline extensions and downscaled quantitative indicators to provide context for various sectors and regions (Ebi et al., 2014; Absar and Preston, 2015).

At the opposite end of the scenario development spectrum is a range of bottom-up scenario approaches (Rotmans et al., 2000; Kok et al., 2006a,b, 2007; Harrison et al., 2013; Beach, 2015). A key characteristic of these approaches is the participation of stakeholders drawn from the system of interest. Stakeholders provide contextual expertise and experience regarding the system and are also the actors potentially in a position to facilitate or be affected by change. Participation can be enabled through workshops, focus groups, interviews, surveys, or other deliberative techniques. Of these, the scenario workshop is perhaps among the most common. For example, participatory workshops have been used to develop local scenarios for communities in the Mediterranean (Kok et al., 2006b) and East Africa (Chaudhury et al., 2013). They have also been used at national or continental scales as part of integrated modeling efforts (Harrison et al., 2013). In addition to producing beneficial scenario outcomes, the scenarios process itself has ancillary benefits. Scenario workshops enable discussions among participants who may not normally interact, and they facilitate discussions around futures that are seldom considered. Engaging stakeholders and treating them all equally as experts in the process boosts the credibility, relevance, and legitimacy of outputs (Chaudhury et al., 2013).

Although scenarios can be developed at a single level of organization, often there is a need for, or value in, linking scenarios across levels. Top-down scenario processes can be used to provide context or 'boundary conditions' for scenarios at more local levels. Some efforts have focused on downscaling quantitative projections generated by scenarios to more local scales (van Vuuren et al., 2007). For example, the *Special Report on Emissions Scenarios* (Nakićenović and Swart, 2000) generated socio-economic scenarios for use with the IPCC's Third and Fourth Assessment Reports. A number of quantitative indicators were developed as part of that scenario process, but they were confined to large regional aggregations. These indicators were subsequently downscaled to higher spatial resolutions (Gaffin et al., 2004; Bierwagen et al., 2010). Similarly, a number of quantitative indicators have been developed at the national level, consistent with the global SSP storyline (Samir and Lutz, 2017). Other efforts have focused on developing nested narratives that articulate how high-level narratives might manifest at local levels. For example, nested sub-global narratives were developed as part of the Millennium Ecosystem Assessment for 18 locations around the world (Lebel et al., 2005). Similar approaches have been applied to the SSP narratives (Absar and Preston, 2015). Rather than starting from high-level scenarios and working down, it is also possible to conduct a bottom-up, participatory scenario process and then map the resulting scenarios back to other scenarios at higher levels that appear consistent (Absar and Preston, 2015). Such methods enable scenarios that span multiple levels or organizations without placing a priori constraints on bottom-up scenario development.

8.2.4 Scenarios in the context of vulnerability, risk, and uncertainty

Scenarios are a particularly valuable method for the Arctic because their focus on the future engages key streams of enquiry related to vulnerability, risk, and resilience (Ford and Smit, 2004; Preston et al., 2011; Absar and Preston, 2015). Such knowledge can subsequently assist in adaptation planning and in the analysis of opportunities and constraints that may influence adaptation processes under conditions of uncertainty (see Section 8.2.4.2). When actors seek to explore future vulnerability, risk, and resilience over the long term, two interacting elements pose challenges that scenarios can address. The first element is that community or ecosystem vulnerability, risk, and resilience are determined by social values and perceptions. Therefore, knowledge of how climate and other environmental conditions could change in the future is often insufficient for understanding community risk and resilience. The second element relates to the inherent 'deep' uncertainty regarding the future, which limits the utility of using prediction to understand risk. In both cases, by expanding the view of possible futures, people today can plan more proactively for adaptation, rather than viewing adaptation as a reactive response to the unknown.

8.2.4.1 Vulnerability, risk, and resilience as social processes

Formal, institutionalized assessments and management of vulnerability and risk have generally followed an expert, science-based regulatory model in which discrete actions are proposed to mitigate against specific risks. For climate change, this approach often manifests as analyses of system responses to different projections of changes in climate variables (e.g., temperature, precipitation, or sea level rise). However, risk and risk management are fundamentally social processes. At a global level, changes in the climate system are a function of the energy use and consumption that contribute to greenhouse gas emissions. Meanwhile, climate vulnerability and risk at the local level are influenced by social, cultural, economic, and institutional contexts and drivers. Hence, climate risk management increasingly recognizes the importance of trade-offs and conflicts among the diverse needs and interests of the public and decision-makers regarding appropriate responses to risk (Klinke and Renn, 2002; Renn, 2008). From a social justice perspective, this recognition is important. Scenarios promote discussion and can also enhance democratic practices by bringing together competing interests to analyze and debate trade-offs related to planning for the future (Box 8.2). This feature of scenarios matters when considering risks and vulnerabilities to climate change or disaster, because the social nature of these challenges is tightly tied to the kinds of information and values used for future planning (Hewitt, 1998; Marino, 2012). The more engaged those affected by decisions across scales are in the process of exploring various *what ifs,* the more likely it is that sustainable and just policies can be crafted.

Accordingly, scholars have attempted to develop guidelines for holistic risk management practices based on distinctions such as type of uncertainty, level of conflict regarding preferred method of prevention, acceptability of outcome, and the actors involved,

Box 8.2 Scenarios as a tool for enhancing deliberation and democratic practices

Participatory tools can add value to environmental decision-making processes by increasing their legitimacy and scientific accuracy (Wesselink et al., 2011). Practitioners of social-ecological resilience should seriously consider participatory tools – such as scenario-building workshops – in their efforts to promote resilience in regional systems. This box explores the potential roles of deliberative democratic practices in promoting the social-ecological resilience of rapidly changing regions through participatory tools for futures thinking.

What is deliberative democracy?

Deliberative democracy is a framework for decision-making that emphasizes discussion, debate, open-mindedness, and mutual consideration among the individuals who might be affected by a decision at hand. Baber (2004, p. 332) stated that deliberative democracy commonly means "a school of political theory that assumes that genuinely representative public participation in decision-making has the potential to produce policy decisions that are more just and more rational than actually existing representative mechanisms". Gutmann and Thompson (2009) expanded on this definition by offering three specific requisites: deliberators must be free and equal citizens in terms of power and knowledge; deliberators must justify their preferences to one another by giving reasons that all others find acceptable; and the deliberations must reach conclusions that are binding but also open to future deliberation. Deliberation about particular problem domains is often achieved through specific local events or deliberative fora such as citizen panels, deliberative polls (Goodin and Dryzek, 2006), and scenario workshops.

What are the challenges of deliberative democracy?

Irvin and Stansbury (2004) used a failed deliberative process to illustrate seven disadvantages of civic participation that can also serve as cautions in designing participatory scenarios processes: (1) financial cost to the organizers and participants, (2) the difficulty of diffusing citizen goodwill (i.e., the resultant policies may be legitimate only to those who participated in the process), (3) the complacency of many citizens and a common aversion to actually deliberating public policies, (4) patrician domination of the deliberative process, (5) the lack of authority to turn deliberative results into policy, (6) the power of wrong decisions (e.g., government representatives may be politically obliged to accept the results of a public panel even if the panel was hijacked by special interests), and (7) the persistence of selfishness (i.e., participants seek only their own self-interest rather than entering deliberations with some openness to changing their minds).

What are the benefits of deliberative democracy?

In spite of these challenges noted above, Reed (2008, p. 2,417) found that "there is evidence that stakeholder participation can enhance the quality of environmental decisions by considering more comprehensive information inputs". Baber (2004) argued that special interests (namely large corporations) tend to dominate existing representative mechanisms and that such interests may lack ecological rationality due to their profit-maximizing imperative. In contrast, the general public *does* possess ecological rationality, the author contended, which is engendered by the collective desire for survival. This is particularly true for many Arctic locations where residents rely on subsistence practices, and even those who may not themselves hunt or gather generally remain highly aware of their environment and its effects on well-being (e.g., costs and availability of goods, mobility, or communication). Therefore, deliberative democratic processes can create more ecologically and politically sustainable policies by channeling a public's ecological rationality into government decision-making at a scale appropriate to policy needs.

(see, for example, Klinke and Renn, 2002). Navigating the risk management process is contingent on public engagement and input as well as incorporation and reconciliation of a broad range of values and knowledge systems (Petts and Brooks, 2006; Gooch, 2007). Others have suggested shifting from risk-avoidant formal management processes toward processes that manage risks for resilience when current management practices cannot handle complex issues. Stated differently, new innovative approaches are needed to explore risks and sensitivities when outcomes are uncertain and understanding is lacking on how societies may address both known uncertainties and surprises (Vis et al., 2003; Twigg, 2009; Cardona et al., 2012; Mitchell and Harris, 2012).

These various social dimensions of vulnerability, risk, and resilience highlight the value of scenarios. While biophysical changes in the Earth system are an important driver of future climate impacts, socio-economic changes are also important, perhaps more so when it comes to deciding how to manage socio-ecological change that is rapid and complex. Therefore, alternative narratives about future societal development provide important context for considering the risks of climate change as well as the capacity to manage that risk (see Section 8.5). For example, the SSPs use challenges to mitigation and adaptation as key uncertainties constraining alternative development pathways (O'Neill et al., 2017). This approach reflects the importance of considering not only demographic and economic changes as climate change consequences and responses, but also changes to institutions, governance, and societal preferences for different behaviors and livelihood strategies.

8.2.4.2 Using scenarios to address deep uncertainty

Scenarios are particularly useful for decision-makers when uncertainties about drivers of natural systems or patterns of human development are high relative to stakeholders' abilities to predict or adjust (Schoemaker, 1995; Cavana, 2010); scenarios are also particularly useful when there are strong differences of opinion, with multiple opinions having merit. These circumstances lead to conditions where knowledge regarding both the scale of the problem and the scale and efficacy of potential solutions is limited and even ambiguous. Such conditions are often characterized as deep uncertainty (Kandlikar et al., 2005) or complex risks (Sachs and Wadé, 2013). Forecasts or predictions of such complex risks may be of limited value due to the inherently low confidence in the information. Rather than attempting to predict risks that might arise in the future, scenarios aim to span a range of possible alternative futures and their implications (Duinker and Greig, 2007). Hence, while scenarios do not eliminate uncertainties (Walker et al., 2003), they can help to make uncertainties explicit and to prioritize key uncertainties of particular relevance, thereby assisting in the design of robust strategies for addressing them (Schoemaker, 1995; Klinke and Renn, 2002; Petts and Brooks, 2006; Cavana, 2010). Hence, by using scenarios, "the analytical focus is shifted away from trying to estimate what is most likely to occur toward questions of what are the consequences and most appropriate responses under different circumstances" (Duinker and Greig, 2007, p. 209), and "scenario planning attempts to compensate for two common errors in decision-making – under-prediction and over-prediction of change – allowing a middle ground between the two to be charted" (Duinker and Greig, 2007, p. 210).

A specific category of complex risks relevant to scenarios are those perceived as a surprise relative to available knowledge, evidence, and experience (Aven, 2013). These 'black swans', often called 'wild cards' in scenario development, pose a particular challenge for risk assessment and management because such futures are not necessarily expected or considered likely and statistical information regarding such events may be limited or absent – which means the risk may go unrecognized. Scenario development therefore represents a deliberative process that enables both the identification of potential wild card events and the analysis of their potential implications. This element of surprise is one reason why a diversity of participants in a scenario development process is valuable. Participant diversity can significantly expand the set of futures developed and thus enable exploration of a wider range of risks, planning options, and adaptation strategies.

8.3 Overview of scenarios and futures thinking in the BCB Arctic

Scenarios have been used in the BCB region for several decades, including scenario exercises over different spatial and temporal scales as well as for different industry, government, and community-based stakeholders. These prior efforts provide valuable context for understanding the driving forces and uncertainties that are important to different stakeholder communities in the region. Driving forces and uncertainties have important implications for the timing, nature, and magnitude of climate change impacts as well as ecological and societal adaptation. For example, scenarios have been used to identify adaptation options for US National Park Service facilities in Alaska (Winfree et al., 2014a,b) and to help plan the proposed Mackenzie Gas Project in Canada's Northwest Territories (Cizek, 2005; Holroyd et al., 2007). Scenarios were also a key element of the Arctic Marine Shipping Assessment (AMSA) (Arctic Council, 2009), which presented examples of rigorous futures thinking about the Arctic.

This section synthesizes a number of these prior scenario activities to further illustrate how scenarios have been used in different geographies and sectors in the BCB region. In addition, this section identifies common driving forces and uncertainties among different scenario activities that can be instructive for the consideration of climate impacts, resilience, and adaptation elsewhere in this report (Chapters 5–7). In so doing, this discussion relies on publicly available scenarios and thus cannot capture the use of scenario methods in private or corporate settings where the methods and results are proprietary and confidential. However, the synthesis demonstrates the breadth and significance of research and participation in thinking about the future of the BCB region.

8.3.1 Pan-Arctic scenarios

Multiple interdisciplinary scenario efforts have targeted broad geographic areas of the Arctic that overlap with, and are therefore relevant to, the BCB region but are not necessarily confined within the BCB regional boundaries (see Section 1.2). Because such pan-Arctic scenarios span large and heterogeneous areas, they often capture high-level driving forces and trends. While useful for identifying global drivers and uncertainties that have regional implications, such scenarios may be less informative for exploring place-based futures for specific locations or communities.

Arctic Business Scenarios 2020 (Loe et al., 2014) was commissioned by the Norwegian Shipowners' Association and the Arctic Business Council. A second activity (Goldsmith, 2011) was funded by Northrim Bank as part of the Investing in Alaska's Future research initiative led by the University of Alaska Anchorage. Both scenario development processes pursued an expert-judgment approach led by private consultancies and university researchers. As such, the resulting scenarios were largely top-down scenarios, with a strong emphasis on interpreting global energy and economic driving forces in the context of the Arctic, with little bottom-up participation by local communities and stakeholders.

The scenarios of Goldsmith (2011) all explore similar themes. Three of the scenarios represent alternative futures characterized by the ebb and flow of oil revenue. Either fossil energy extraction continues to expand, driving economic development, or fossil-fuel development declines – slowly or in an acute crash. In both cases – expansion and contraction – Alaska's future economy is driven by outside market forces. A fourth scenario articulates a future where Alaska's economy is less tied to trends in global energy markets, as a result of strategic planning by the state to steer development in a way that maximizes benefits for Alaskans.

AMSA stands out as a comprehensive navigation and shipping assessment that extensively applies scenarios and narratives. Partnering with Global Business Network (GBN), the Arctic Council's Protection of the Arctic Marine Environment (PAME) created the AMSA to "systematically consider the long-term social, technological, economic, environmental, and political impacts on Arctic Marine Navigation" (PAME and Global Business Network, 2008). Modeled after GBN's scenario-planning process and facilitated by the GBN, the AMSA involved a diverse set of Arctic maritime experts in scenario planning workshops that served as the basis for the development of scenarios and, later, narratives.

Brigham (2007) described a set of scenarios for the Arctic in 2040, with an emphasis on Alaska. These scenarios reflect future prospects for a number of sectors, including fisheries, oil and gas, and tourism. The four different futures are largely

Changes in the timing of ice break-up in spring have major consequences for coastal settlements such as Uelen, Chukotka

distinguished by three factors – the degree of international cooperation in Arctic governance, the degree of local versus global control over decision-making, and a varying emphasis on the principles of sustainability.

8.3.2 Place-based and regional scenarios

In contrast to the pan-Arctic scenarios, place-based, local scenario activities have also been pursued within or near to the BCB region. Such scenarios often use local context and concerns as a starting point for bottom-up scenarios development. These efforts may focus on a particular community (e.g., town or village) or a specific ecosystem or landscape.

Working with the Indigenous community of Old Crow, Yukon, Canada, Berman et al. (2004) utilized a hybrid of agent-based modeling and scenarios. Their objective was to determine how climate and economic changes could influence the community's future wages, subsistence, and well-being. The two key factors considered were tourism and government spending, which yielded eight scenarios looking over 40 years ahead. The authors explained that while these eight "job scenarios bracket the likely range of future economic opportunities for Old Crow, the ultimate effects of climate change in the region are highly uncertain" (Berman et al., 2004, p. 409). They go on to point out one clear advantage of a scenarios process: the integration of data from multiple sources and perspectives through community engagement, which does not often happen in disciplinary studies.

Another local-scale participatory research project used qualitative scenarios to address vulnerability and adaptation for the rural, mostly Indigenous, natural resource–dependent community of Fort Resolution, Northwest Territories (Wesche, 2009). The researchers developed a set of four storylines based on the two axes of 'climate change' and 'resource development' – a standard four-quadrant scenario process (Wesche and Armitage, 2014). The scenarios integrated data from multiple sources, including local knowledge about past and current socio-economic and cultural trends, scientific data on past and anticipated climate trends, and accounts of past and prospective resource development projects in the area. This 'actor-oriented' scenario process engaged stakeholders through focus groups, interviews, and an adaptation workshop to identify vulnerabilities and corresponding anticipatory adaptation options. The authors noted that the workshop enabled the participants to better understand their levels of preparedness in terms of adapting to change and identifying barriers to overcome. The scenarios methodology proved useful in shaping a better understanding of the nuances of vulnerability of local stakeholders; incorporating multiple forms of knowledge and perspectives, including Indigenous knowledge; and enabling co-production of knowledge to better inform and develop bottom-up adaptation strategies to address imminent change. Such participatory processes have the potential to enhance Indigenous engagement in environmental governance processes, which is key to achieving a sustainable future for the Arctic.

Multiple place-based scenario development activities can be integrated to provide a regional perspective that captures underlying contexts at more local scales. For example, as part of the US National Park Service's Climate Change Response Program, the agency's Alaska Region led a scenario-based planning activity in natural resources and conservation management (Winfree et al., 2014a,b). This activity included five climate change scenario planning workshops conducted between 2010 and 2012, three of which included a focus on Arctic regions – the Interior Arctic, Northwest Coast, and Central Alaska Parks scenarios workshops (Moore et al., 2013; NPS, 2014).

Resource development scenarios are frequently described in permitting and environmental compliance assessments by regulatory agencies to investigate the potential cumulative impacts of resource developments that may occur in the future. For example, scenarios are often used in environmental impact statements, specifically for their utility in cumulative effects assessments to explore uncertainties and consequences of alternative futures (Duinker and Greig, 2007; Greig and Duinker, 2007). It is important to highlight that in such cases, even though low-development scenarios are possible, more emphasis is placed on considering a broad range of development activities in a region and their potential impacts. The use of the term scenarios in this sense may also be misleading, as the outcomes may be more accurately described as projections (see Box 8.1) of, for example, numbers of wells and drilling pads or lengths of new roads built (National Research Council, 2003; BLM, 2012; BOEM, 2015). Technical innovations and estimated geological distributions of resources may also be considered in the generation of these scenarios, but rarely is the full range of drivers explored, and as a result, broader narrative discussions are not provided. However, the Mackenzie Gas Project (Canada) is one example where experts advocated extensively for scenario analyses during the review process to explore possible development trajectories and socio-economic and environmental impacts (Greig and Duinker, 2007; Holroyd et al., 2007).

More recently, the North Slope Science Initiative (NSSI) used a scenarios approach to determine a range of plausible resource extraction activities and supporting activities on Alaska's North Slope and adjacent seas through the year 2040. Twenty-five years was chosen as a reasonable future time frame – one in which uncertainties make resource extraction activities difficult to predict, but not so far into the future as to render the scenarios ineffective at helping resource managers to address strategic research and monitoring needs. A spatially explicit component of the NSSI scenarios project was important to help member agencies plan research and monitoring needs into the future. Such science-based research prioritization was recognized following an assessment of more than a dozen emerging issues relevant to North Slope resource managers (Streever et al., 2011). The NSSI project used a participatory scenarios process that incorporated multiple views from a range of experts and stakeholders from local communities, nongovernmental organizations, industry, academia, and federal, state, and local agencies. The first step involved obtaining feedback from a range of experts and stakeholders on key drivers of change. Given the range of interests and stakeholders consulted in the iterative survey process, the list included not only economic drivers (e.g., the price of oil and gas) but also socially relevant drivers (e.g., community environmental health), biophysical drivers (e.g., sea ice change, climate change, and erosion), and political and regulatory drivers (e.g., global political stability and the regulatory environment). Outcomes from this scenarios work included the public release of scenario narratives and the corresponding spatial data that describe the implications of the scenarios, as well as the research and monitoring needs related to scenario implications (Vargas Moreno et al., 2016).

The Northern Alaska Scenarios Project (NASP) was developed to help identify and synthesize input related to the future of healthy sustainable communities by engaging expert residents of the North Slope and Northwest Arctic boroughs (University of Alaska Fairbanks, 2016). This project used a participatory scenario workshop process to foster effective communication among these experts across different interests, such as education, justice, mental and physical health, subsistence, Iñupiaq values, and business development. A series of three workshops in 2015–2016 brought people together from both boroughs to share creative strategies for the next few decades so that those living in Arctic Alaska can proactively shape their futures.

8.3.3 Synthesis of BCB scenarios

Among the aforementioned scenario activities, the top-down scenarios of Goldsmith (2011) and Brigham (2007) sought to be comprehensive by addressing multiple economic sectors and governance arrangements. However, the majority of scenario development processes have been more focused, in order to address a particular stakeholder community at the scale of its concerns. For example, several sets of scenarios have targeted the issues of energy and resource development or Arctic navigation. Other scenario activities have focused on specific communities within the region, rather than a particular economic sector. Community-focused scenarios therefore provide more place-based insights regarding what aspects of change are perceived as being particularly important or uncertain relative to large-scale, top-down scenarios.

Existing BCB scenarios reflect a range of methodological approaches. For example, participatory scenario development processes (e.g., NSSI and NASP) have been used to engage sector or community stakeholders. Such scenarios are consistent with the bottom-up approaches discussed in Section 8.2.3. Other BCB scenario activities have been top-down in that they were developed largely by sectoral, often non-resident, experts and may lack a diversity of perspectives or local context. For example, scenarios for the Alaska business environment (Goldsmith, 2011) have been generated by teams of experts. Still other scenarios have been generated largely through the use of quantitative models. Berman et al. (2004) used agent-based modeling in conjunction with qualitative scenarios to determine how climate and economic changes could influence local wages, subsistence, and well-being. Meanwhile, Mueller-Stoffels and Eicken (2011) used computer software designed for scenarios to perform robustness analysis on the AMSA workshop process after it ended. The goal was to create a more informative set of data than a four-quadrant analysis alone could provide. They were able to refine, through an examination of the plausibility and consistency of key factors, the narratives and possible scenarios that AMSA produced, thus demonstrating the important role of regional factors in the discussion of global shipping.

Each BCB-relevant scenario activity identifies driving forces or uncertainties that are key shapers of the region's future socio-economic systems. Despite using different methods and focusing on different sectors and stakeholder communities, the different scenario activities identified a number of common drivers. In particular, future demands for Arctic energy resources were identified as a key factor affecting the future of the energy sector as well as future shipping and navigation and environmental sustainability. Regional economic development and globalization, another common theme across scenarios, were closely tied to energy demand. Governance and the role of institutions were also frequently identified as important drivers of the future of national security, marine navigation, local community capacity, future business activity, and environmental sustainability. In addition to key driving forces, the Arctic marine navigation scenarios (Arctic Council, 2009) identified a range of 'wild cards' to consider – natural disasters, shifts in geopolitics, abrupt climate change, or technology breakthroughs (Section 8.2.4).

Figure 8.1 Summary of socio-economic scenarios for the BCB region, based on a synthesis of prior scenario activities from the region.

8.4 Framing scenarios for the BCB region

The existing BCB scenarios provide a useful foundation for developing a coherent set of new scenarios to inform discussions of impacts, resilience, and adaptation. For example, the key dimensions of *global energy demand & economic growth* and *institutions & governance* can be used as axes to define four alternative future socio-economic states (Figure 8.1). These axes can be thought of as 'axes of uncertainty'. It is important to remember that plausible futures need not be a result of only two axes and their four quadrants, but this method is a commonly used one. Furthermore, different scenarios methods may produce more or less plausible and more or less internally consistent results, depending on the goals (Walsh et al., 2011). For example, the ongoing NASP work on healthy sustainable communities (Section 8.3.2) is using 21 key factors derived from resident expert participation and does not reduce them to two axes. When the data are fully analyzed, the plausible futures produced will be rich and, compared to an outcome based on fewer key factors, will provide more information about the plausibility of each factor and the relationships of different uncertainties to one another.

Figure 8.1 presents a simple four-quadrant scenario for the BCC region using two themes emphasized by Arctic experts and stakeholders from various sectors: energy demand and governance. This is then down-scaled for each subregion to illustrate the importance of scale to futures thinking. Different combinations of the two elements can be used to explore alternative plausible socio-economic futures relevant to BCB regional and local concerns.

8.4.1 Focal questions for the BCB scenarios

For the purposes of developing scenarios relevant to the BCB region, the following focal questions were considered:

What do regional and subregional scenarios reveal about the influence of socio-economic factors on the future of the BCB?

What are the implications of BCB scenarios for regional impacts, resilience, and adaptation?

The first question is addressed in Section 8.4.2 through a suite of illustrative scenarios based on prior and ongoing scenario activities at both the regional and local/place-based levels. These scenarios describe the key social, economic, and environmental factors that will shape the future of the BCB region, as well as the uncertainties associated with how those factors may evolve over time. The second question is addressed in Section 8.5.

In designing scenarios processes and using their outputs, careful attention must be paid to the focal question and the scale of the inputs. Scenarios processes designed primarily to stimulate narratives about what the world may look like and to get people thinking may not be appropriate for siting observational equipment, organizing monitoring schemes, or formulating policy. As noted in Section 8.2, scenarios come in many forms. The research and policy planning needs of the Arctic can draw on many different types of futures thinking, but the scale must match the research question, especially if adaptation planning is the primary concern. The focal question serves as a research question for the participants, whether they are distant experts working with data sets or community participants addressing local concerns. It is through this singular question that key factors – system drivers – are evaluated.

The scenarios presented in Section 8.4.2 did not stem from a participatory process, but are illustrative of how regional uncertainties can be evaluated to explore possible futures. Consequently, the two questions at the start of this section were used as focal aids. This focus led to the identification of two key uncertainties that became the axes for the scenarios. The same axes are used for the regional scenario (shown in Figure 8.1) and the subregional scenarios (presented in the following section), yet the content of the scenarios changes with the focus on more levels. While this is an informed thought experiment, it should be noted how the scenarios differ and that results from participatory or industry-expert scenarios processes would offer those concerned with energy production a much more robust view of possible futures for the region.

8.4.2 BCB regional scenarios for 2050

At the scale of the BCB region, two key socio-economic uncertainties appear to be critical for shaping the future: (1) global energy demand and economic growth and (2) institutions and governance. The resulting scenarios are tightly tied to climate-related changes as well as other social, cultural, and economic changes that are ongoing in the circumpolar North. For simplicity, however, this exercise uses two axes that are socio-economic (Figure 8.1) to make explicit the policy and planning value of scenarios for the Arctic, within the context of environmental changes reported in the other chapters. A key utility of scenarios is the ability to shift the perspective on the future. For example, it would be possible to replace either axis with 'climatic changes' and reveal a different narrative about the possible futures of the BCB region.

The first uncertainty is the global demand for energy and other resources (Figure 8.1, vertical axis), which is largely a function of the future evolution of global energy technologies and markets (Sections 4.5.3–4.5.4). This uncertainty was highlighted in several BCB scenario activities. At the upper end of this axis of uncertainty, higher global demand and prices, particularly for natural gas and oil resources, are assumed to drive greater investments in extracting BCB resources, particularly offshore oil and gas in the Bering and Beaufort seas around northern Alaska and Canada. However, the volatility of demand, as well as shifts to alternative sources of energy, could slow the development of offshore resources, increasing pressure to exploit onshore resources. In addition, global demand for energy resources is likely to be accompanied by greater demand for commodities more generally (Section 4.5.4), suggesting growth in investment in mining in both Chukotka and Alaska. Because energy resources and commodities are important drivers of BCB regional economies, higher demand for energy is anticipated to be accompanied by more rapid rates of economic growth. In contrast, lower global demand for energy, due to shifts away from fossil resources or overall slowing of the global economy (lower end of the vertical axis), would reduce investment opportunities for energy and other commodities in the BCB region – which would have direct implications for the overall economy of the region, even with efforts toward economic diversification. The unexpected 2014 crash of the oil market has already caused changes in industry production, government budgets, and regulatory frameworks.

The other key uncertainty that arises from prior BCB scenario activities is associated with the role of institutions in governing the BCB (horizontal axis in Figure 8.1) – such as national governments, state/territory/district governments, Indigenous organizations, tribal and municipal governments, and individual communities (Section 4.5.2). Furthermore, the private sector plays an important role in influencing investment, infrastructure development, and strategic planning. Most of the prior BCB scenario activities make a clear distinction between futures based on collaborative governance arrangements and those based on more competitive outlooks. Collaborative governance includes cooperation among national governments to resolve disputes regarding territorial boundaries, rights-of-way for shipping, and transboundary externalities of natural resources management practices. At its strongest, collaborative governance also includes the sharing of power among different levels of government within nations, including participation of Indigenous communities and organizations. Such forms of governance are often based on suites of regulations and are enforced by formal rules such as treaties, legislation, and policies that specify actions, responsibilities of different actors, and sanctions in the event of non-compliance. In contrast, governance based on competition generally precludes such cooperation except to establish market conditions. In general, institutions in a competitive system operate with a strong aversion to risk, which inhibits sharing of power, behavioral change, and possibly investment, even when such decisions could create positive benefits. At its strongest, competitive governance is a regime with few regulations across levels of governance and with low levels of concern about regulatory enforcement.

As with a number of the earlier BCB scenario activities, these two axes of uncertainties can be used to frame future scenarios for the BCB region as a whole. At this aggregate scale, such scenarios are quite general, focusing on a common set of key issues that are strongly connected to these uncertainties. These issues include regional energy futures, economic development, the environment, governance, and Indigenous communities. The four resulting scenarios, which are largely informed by aspects described in prior studies relevant to the region, reflect quite disparate socio-economic futures. Each scenario suggests different upsides, downsides, and trade-offs, but each can be considered plausible given historical events and the inherent uncertainty of the future. More importantly, the consequences of climate change in each of these futures would also vary, because the futures differ in their implications for vulnerability, adaptive capacity, and resilience.

The BCB region is not, however, homogenous in terms of its climate, natural resources, landscapes, or people. Therefore, the driving forces, values, and uncertainties that emerge from considering scenarios at the scale of the BCB region are not necessarily the same as those that emerge at local levels. It is therefore important to explore how the same axes in different geographic areas produce different outcomes. This utility is illustrated for the three different subregions of the BCB: Chukotka, Russia (Section 8.3.2.1); northern Alaska, United States (Section 8.3.2.2); and Beaufort, Canada (i.e., northwestern Canada; Section 8.3.2.3). For each subregion, current conditions are summarized based on the preceding chapters (particularly Chapters 3 and 4) to provide context, and each is accompanied by a graphical representation of the scenario outcomes that provide a forward-looking subregional perspective. Throughout, the key axes of uncertainty are preserved in order to maintain some internal consistency in scenarios across the different levels and different locations.

8.4.2.1 Subregional scenarios: Chukotka, Russia

Chukotka Autonomous Okrug (CAO) is situated in the northeast of Russia. The geography of Chukotka, with its far north location and severe climate, to a large extent defines the past and future socio-economic development patterns of this area of Russia.

In 2014, the population of Chukotka was 50,555 (CAO, 2015). At the end of the 1980s, it had exceeded 150,000 but then declined rapidly during the post-Soviet era. According to current forecasts, the population of Chukotka is expected to decline to 36,000 by 2030 (Section 4.5.1). About 70% of the Chukotka population resides in the cities. During the 2000s, an upward trend in the proportion of the population living in urban areas was reported (CAO, 2015), and this trend is forecast to continue into the future.

The Indigenous population in Chukotka constitutes about 35% of the region's total population (CAO, 2014b). The main occupations of the local Indigenous people are reindeer herding, fishing, and hunting. Although the number of reindeer has declined sharply – from 500,000 in the Soviet period to less than 200,000 currently (Section 5.2.3) – the prospects for processing and selling reindeer products such as meat, leather, cheese, and clothing are encouraging, as are the economic prospects associated with fisheries and fish processing. In 2013, total Chukotka exports were approximately USD 90 million, with exports of fish products (40% of total exports) almost equal in value to the export of mineral resources (mostly gold-containing concentrates). In 2014, total exports increased to USD 138 million, with the dominant share (95%) coming from gold-containing concentrates from high-grade deposits at the Mayskoe mine (CAO, 2014a); in 2015, gold accounted for more than 98% of Chukotka's total exports.

Today, the stability of Chukotka's energy sector is provided by the Bilibino nuclear power station, which has a capacity of 48 megawatt electric (MWe) (International Nuclear Safety Program, 2004). This plant is planned to be decommissioned by 2020. In 2016, construction began on coastal infrastructure for a new floating nuclear station (70 MWe and 50 gigacalories per hour) that is planned to go into operation in 2019 (Rosatom, 2016). For areas outside the Bilibino grid, local heat and electricity suppliers use local coal deposits to cover current demand; these supplies are expected to also meet future demand over the next decade.

The mining industry is the leading economic sector in Chukotka, owing to large deposits of oil and gas, coal, gold, copper, tungsten, and other minerals. Gold mining alone generated approximately 20 tonnes annually from 2008 to 2013, and over 30 tonnes in 2014 (Ernst and Young, 2015). Production of tungsten and tin stopped during the post-Soviet period. Taking into consideration current trends in the world oil and gas market, increased oil and gas development is anticipated for the polar areas of Chukotka. Other types of mining are highly contingent upon progress in transport infrastructure development, which could significantly reduce the costs of delivering product to consumers. In 2012, construction began on a new Kolyma-to-Anadyr highway, which is expected to provide an important land-based connection between Chukotka and the rest of Russia's Far East and with future Asia-Pacific export markets.

Investments in the economic development of Chukotka are channeled through a number of federal programs and foreign investors. During Roman Abramovich's tenure as governor of Chukotka (2000–2008), foreign investments into Chukotka's regional economy increased by up to USD 200 million. The major investments were channeled from the United States, Canada, South Korea, and Cyprus. If recent Western economic sanctions against Russia are continued, then the profitability of economic development in Chukotka will be undermined due to reduced foreign investment and disruption of supply chains. In recent years, foreign investment has declined to several million dollars from its high levels of a decade ago. In 2014, foreign investments constituted about 11% of the investments in fixed capital (CAO, 2015).

Currently, a fragile balance is maintained between the natural systems and economic development of Chukotka. Regular monitoring and scientific assessment of a range of challenges related to Chukotka's development is essential to avoid negative consequences of climate change.

The AACA illustrative socio-economic scenarios for the Chukotka subregion are shown in Figure 8.2.

8.4.2.2 Subregional scenarios: Arctic Alaska, US

The Arctic in the United States is located entirely in the state of Alaska, which borders the territory of Yukon, Canada, to its east and shares the Bering Strait with Russian Chukotka to its west. Communities in the Alaskan Arctic are defined primarily as coastal but do include inland populations on tundra and the edges of the taiga. The subsistence livelihood activities that continue to be important in these areas are influenced by the physical geography. Thus, the Iñupiat on the coasts rely on whaling (e.g., bowhead, beluga) and other marine resources, while inland communities rely more heavily on caribou. To the east, around the Seward Peninsula, walruses account for the majority of marine harvests.

This subregion is made up of two public governments or boroughs, whose populations are predominantly Indigenous, mostly Iñupiat, plus an unincorporated census area. The North Slope Borough, with a population of approximately 9600 (US Census Bureau, 2015), has its hub in Utqiagvik (Barrow) and is home to the massive infrastructure surrounding the Prudhoe Bay oil fields. The Northwest Arctic Borough, with about 7700 residents (US Census Bureau, 2015), is home to the Red

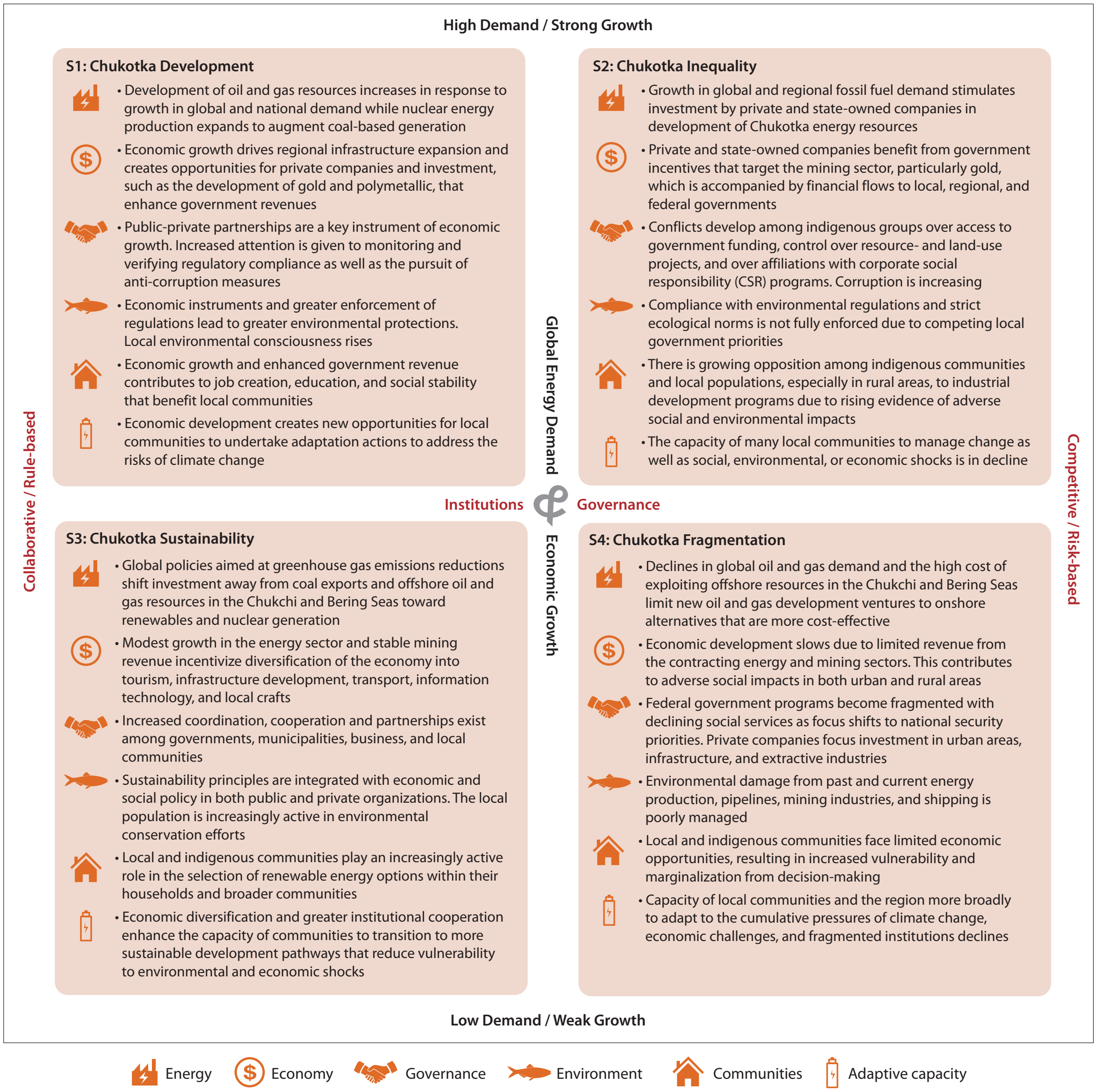


Figure 8.2 Socio-economic scenarios for the BCB subregion: Chukotka.

Dog zinc mine, which is its major industry. In each borough, there are fewer than 20 small, primarily Indigenous, villages. The Nome Census Area, which encompasses much of the Seward Peninsula on the Bering Strait, is unincorporated, with a population of roughly 9800 people (US Census Bureau, 2015).

Land ownership in this subregion is mixed: state government, Alaska Native Corporations and other private landholders, and federal government. The result is a complex patchwork of governance related to social policies, environmental management, and extractive industries and other economic development. In 1971, the Alaska Native Claims Settlement Act (ANCSA) was passed in response to the combined pressure of mounting Native land claims and the desire to settle land disputes to encourage construction of a trans-Alaska oil pipeline. Rather than designating reservations, the passage settled claims to the land through the creation of 12 regional corporations and a 13th at-large corporation in addition to over 200 village corporations, which collectively received roughly 45 million acres of land and a billion US dollars (Linxwiler, 2007). Village corporations received surface rights to their land while regional corporations received surface and subsurface rights – a differentiation that has proven to be significant. Because regional corporations own the resources under their lands (e.g., oil and gas), they can profit accordingly. Village corporations, on the other hand, are restricted to taxing the industrial activities that occur on the surface of their lands (e.g., mining, oil and gas infrastructure).

After ANCSA, the next major shift in land management occurred in 1980, with Congress's passing of the Alaska National Interest Lands Conservation Act (ANILCA), which appropriated 104 million acres of federal land for the US conservation system, with 56 million of those acres being designated as 'wilderness', the most protected federal status. This law, as well as those that preceded it, however, has left many stakeholders unsatisfied with land ownership and management in Alaska. Currently, about 60% of Alaska is under federal ownership and 28% is owned by the State of Alaska; Native corporations own 12%, and other

Figure 8.3 Socio-economic scenarios for the BCB subregion: northern Alaska.

private owners hold 1% (Hull and Leask, 2000). Because ANCSA conveyed corporate land instead of reservation land, the option of tribal jurisdiction was extinguished. The inherent rights of individuals have remained protected through Congressional and federal court action, and there is a 'rural preference' for subsistence on federal lands. Most recently, in 2014, the Department of the Interior's Bureau of Indian Affairs issued final rule 25 CFR (Code of Federal Regulations, Title 25), which deletes the 'Alaska Exception' and permits land to be taken into trust through the Secretary of the Interior, essentially permitting the creation of 'Indian Country' in Alaska (BIA, 2014).

The dominance of extractive resources for the Arctic boroughs' revenue means heavy reliance on the prices of minerals and the demand for oil and gas products on the world market. For example, in 2006, the North Slope Borough revenue from local taxes was USD 189 million, and Red Dog Mine paid USD 8.6 million into the Northwest Arctic Borough (Goldsmith, 2008). These revenue streams tie these boroughs tightly to regulatory regimes related to extractive industries and the affiliated concerns of environmental quality, jobs development, and coastal management.

The AACA illustrative socio-economic scenarios for the northern Alaska subregion of the BCB are shown in Figure 8.3.

8.4.2.3 Subregional scenarios: Beaufort, Canada

The western Canadian Arctic encompasses the Northwest Territories (NWT) and the smaller territory of Yukon, which borders Alaska to its west. Of Yukon's 37,642 total population, approximately 21% are Indigenous (Yukon Government, 2016); of the NWT's 44,469 population, approximately 50% are Indigenous (Government of the Northwest Territories, 2016). This subregion of the BCB includes a significant number of small, primarily Indigenous (Inuit, First Nations, and Métis) communities. Communities in the northern tundra region of the NWT are primarily coastal and are predominantly inhabited by Inuit, whereas those located inland in taiga and boreal ecosystems – including the entire territory of Yukon and much of the NWT – are predominantly inhabited by First Nations and Métis. Subsistence livelihood activities continue to be important in these regions and are linked to ecological conditions. As such, Inuit communities rely heavily on marine systems for harvesting and travel, while First Nations and Métis rely on forest and freshwater systems.

Since Yukon and NWT are not fully-fledged provinces, the Government of Canada has long played a dominant role in territorial decision-making. However, many responsibilities have been devolved over the past decades, including significant authority and responsibility for public lands, water, and resource management. While the Government of Yukon has held some control and garnered revenues from the oil and gas sector since 1993, the territorial government formally took over responsibility for land, water, and resource management in 2003 when the Yukon Act came into effect (INAC, 2013). In the NWT, a similar devolution of responsibilities took effect in 2014, including stipulations for resource revenues for both the NWT and Indigenous government signatories (primarily those with settled land claims) (Government of the Northwest Territories, 2015).

Indigenous rights and title to land are increasingly being recognized, and this subregion includes a patchwork of Indigenous cultures and associated land claims. In Yukon, an overarching Umbrella Final Agreement of the Yukon Land Claims package was finalized in 1990 among the governments of Canada and Yukon and the territory's 14 First Nations. To date, 11 of the 14 First Nations are self-governing (Council of Yukon First Nations, 2016). In the NWT, negotiations among Indigenous groups and the federal and territorial governments around land, resources, and governance began in the 1970s (INAC, 2007). To date, three comprehensive land claims have been settled, including Inuvialuit (1984), Gwich'in (1992), and Sahtu Dene and Metis (1993); however, negotiations regarding self-government provisions are ongoing in these areas (with the exception of one Sahtu district, Deline, which ratified a self-government agreement in 2014). An additional comprehensive claims agreement that includes self-government provisions was completed in the Tlicho region in 2003. Other groups' claims in the central and southern NWT are still under negotiation (INAC, 2007).

As such, there is a growing awareness of propriety, and efforts are being made to effectively consult and incorporate all stakeholders, including Indigenous peoples, in strategic planning for various sectors of the Northwest Territories (e.g., water, poverty alleviation, economic development). Indigenous governments are becoming more assertive in demanding that their rights be considered and implemented, and Indigenous groups are forming around specific business and development opportunities (e.g., Aboriginal Pipeline Group, Northern Aboriginal Business Association).

The AACA illustrative socio-economic scenarios for the Canada subregion of the BCB are shown in Figure 8.4.

8.5 Scenario implications for impacts, resilience, and adaptation

The Arctic is currently facing, and will continue to face, unprecedented rates of environmental and social change in the near future as well as over the long term. The various socio-economic scenarios outlined for the BCB region as a whole (Figure 8.1) and the BCB subregions of Chukotka, Alaska, and Beaufort (Figures 8.2–8.4) reflect alternative trajectories along which these regions and communities could plausibly evolve. Such alternative futures reflect the potential for quite disparate consequences of future climate change as well as disparate capacities of regions, states, and local communities to adapt in order to avoid or reduce those consequences. In addition, such scenarios can be used independently or in conjunction with projections of future climate change (Box 8.3 and Chapter 4) in an integrated assessment of future biophysical and socio-economic change.

As discussed in Chapter 5 (Section 5.4), the impacts of climate change on BCB residents and communities are strongly shaped by interactions between climate, subsistence, and the physical, economic, and socio-cultural well-being of those residents. Although climate change can adversely affect the quantity, distribution, accessibility, and abundance of subsistence resources, those impacts can be ameliorated or exacerbated by socio-economic trends that enhance or degrade the value of subsistence livelihoods and traditional knowledge within Indigenous communities (Sections 4.5.2, 4.5.5, and 5.2.3). Similarly, the implications of climate change for housing and infrastructure will be contingent on changes in population, migration, and demography, which all affect housing and infrastructure demand, as well as on the extent of new or declining investment in housing and infrastructure development and maintenance (Section 5.2.2). All of the consequences of climate change will also be influenced by public policy and private decision-making at multiple scales – local to international.

The scenarios presented in Section 8.4 explore alternative trajectories along which some of these driving forces could evolve. Scenarios associated with high rates of economic development (e.g., the S1 and S2 series of the scenarios; Figures 8.1–8.4) imply growing pressure on natural resources in the BCB region and within specific subregions and communities. However, in the S1 series, strong, collaborative institutions help to reduce the adverse impacts of development. This collaboration limits the potential for adverse impacts of climate change on social and environmental systems. In contrast, the S2 series implies significant trade-offs between development and the protection of vulnerable social and ecological systems. With the S3 and S4 series, the lower rates of economic development pose different challenges for managing the risks of climate change. Lower growth reduces the flow of financial capital into the region, which reduces overall financial resources available for funding adaptation. However, under the S3 series, strong institutions help to maintain environmental quality and promote diversification of the economy. This emphasis on a smaller but sustainable economic footprint could ultimately offer benefits for adaptive capacity. Under the S4 series, lower growth has more adverse effects, with different stakeholders vying for the few resources that can be economically extracted. In such a future, stakeholders may have significant difficulties pursuing effective adaptation strategies.

These different scenarios also reflect fundamental differences in the resilience of BCB ecosystems and subregions, particularly regarding the risk of exceeding critical thresholds (see Chapter 6). For example, socio-economic trends that undermine the autonomy of Indigenous communities and the value of traditional knowledge may increase the likelihood that climate change could contribute to the failure of subsistence livelihoods (Sections 5.2.1 and 5.2.3). Similarly, fisheries management policies and practices that enable overexploitation of resources could enhance the risk of fisheries collapse if climate change drives changes in the distribution of fisheries or degrades fish

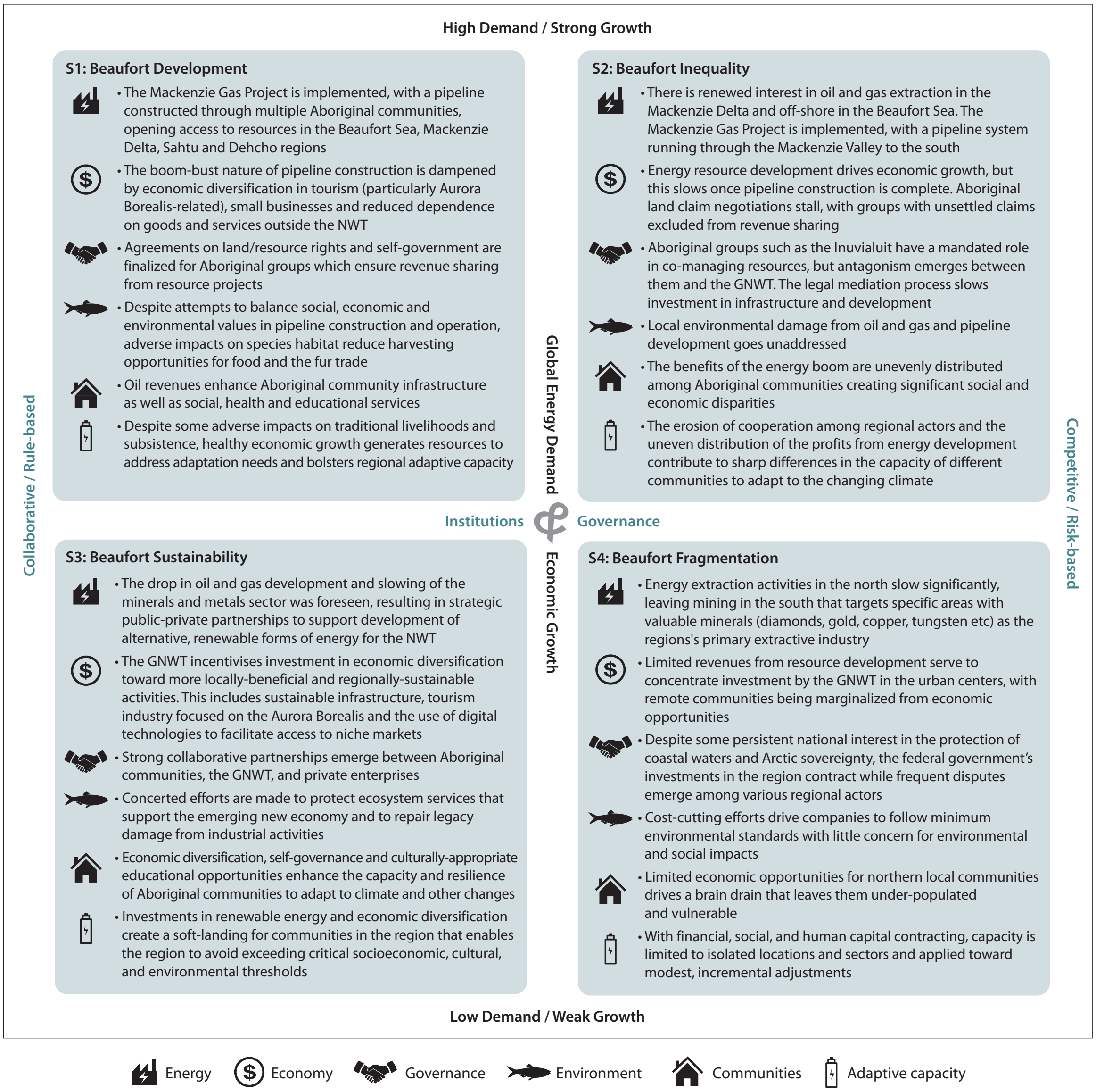


Figure 8.4 Socio-economic scenarios for the BCB subregion: Beaufort in the western Canadian Arctic.

stocks (Section 5.2.3). In contrast, socio-economic trends that enhance the capacity of stakeholders to manage resources under stress can enhance resilience and thereby prevent systems from encountering critical thresholds. At the same time, however, system resilience can be maladaptive if it acts to maintain conditions or trends that degrade natural or social systems. Efforts to maintain the resilience of the energy resource economy in the BCB region, for example, could destabilize natural ecosystems, populations, or species. Scenarios can therefore be useful in identifying, or at least exploring, such trade-offs.

The BCB socio-economic scenarios (Figures 8.1–8. 4) also reveal that the climate change impacts of concern at the regional level may vary from those of concern at the local level. Local economic activity, livelihoods, and ecosystems may have their own distinct vulnerabilities to a changing climate (Sections 5.2 and 5.3). For example, in Canada's Beaufort region (Figure 8.4), future development of the Mackenzie Gas Project is a key factor affecting local economic development and pressures on natural ecosystems and their services. In Alaska (Figure 8.3), some scenarios suggest the possibility of opening the Arctic National Wildlife Refuge to energy development, which raises concerns regarding trade-offs between development and the maintenance of ecosystem integrity and ability to naturally adapt to the changing climate. The effectiveness of efforts to manage the impacts of climate change and development are contingent on the balance of power among federal and state governments, the private sector, and Native Corporations.

Given that the various scenarios presented in Section 8.4 demonstrate the possibility of disparate socio-economic futures for the BCB region and its communities, the inherent uncertainty about the future is an important element to consider when reading the material presented in other chapters of this report – on impacts (Chapter 5), resilience (Chapter 6), and adaptation (Chapter 7). Many of the studies reviewed in these chapters do not directly incorporate socio-economic scenarios or a common scenario framework in their treatment of climate

Box 8.3 Integrating socio-economic scenarios and climate projections

Socio-economic scenarios can be usefully integrated with projections of future climate change to explore the joint implications of both climatic and socio-economic change for impacts, adaptation, and vulnerability. Scenarios can be developed with explicit assumptions regarding both socio-economic and biophysical (i.e., projected changes in climate) futures. However, in other instances, future changes in socio-economic conditions are treated as being independent of changes in the climate. For example, the 'parallel process' has been developed as a new scenario framework for integrated assessment modeling, Earth System Modeling, and explorations of climate change impacts, adaptations, and vulnerabilities. The representative concentration pathways (RCPs) were developed to represent alternative greenhouse gas forcings to drive Earth System Models and their projections of climate change. The shared socio-economic pathways (SSPs) were developed to provide richer socio-economic understanding of the driving forces that are consistent with the RCP forcings (Moss et al., 2010; Kriegler et al., 2012).

The scenario matrix architecture (SMA) provides the framework for the integration of RCPs and SSPs for integrated impact assessment (Moss et al., 2010; van Vuuren et al., 2012, 2014; Eom et al., 2013; van Ruijven et al., 2013; Ebi et al., 2014). There is a range of pathways by which such an SMA can be implemented, depending on the objectives of researchers or practitioners. For example, socio-economic storylines could be coupled with climate scenarios within a qualitative vulnerability assessment or risk assessment that explores the potential or likelihood for harm to different sectors given alternative climate futures and socio-economic conditions. Such an application would largely rely upon normative judgments in order to posit the future implications of alternative climate and socio-economic futures. Such an approach may be particularly useful for participatory visioning and assessment exercises with stakeholders (Carlsen et al., 2012; Harrison et al., 2013). Alternatively, socio-economic scenarios could be used to parameterize quantitative inputs for biophysical or economic impact models or integrated assessment models.

An additional step in the parallel scenario process is the integration of assumptions about the climate policies (mitigation and adaptation) that would be required to reduce the risks of climate change to a certain level. Not all types of climate policy are equally likely under each of the socio-economic pathways. To this end, a small number of shared (climate) policy assumptions (SPAs) has been developed (Kriegler et al., 2014), describing combinations of policies that are compatible with the shared socio-economic pathways. Consistent with this framework, BCB-relevant SPAs could be developed to reflect policy mitigation and adaptation options at different levels of governance (international, national, or regional), as well as their implications for risk reduction. When used within this framework, BCB socio-economic scenarios could include a set of policy assumptions related to adaptation. Hence, scenarios have potential value not only for outlining alternative development pathways and their implications but also for exploring the costs and benefits of policy responses.

change impacts, resilience, or adaptation opportunities in the BCB region. Hence, particularly for projections of climate change impacts that are likely to be contingent on future socio-economic trajectories or decision-making by actors across different scales, it is useful to consider the role of socio-economic uncertainty in evaluating that information. In addition, it is useful to consider how deliberate choices regarding economic development and environmental management could enable or constrain efforts to adapt to a changing climate.

8.6 Engaging the science/policy interface

Proactive adaptation requires a balance of those organizational forces that shape human behaviors through rules, values, and science. Such forces are generally discussed as 'institutions' by social scientists and are connected to governance by suites of rules and their institutional mandates (e.g., the 1973 Agreement on the Conservation of Polar Bears, the Arctic Council, the Chukotka Autonomous Okrug). When considering how top-down or bottom-up scenarios may create connections between science and policy, it is generally through such institutions. When it is necessary to know how institutions may shape the Arctic environment and the behavior of its inhabitants, the discussion concerns governance. Institutions of governance across the Arctic (e.g., governments, self-governing municipalities, and non-profit, Indigenous and other organizations) and at different levels of organization will need to be both nimble and robust enough to adapt to rapid changes (Figure 8.5). As such, these

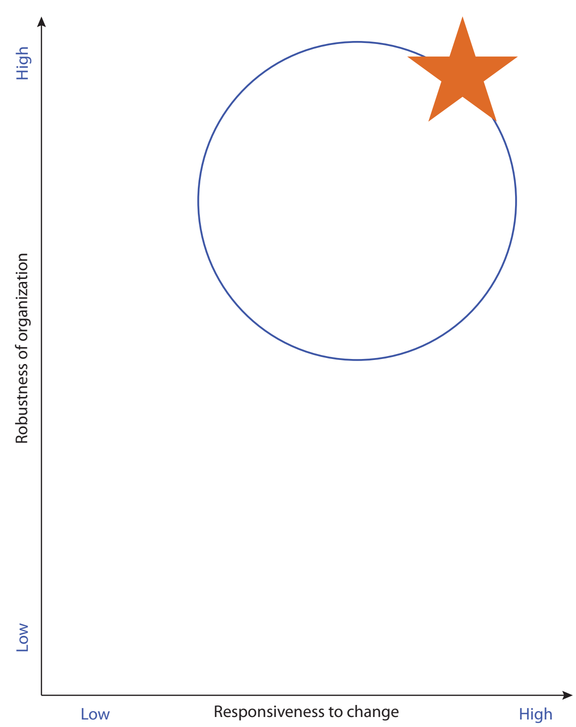


Figure 8.5 Effective institutions must be resilient but also nimble. Adaptive institutions should therefore occupy the space within the circle. Ideal institutions (orange star) perform optimally in robustness and responsiveness (adapted from Lindgren and Bandhold, 2009).

institutions cannot be so responsive that they lack consistency in research, application, or policy or so rigid that their mandates and practices resist change.

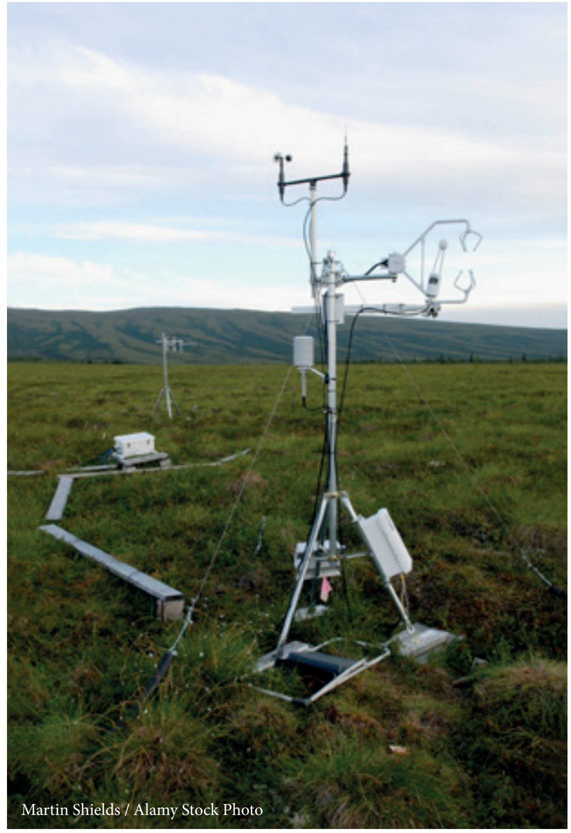
The relationship between the science of scenarios (the research that goes into identifying and prioritizing system drivers and their effects) and the potential for policy outcomes (planning for possible futures) produces four important interrelated aspects: integrating multiple sources of knowledge, guiding science investment, developing early warning systems, and problem framing and communication.

8.6.1 Integrating multiple sources of knowledge

The scenarios process, due to its interdisciplinary nature and open-ended focus on *what if?* inherently welcomes multiple sources of knowledge. Also, the narrative nature of scenarios can be congruent with Indigenous oral traditions and the human storytelling impulse to make meaning. To be fully effective, scenario development requires the integration of multiple sources of knowledge to form multiple comprehensive narratives (Bennett and Zurek, 2006; Bohensky et al., 2011). The BCB region has a mixture of Western and Indigenous knowledge systems that interact in varying ways through co-management of resources, formulation of social policy, education, and in some cases governance. It has been repeatedly demonstrated that Indigenous and local knowledges can provide insights, research methods, and data that enhance understanding of social-ecological systems and complement Western investigatory methods. It is only through acknowledging and engaging multiple sources of knowledge, in particular those that have been marginalized, that society can be sure it is considering the full range of future possibilities. By including multiple knowledge standpoints, 'less partial and distorted accounts of the entire social order' are produced (Harding, 1992, p. 583). This clearer view can be of particular importance when considering black swans or outlier variables that may unexpectedly drive a system. Different sectors of society may have access to information that is beneficial for planning, but their knowledge often exists in relative isolation (e.g., business, government, tribal organizations, Arctic residents). Scenarios can bring these sectors and their data together to bear on the future and thus create a knowledge base around a focal question that not only identifies different kinds of information but also can synthesize and examine their interactive effects (e.g., through knowledge co-production).

8.6.2 Science investment

Because scenarios provide insights regarding stakeholder values and priorities (Chapter 2), they can be used to direct future research investments toward those areas that are likely to have the greatest impact on people's lives. National, subregional, and local governments have recognized the need for long-term observations to track a rapidly changing Arctic. This recognition has created funding opportunities in the US and Canada through research communities (e.g., National Science Foundation, Natural Sciences and Engineering Research Council of Canada) whereby government agencies and other organizations identify priorities, measurement sites, and methods for such observations (e.g., Arctic Observing



Martin Shields / Alamy Stock Photo

Measuring carbon dioxide exchange between thawing permafrost and the atmosphere, Alaska

© B&C Alexander / ArcticPhoto

Reindeer at a winter camp on the tundra, Chukotka

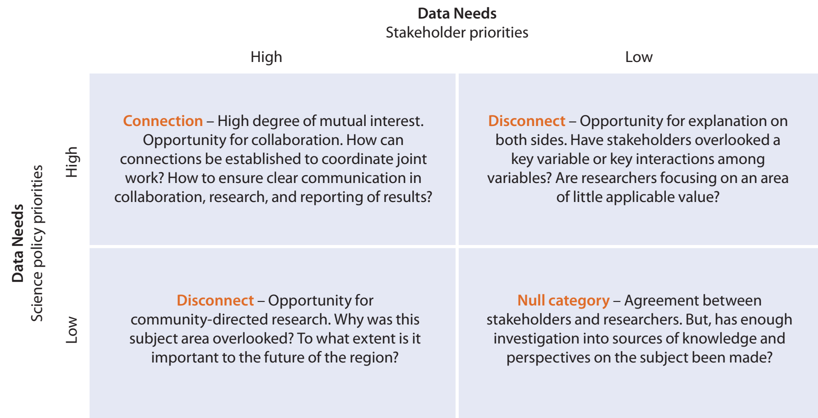


Figure 8.6 Implications of agreements or disagreements among stakeholders and the scientific community regarding the value of different kinds of data. The data needs of stakeholders for decision-making are compared against data availability, which is a function of research priorities and investments defined by science policy.

Network, Study of Environmental Arctic Change, ArcticNet). It is reasonable to assume that over the course of the next decade or so, several tens of billions of dollars will be spent in the Arctic to put into place and sustain long-term observing networks for a variety of indicators of ecosystem and climate system change. But what matters the most to residents and communities in the Arctic? In times of changeable budgets, it is vital that investment in science matches the adaptation information needs of people across different scales in a manner that can be sustained (Lovecraft et al., 2012). The types of information and exchange that scenarios processes develop can help to direct investment by identifying and prioritizing areas of socio-economic uncertainty that are key to successful adaptation.

8.6.3 Early warning systems

Because scenarios help to identify key sources of uncertainty critical to future conditions, they may suggest important areas for monitoring in order to receive advanced warning of system trajectories. This benefit relates directly to the opportunities discussed in Sections 8.6.1 and 8.6.2. By engaging multiple sources of knowledge and sifting through what remains uncertain, scientists, decision-makers, and Arctic residents can design and be a part of early warning systems that leverage the power of local observations in tracking key uncertainties in the social-environmental system.

8.6.4 Problem framing and communication

Scenarios processes that are participatory or collaborative in nature can enable the communication of significant information among people (e.g., scientists, decision-makers, stakeholders, residents) bound by a shared problem. The participatory approach, both qualitative and quantitative, enables those most keenly affected by the future to identify key drivers of change and participate in data collection and review. This approach also begins a process of evaluation that can provide context for the data used by modelers. During and after a scenarios process, as participants determine what they view as the key factors and prioritize them, there is a knowledge exchange that informs both the investigators using the scenarios process and its participants. For example, in a standard four-quadrant scenario of climate change and extractive resources with a focal question of "*How does a small community in Russia maintain its watershed in 2050?*" the information about water quality, flow rates, important species, and usage will be of use to the community, but the participants may also be able to communicate significant data to researchers about important recreational or spiritual uses for the water, or that they no longer rely much on a particular fish. Because scenarios focus participants on how to maintain, develop, or avoid some attribute for the future, they rely on participants to focus on normative values and core system functions. These exchanges are informed by what science can bring to the participants, but participants also inform scientists about what matters to them; what questions need to be answered? The power of this communication can be visualized in four possible outcomes related to data needs and availability in a system (Figure 8.6). Each outcome, as perceived by researchers and community members (and other stakeholders), poses significant questions whose answers are highly pertinent to future outcomes. Furthermore, significant disconnects can inform institutions of unclear or contested definitions of policy problems. Policies for Arctic regions, due to the general nature of these regions at the peripheries of national cores, are especially susceptible to misunderstandings when social problems, their attributes, and solutions are being defined. In Arctic communities, such misunderstandings are routinely observed at the local level because their concerns are not broken into disciplinary pieces – they are lived realities.

The split between pure and applied science can be problematic. For example, depending on research goals, scientists often make ice measurements some distance from communities in order to obtain samples or data free of the artifacts of human influence. But another observational perspective of ice is at the household level where ice cellars have experienced increased flooding over the last decade, posing a major threat to community food security. From both community and researcher perspectives, the melting and thawing of the Arctic cryosphere is a core investigatory concern, but what that means to the future may be different for one that relies on an ice cellar for one's livelihood versus a researcher who ultimately flies home to a refrigerator.

8.7 Conclusions

Socio-economic trajectories are often associated with significant path dependence, but changes in policy, technology, economic systems, and perceptions of risk contribute to inherent and irreducible uncertainty regarding the future of human systems and communities. The challenges that such uncertainty poses to adaptation decision-making and planning have been well documented; yet, various tools exist to help manage that uncertainty, and scenarios are a common one. Scenarios have been developed and applied using a range of methods, across different scales and contexts – both in the Arctic generally and in the BCB region specifically. When developed using a participatory process, scenarios can be a powerful tool for eliciting insights from a range of perspectives regarding key drivers and uncertainties of the future.

Scenario activities in the Arctic and BCB region over the past decade have consistently identified uncertainties regarding the future evolution of global energy demand, extraction of Arctic energy resources, and Arctic regional governance as critical to understanding future socio-economic development pathways. Moreover, those uncertainties have important implications for the consequences of climate change, the resilience of BCB ecosystems and communities, and the capacity of decision-makers and stakeholders to adapt to a changing climate. Hence, continuing to assess the potential impacts of climate change under different scenarios of climatic and socio-economic change will be an important component of problem framing and of developing a robust adaptive response within the BCB region. In addition, scenarios can contribute to the development of early warning systems and the prioritization of regional research needs to enhance social benefits.

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