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Scenarios and Surprises

*When Change Is the Only Given*¹

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Introduction

The vision of the Arctic as a treasure chest of natural resources has gained renewed traction in recent years due to a combination of climate change, expectations of increasing global demand, and geopolitical concerns about securing the supply of critical innovation metals. This increasing interest often stems from global and national perspectives on the Arctic. While regional authorities and some local communities welcome the potential for new job opportunities and economic investments, concerns about the long-term sustainability of extractive industries have also led to conflicts over land use and criticism about the lack of sufficient dialogue with Indigenous peoples, not least in the Nordic Arctic (Koivurova et al., 2015; Bjørst, 2016; Lawrence & Larsen, 2017; Beland Lindahl et al., 2018; Dannevig & Dale, 2018; Harnesk, Islar, & Stafström, 2018; Magnusson & Dale, 2018; Zachrisson & Beland Lindahl, 2019; Österlin et al., 2023, see Chapter 5). Such conflicts raise questions about who has a legitimate right to define sustainable development in a local and regional context. The level of conflict between different interests suggests a lack of legitimacy of current impact assessment processes and has also led to calls for approaches that take a more holistic view of the environmental and social impacts compared to current decision frameworks (Karvinen & Rantakallio, 2019). The need for improved assessment processes concerns the quality of the knowledge base for politically negotiated decisions about mining and related industries but also relates to calls for transparency and equal participation for those who are or would be affected by the decisions.

The aim of this chapter is to discuss how exploratory scenario methods could be used in the context of improving assessment processes related to mining. We argue that scenario exercises have the potential of involving local and regional actors in the visioning of Arctic futures in ways that would not only provide a broader view

of the role of extractive industries for the future of a region but also include attention to the social, environmental, and technological uncertainties that are unavoidable when trying to assess the long-term impacts of mining. We discuss some limitations of current scenario approaches based on a synthesis of published scenarios of possible Arctic futures, summarize key insights from a series of participatory scenario workshop focusing on local views of sustainable development, and use this as a base to suggest steps for improving participatory scenario methods. We thereby specifically add attention to the potential impacts of so-called wild-card developments. We furthermore suggest that insights from such improved scenarios can be used for exploring how both known drivers of change and surprises may affect the dynamics of social-ecological-technological systems to provide more holistic and proactive assessments of the impacts of extractive industries.

Exploratory Scenarios of Arctic Futures

Exploratory scenarios have been used widely for a few decades to understand the dynamics of change in situations of uncertainty and can also be used for exploring how large-scale drivers might affect local developments (Millennium Ecosystem Assessment 2005; van Vuuren et al., 2012). The scenarios are not projections or predictions of the future but describe various alternative plausible futures and provide schematic descriptions of how the future might unfold under a logic framed by variations in key drivers of change. Because they outline plausible development paths without being policy prescriptive, they are useful for assessing the robustness of different policy options in situations of uncertainty about the drivers of change that are in focus (Kok, Biggs, & Zurek, 2007).

There is a large number of published scenarios that explore potential Arctic futures in light of climate change and various visions of industrial development in the region (for reviews, see Arbo et al., 2012; Nilsson, Bay-Larsen, Carlsen et al., 2017a; Erokhin & Rovenskaya, 2020). However, while some general insights about the role of extractive industries can be gleaned from the scenario literature, none of the published scenarios explicitly targets the relationships between extractive industries and Arctic local communities. Furthermore, many scenario narratives focus on a limited set of mainly large-scale drivers of change and pay limited attention to the impact of surprises (Nilsson et al., 2019). Surprises are here seen as “wild cards”: imaginable and concrete events or developments that may seem unlikely but could have wide-ranging impacts if they became a reality (Fergnani, 2021).

In our review of insights from already conducted scenario exercises, we first classify five published Arctic scenario narratives under general scenario archetypes

(Harrison et al., 2019) in order to draw out some insights that relate specifically to extractive industries. We then add nuance to the discussion about drivers of change by drawing on local perspectives from nine bottom-up scenario exercises that have been conducted across the Nordic Arctic, and we then elaborate on some potential wild cards that are relevant for different scenario archetypes.

Scenario Archetypes

Taking a starting point in a review of Arctic scenarios by Erokhin and Rovenskaya (2020) and adding relevant additional published scenarios, we have selected five scenario sets for further analysis based on their relevance for resource extraction. The following studies were selected: Loe et al. (2014) present three scenarios for business opportunities in the Arctic in 2020 with a special focus on petroleum, mining, seafood, and shipping based on workshops and in-depth interviews with business leaders and Arctic experts. Brigham (2007) presents four narratives exploring implications of major drivers of Arctic change, including increasing natural-resource extraction activity. Lazariva et al. (2021) combine desktop research with a series of in-depth interviews and seminars with key stakeholders and develop four narratives for the Arctic until 2050. Haavisto et al. (2016) present six narratives for the Eurasian Arctic by 2040 focusing on the development of shipping, resource extraction, and tourism industries based on a literature review, pre-survey, and an expert workshop. Burkhart, Seadas, and Wichmann, (2016) present four narratives exploring two critical uncertainties: global oil price and Arctic governance, based on interviews with government officials, industry leaders, Indigenous groups, and scientists.

The selected scenario sets were organized according to six scenario archetypes proposed by Harrison et al. (2019). The archetypes are business-as-usual, economic optimism, regional competition, regional sustainability, global sustainable development, and inequality. To capture the breadth of Arctic scenario narratives, we added one more archetype, which we call Frozen development. This scenario type was identified based on the Arctic scenario exercises we reviewed. The results of the analysis are summarized in Table 4.1.

The scenario archetypes have varying implications for the relationship between extractive industries and local communities: While “Economic optimism” may bring benefits for Arctic communities, it also implies the undermining of traditional livelihoods. The “Regional competition” and “Inequality” scenarios have mostly negative implications for local communities. Sustainability at global scale appears to be beneficial also for Arctic communities but includes a risk that the economy and global environment are emphasized at the expense of local socio-cultural issues. At its extreme, a focus on environmental sustainability may even lead to a situation where economic activities in the Arctic are banned.

Table 4.1. *Arctic scenario narratives typologized under general scenario archetypes (Harrison et al., 2019) and their implications for relationships between extractive industries and Arctic local communities*

Global Scenario archetypes	Arctic scenarios narratives	Implications for natural resource extraction in the Arctic	Potential implications for local communities in the Arctic
<p>Business-as-usual: Moderate population and economic growth; Persisting inequality; Markets and institutions are stable.</p>	<p>“Managed boom” (Burkhart et al., 2016)</p>	<p>Extensive extractive activities while some sustainability norms are in place governing economic activities.</p>	<p>Some conflicts; Moderate regulation of extractive projects where local communities are mainly engaged via impact assessments.</p>
<p>Economic optimism High economic growth; Low regulation; Population growth low; Reactive attitude to environmental problems; Efficient technologies.</p>	<p>“Free for all” (Burkhart et al., 2016) “Globalized frontier” (Brigham, 2007) “Oil in demand” (Loe et al., 2014)</p>	<p>International access to Arctic resources, and growing interest in extractive industries; Lack of regulation; Rising global prices of minerals intensify extractive activities but may lead to conflicts and environmental damage.</p>	<p>Indigenous and local people benefit from employment opportunities; Economic growth; Due to low regulation, traditional livelihoods and ecosystems tend to suffer.</p>
<p>Regional competition Social fragmentation; Competition, instability erode international trade and cooperation; Emphasis on national and regional self-sufficiency; Technological innovation low.</p>	<p>“Polar lows” (Burkhart et al., 2016) “Wild west” (Haavisto et al., 2016) “Age of discovery” (Lazariva et al., 2021) “Fortress frontier” (Brigham, 2007) “Re-freeze” (Loe et al., 2014)</p>	<p>Intensive development of extractive industries; Arctic states guard their resources; Low and fragmented regulation; Rush to resources makes Arctic more and more profitable and attractive for private investors, and related risks are covered by states; Escalating climate crisis.</p>	<p>Development driven by large/multi-national corporations and resources are mostly privatized; Local livelihoods deteriorate; Indigenous peoples and their claims are ignored; Arctic society splits: urban communities and professional opportunity-seekers flourish, while Indigenous peoples suffer.</p>

Regional sustainability

Local and regional policy focusing on welfare, equality, and environmental protection; International collaboration low; Technological innovation and economic growth moderate but uneven.

Global sustainable development

High cooperation and top-down governance with proactive regulation for the environment; Rapid innovation in green and resource-efficient technologies.

Inequality

Political and business elites have most power, leading to increasing economic, political, and social inequalities and fragmentation.

“Isolated Arctic” (Burkhart et al., 2016)

“Equitable frontier” (Brigham, 2007)

“Shangri La” (Haavisto et al., 2016)

“Renaissance” (Lazariva et al., 2021)

“Adaptive frontier” (Brigham, 2007)

“Green Transformation” (Loe et al., 2014)

“Silicon Valley” (Haavisto et al., 2016)

“Exploited colony” (Haavisto et al., 2016)

“Conflict zone” (Haavisto

et al., 2016) “Dark ages” (Lazariva et al., 2021)

Extractive projects sustainable; Multi-level regulation is clear and equitable; Efficient resource extraction; Respect for carrying capacity.

Balanced sustainability and strong regulation of extractive projects. Incentives for sustainable technologies; Oil and gas not used; New clean technologies boom; Corporate Social Responsibility; Economic growth does not increase environmental footprint.

Fierce competition over resources; Short-term profits drive resource extraction; Companies seen as pillars of national economy; Rules and regulations weak; Deep-sea mining; Decreasing opportunities for diversification and new market development; Economy based on extractive industries.

Conflict-free Arctic; Indigenous rights; More income for local communities also from extractive projects; Good prospects for local livelihoods.

Fly in fly out workers; Indigenous peoples maintain traditional ways of life, languages, and cultures, and are participating in the decision-making processes. However, socio-cultural aspects may lag behind due to strong focus on economy and environment.

Conflicts between native people, immigrant workers, and public authorities; High influx of workers to the area because of increased employment possibilities leading to hub-based development and urbanization; Arctic becomes a depopulated and devastated industrial site. Indigenous people assimilate and out-migrate.

Table 4.1. (cont.)

Global Scenario archetypes	Arctic scenarios narratives	Implications for natural resource extraction in the Arctic	Potential implications for local communities in the Arctic
	<p><u>Frozen development</u> “Antarctic” (Haavisto et al., 2016) “Romanticism” (Lazariva et al., 2021)</p>	<p>Very strict environmental regulation as risks related to the impacts of Arctic resource exploitation are considered too high; Arctic is turned into a sanctuary; Only sustainable energy and transport, no mining or extractive projects.</p>	<p>Traditional livelihoods flourish, ecotourism brings external revenue; Economic activity has been limited to sustainable fishing and herding, local crafts, and sustainable tourism; Indigenous peoples maintain their traditional way of life and receive social payments; Lack of economic opportunity and declining living standards lead to out-migration of professionals and the urban population.</p>

Insights from Participatory Scenario Exercises

To complement the synthesis of Arctic scenarios, we draw on insights from a series of scenario exercises based on a method to develop so-called extended shared socio-economic pathways (Nilsson et al., 2017b). The method includes asking the participants an open question: What future changes may influence this region economically, environmentally, and socially within the perspective of one to two generations? The question guided nine participatory scenario exercises that were conducted between 2015 and 2020, covering various local contexts across the Nordic Arctic, with and without mining or proposed mining activities. These were held in Sweden: in Pajala in 2015 (Nilsson, Carlsen, & van der Watt, 2015) and in Kiruna in 2019 (Nilsson, 2020); in Norway: in Bodø in 2015 (van Oort, Bjørkan, & Klyuchnikova, 2015) and 2020, and in Alta in 2018; in Greenland: in Ilulissat in 2018 and in Narsaq in 2019; (Vangelsten et al. 2022); and in Finland: in Inari in 2015. In addition, one workshop was conducted in Kirovsk, Russia (2015) (van Oort et al., 2015) (Figures 2.1 and 2.2). The methodology provided the participants with an opportunity to brainstorm freely in relation to the open question about what future changes may influence the region, followed by a conversation in which local drivers of change were discussed in relation to various global development paths in the so-called Shared Socio-economic Pathways (SSPs) (O'Neill et al., 2017). The SSPs are narratives of potential global futures that were developed to provide a base for assessing challenges to climate mitigation and adaptation. A major contrast between the local scenario exercises and the scenarios reviewed in our literature synthesis was the focus on drivers of change that were deemed especially relevant for local and regional development paths, as envisioned by the participants in the exercises. The results thus provide a different perspective than the scenarios of circum-Arctic futures (see Table 4.1) that often focus on larger-scale developments.

For the analysis in this chapter, the raw data from the brainstorming exercises was compiled according to the categories of drivers that guided the development of the global SSPs (Nilsson, 2021). Our analysis was then guided by eight generic components of social-ecological-technological systems as elaborated by (Nilsson, Avango, & Rosqvist, 2021a): the abiotic environment, biodiversity and ecosystem, technical artifacts, social networks and demography, actors and agency, markets, knowledge, and institutions. Based on the analysis, we selected four overarching themes to discuss in more detail: market demand, politics and power relations, demographic trends, and technology. They were selected because they appear to be relevant in shaping the future of the Nordic Arctic regardless of the specific economic, cultural, and political context in each scenario exercise location, and, furthermore, they relate to key features of social-ecological-technological systems that are especially relevant for understanding the expansion of extractive industries. In the following text we explore these issues in more detail.

Extraction of resources in the Nordic Arctic would not happen without *expectations of market demand*. Historically, this demand has shifted many times, leading both to local boom economies and to bust cycles with abandoned mining towns or towns in economically dire situations (Huskey, Mäenpää, & Pelyasov, 2014; Malmgren et al., 2023, see Chapter 11; Sörlin et al., 2023, see Chapter 2). As long as the local economies are narrow, which is often the case in the Arctic, this dependency is likely to continue. With growing awareness about the need to radically cut emissions of greenhouse gases, expectations of market demand for Arctic resources are now overlaid with a larger-scale technological shift away from the hegemony of fossil-fuel energy, which is still in high demand, to an increasing demand for some metals and for wind and solar power. Consumer preferences may play some role in this shift. In several scenario exercises, issues related to lifestyle choices were mentioned, which may affect what products and services would be desired, for example the demand for electric vehicles, travel habits, and dietary diversity. Another and potentially more important driver of this shift is technical innovations, which are often supported by politically decided economic incentives, such as public investments and tax structures. They thus link to an ongoing shift in overarching social norms at the national and international levels about the importance of mitigating climate change, including the uncertainties and the social negotiations that are inherent in major normative shifts. Another recurring issue in scenario exercises was attention to the potential of tourism and the tourism market's demand for Arctic environments with pristine nature and quiet surroundings.

While many industrial actors expect mining to expand, the local scenario discussions also included concerns about what may happen when a specific mine is no longer economically viable. Even slight shifts in market conditions can affect the profitability of a mine, and the consequences could be major if the local social-ecological-technological system is not resilient, as witnessed by Arctic ghost towns that were once lively mining settlements (Keeling & Sandlos, 2017; Malmgren et al., 2023, see Chapter 11). However, expectations of increasing demand can have equally large implications locally if they lead to new or expanding mining activities. Expectations can raise hopes among unemployed youth but also lead to competition over the available labor force. As mining plans materialize, expectations can also create demand for new housing, a need for local investments in infrastructure, as well as in-migration that changes the social dynamics of a place.

Expectations of future demand (increasing or decreasing) are interlinked with political ambitions (environmental as well as industrial) and geopolitical considerations that may affect permit processes and public investment in supporting infrastructure. A strong message from the local scenario exercises was that the participants saw *power relations* as central to how the local future might develop. Furthermore, many people who took part in the exercises expressed

that power over local futures lies somewhere else, in the national capital or among transnational corporate actors. Power often relates to institutional structures that support extractive activities because they are framed as valuable from national and international perspectives. Meanwhile, local and regional power is in practice often limited in decisions about extractive industries in the Nordic Arctic. But some local power exists. In Norway, municipalities have a veto. In Sweden, national interests (*riksintressen*) weigh heavily but those are many. Furthermore, local voices often have less economic and narrative clout than industrial actors, which is critical in deciding whose narratives drive processes of “development.” However, an ongoing change in norms with implications for power relations is the increasing recognition of Indigenous rights in international law. For example, scenario exercise participants in a workshop that mainly included young reindeer herders saw future development and its local implications as uncertain but important for Indigenous livelihoods and recognition of Indigenous knowledge, as well as for the sense of inclusiveness in local societies.

Often, the power of people who live in the north seems to lie mainly at the personal level, in decisions about whether to move or stay. A place must be attractive to live in, as highlighted by one workshop participant in Kiruna, while the importance of incentives to “come back” was mentioned in the scenario workshop in Alta. *Demography* thus becomes a central concern, with issues ranging from settlement pattern/urbanization to concerns about out-migration of young women and an aging population. The question that follows is whether extractive industries make a place more attractive both in the short and long term. The answers are likely to differ depending on who you are: age and gender play a role but also education (Can I get the relevant education? Do my skills fit the new job market?), and personal affinity to a place, where both the natural environmental and social networks are important. Demographic patterns and changes in them are thus critical factors to consider in assessing the potential impacts of extractive industries, as has also been highlighted in a proposal about issues to include in social impact assessments (Suopajarvi & Jungsberg, 2016).

Another demography-related issue that was brought up in several scenario exercises was in-migration and its potential impacts on the local society. Sources of such influx were discussed primarily in relation to the global movement of people, including worldwide migration and climate refugees but also people coming in from other countries to work in extractive industries or the tourism sector. The impacts of extractive industries on society have been, and will likely continue to be, reflected in the demography of the Nordic Arctic: where people live and who they are. Historic examples include the ghost town created when mining has ceased and when a decline in the workforce led to the tearing down of housing during a downturn in demand (Keeling & Sandlos, 2017; Malmgren et al., 2023, see Chapter 11), but there are also

less dramatic examples, such as how the opening of a mine near Pajala, near the border between Sweden and Finland, reversed the earlier population decline in the municipality. Another example is how the current industrial boom in northern Sweden has led to demands on politicians to provide incentives for people to move north (Lindberg, 2021). The potential for increased job opportunities in traditional outmigration regions has also been an argument for more mining in policy discussions and in impact assessments (Nilsson et al., 2021).

Technology, including communication and transport infrastructures, is another factor that can be decisive for shaping the future of the Nordic Arctic. In the past, the development of infrastructure has been a precondition for expanding the extraction of non-renewable resources in the Nordic Arctic. This affects not only mining but the potential for economic development more generally, for example, in relation to tourism, where roads and railroads create access to places that can otherwise be difficult to reach. The 500-kilometer-long railroad from Luleå on the Gulf of Bothnia via the inland Arctic mining town Kiruna to Narvik on the Atlantic coast is a case in point.

For future development, digitalization is likely to play an increasingly important role both for mining operations and for society in general. One development highlighted in a scenario exercise was that virtualization and digitalization of industrial processes could pave the way for remote operations. An example from the scenario exercise in Kiruna is the idea that knowhow from a long history of mining could remain an asset even if the local ore was no longer economically viable to mine, as Kiruna could instead become a remote hub for mining operations elsewhere. “Local” mining knowledge could become a key asset in shaping a town’s future, even if the local mine was no longer in operation. However, remote operation of mining in the Arctic could potentially also lead to fewer local mining jobs and thus to outmigration. Another aspect of digitalization relates to the fact that media narratives about the Arctic often emerge from global and national perspectives, where social media are now providing venues for local voices to also be heard (Nilsson & Christensen, 2019).

These are just some of the issues that local people in the north see as critical for shaping local futures, aside from the impacts of climate change with its wide-ranging implications for the temperature and precipitation patterns that shape the region’s ecosystems. In the workshops, the potential consequences of climate change that were raised included both the risk of food shortages and new possibilities for regenerative agriculture and renewable natural resources. The local scenario exercises thus point to a broader set of issues than discussed in the reviewed published scenarios of Arctic futures. They also point to issues that are not necessarily covered in environmental impact assessments, where the focus is often on specific environmental concerns and other issues regulated by law (Nilsson et al., 2021).

What If?

In the recent past, development in the Arctic has been characterized by surprises that have changed political expectations (the fall of the Soviet Union), economic structures (Iceland's financial crash), basic features of the Arctic environment (the dramatic decline in Arctic Ocean sea ice with the sea ice minima in 2007 and 2012 as events with geopolitical implications), and the Covid-19 pandemic with severe impacts on the tourism industry. Exploratory scenarios aim to take the possibility of future surprises into account, and, inspired by discussions during bottom-up scenario exercises and recent trends in the discourse on mining, we have identified several "wild card" or "what if" questions that are important in discussing possible Arctic futures. "What if" questions link to imagining the unexpected. They can help to prepare people for extreme future events by pushing the boundaries of conventional thinking to include the unlikely and to cope with alternative futures (Hukkinen, 2008). Wild cards are low probability and high impact events or developments that can be used to enrich scenario narratives by including a broader view of underlying uncertainties. With a focus on the links between extractive projects and local-regional development in the Nordic Arctic, and inspired by the scenario exercises, we suggest wild cards connected to the scenario archetypes from our earlier review of existing scenario narratives, see Table 4.2.

None of these scenarios may play out as they are suggested in the table. In some cases, strong economic and political interests may be at stake to halt the development, and in other cases social inertias and technological lock-ins may halt or delay a certain course of development. However, they illustrate that no future is inevitable. It is also worth noting that surprising impacts of climate change play a role in only one of these narratives (climate migration) and that additional wild card future narratives could be developed based on dramatic changes in the global climate and its environmental and political implications.

Discussion and Future Directions

A major purpose of exploratory scenarios is to imagine the space of uncertainty to be able to better navigate change, either by adapting within the overarching logic of the current context or by managing a transition to something new. Extractive industries have played a prominent role in shaping northern regions by creating socio-technical systems that include technical hardware, institutions, and actor networks (Avango et al., 2019). Given their impact on land use and thus the environment, it is appropriate to also discuss social-ecological-technological systems impacts (Nilsson et al., 2021). Given strong path dependencies, the ongoing discussion about a green transition with its expectations of increasing

Table 4.2. *Wild cards, their links to scenario archetypes, and implications for extractive projects and local communities in the Arctic (by authors)*

Wild card/ target year	“What if” question	Links between extractive industries and local communities	Links to scenario archetypes
Battery 2040	What if global demand for minerals explodes due to developments in green technology and battery technology?	A strong political focus on climate mitigation leads to a dramatic expansion of mining in the Nordic Arctic, supported by public investments and streamlined permit processes. Local communities cannot say no to mining but derive some benefits, including jobs opportunities and local economic upswings. There is some recognition that the green transition can have negative effects for traditional livelihoods, but it is generally believed that these can be compensated (see Green Deal and Just Transition Mechanism).	Side effects of “Global Sustainability”
Power flip 2040	What if strong Indigenous rights are mainstreamed across all policy sectors and levels?	Extractive projects require consent from Indigenous organizations in the Nordic Arctic. Benefits from extractive industries go to Indigenous people and impacts on Indigenous livelihoods and ways of life are mitigated by agreements reached in negotiations where Indigenous rights and Indigenous knowledge are fully recognized. However, non-Indigenous local people, including other local minorities, do not have a strong voice, resulting in social tensions.	Indigenization and “Regional Sustainability”

Climate migration 2060

What if adverse impacts of climate change escalate globally and lead to millions of refugees?

Climate change creates millions of refugees from southern countries, with large-scale in-migration to northern regions where summer temperatures are still reasonable. In some places, receding glaciers create new opportunities for extractive projects. Some migrants find work in extractive projects while others develop new ecosystem-based livelihoods, including food production. This increases the pressure on the ecosystem base for traditional livelihoods and on Arctic biodiversity, but the region is overcrowded, and other sources of income are hard to find.

Impacts of “Inequality” and climate crisis

After exploitation 2060

What if Arctic minerals and oil and gas deposits are extracted until they end?

Arctic minerals are heavily used until they are exhausted or no longer economically viable. After the boom, many local economies collapse. Heavy exploitation has created toxic environmental legacies and disrupted ecosystems. Some easily accessible ghost towns now function as sites for dark “industrial” ecotourism. Prospects for traditional livelihoods are degraded and people mainly live in urban centers. The outcome is an empty rural Arctic, while urban centers manage to survive based on other economic activities, many of which require advanced education.

After “Economic optimism” and “Inequality”

Table 4.2. (*cont.*)

Wild card/ target year	“What if” question	Links between extractive industries and local communities	Links to scenario archetypes
Gender balance 2040	What if gender relations become balanced in Arctic extractive projects?	Extractive industries offer attractive employment opportunities for women, which changes the trend of brain drain caused by young women moving out from the Arctic. As a result, the social dynamics of mining towns change, creating demographically more viable communities.	Gender and “Regional Sustainability”
Automat 2040	What if extractive industries become fully automated?	Technical advances combined with a need to cut costs lead to increasing automation in extractive industries. In many places, the promise of new local jobs never materializes, but in places with strong know-how and human capital local mining knowledge becomes a resource for export and for creating advanced industrial innovation hubs.	“Economic optimism” and technologization

demand of metals may cement this logic. However, there are also discursive struggles about what is acceptable in terms of environmental costs and impacts on Indigenous peoples' livelihoods, where international norms play a much stronger role today than they did when mining expanded in the Nordic Arctic during the 1900s (Koivurova & Petrétei, 2014; Lawrence & Larsen, 2017; Bay-Larsen, Skorstad, & Dale, 2018). Together with the likelihood of surprises caused by climate change, geopolitical developments, technical innovations, or economic fluctuations, it is thus risky to take the past as a template for assessing the sustainability of mining. We instead suggest that it is necessary to better understand the social, ecological, and technological processes that shape the Nordic Arctic and the potential for changes in feedback mechanisms that could lead either to adaptations within the current logic of the relationships that shape interactions between people and between people, the environment, and technology, or to major transformations. Both possibilities could profoundly influence the sustainability of local communities.

Institutional path dependencies, including persistent legal frameworks and constellations of powerful interests, have played an important role in shaping the Nordic Arctic over the past century, partly through the sociotechnical systems related to mining (Avango et al., 2019; Keskitalo, 2019). The stability of the current logic and structure cannot be taken for granted, however. In the literature on Arctic change, both resilience and the possibility of transformative shifts in feedbacks and structures have been discussed extensively, but the focus in the resilience literature has, so far, mainly been on ecological and social processes (e.g., Arctic Council, 2016). In the literature on resilience and transitions, the role of technologies as an important link between social and environmental processes has received increasing interest (Smith & Stirling, 2010; Ahlborg et al., 2019) but has not been central in the discussions about Arctic change. Given the importance of industry and infrastructure in shaping northern regions, it should be.

Allington et al. (2018) have shown that participatory scenario exercises can be useful for modeling social-ecological systems in settings that include researchers from different disciplines as well as local and regional actors with tacit knowledge of the context in which they live and work. Specifically, they showed that local and regional actors brought up drivers of change that the external experts had not identified, and that an iterative approach that included both system dynamics modeling and scenario exercises forced all the participants to make their assumptions and tacit knowledge explicit. Based on these experiences, we suggest that scenario approaches could also be useful for understanding the role of technologies for societies and environments, including those related to extractive industries. The idea would be to use insights from the scenario exercise to improve the understanding of possible future interactions and feedbacks across different

parts of a regional social-ecological-technological system. For example, they could guide the analysis of how potential changes might affect feedback loops, potentially leading to radical changes for local communities or whole regions. If carried out in an inclusive participatory setting with local and regional actors, such an approach could make both the visioning of Arctic futures and impact assessments not only more transparent but also inclusive of a wider range of perspectives and knowledges. Adding “what if” questions to such exercises would assist in exploring how robust the base is for sustainable local and regional development. Mining-related “what if” questions can be used for specifically exploring whether the presence or absence of extractive industries would support or erode the social, ecological, and technological base for sustainable local and regional futures.

Exploratory scenarios do not resolve conflicts and are unlikely to lead to consensus about extractive industries. Nor is this their purpose. However, they could serve as tools for developing more holistic assessments of the impacts of mining on sustainable development. Furthermore, they could contribute to more transparency of assessment processes and to the quality of the knowledge base for politically negotiated decisions about mining and related industries.

Note

- 1 The participatory scenario exercises that have been summarized in this chapter are the result of several different projects and collaborations. In addition to work carried out in the Nordforsk-funded REXSAC, they include Mistra Arctic Sustainable Development; the Arctic Council project Adaptation Action for a Changing Arctic; Gávnadeapmi 2015; Sustainable Adaptation to Climate Change and Globalization in Disko Bugt, West Greenland, funded by Nordforsk; and Field of Goals, funded by the Norwegian Research Council. The following researchers have been instrumental in organizing the scenario workshop in the Nordic Arctic: L-M. van der Watt, I. Bay-Larsen, M. Bjørkan, B. van Oort, M. Rasch, J. N. Larsen, and B. V. Vangelsten. We furthermore want to express appreciation to all participants in the workshops for sharing their ideas and insights.

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