

Scenarios for Sustainable Development in the Arctic until 2050

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The Arctic region has increasingly come to be seen in a new light because of the global transformations resulting from the disruptive challenges of climate change and shifting global political, social and economic patterns. The harsh environmental conditions there have long constrained economic activity. The climate crisis, while having a negative impact on the region in some senses, opens up new prospects for development in others. The Arctic has become a geopolitical hot spot where global and regional players seek to increase their influence. On one side, the Arctic possesses vast natural resources and increasingly will be an important global source of bio-resources. The area is also one of geopolitical tension. On the other side, the Arctic represents a “temperature gauge” for distant pollution and waste in the sea. At the same time, powerful voices from supranational institutions are putting heavy pressure on preserving the Arctic as a kind of “nature protected area” with severe restrictions on economic activity and human impact. This paper draws attention to the tension between the regional interest in maintaining and developing a socially, economically and biologically sustainable area of human settlement and the more detached interest in preserving the Arctic as a nature reserve. The study approaches Arctic development from a social, ecological and environmental point of view, mapping key development drivers and the changing geopolitical context. The research utilizes scenario methodology and qualitative expert interviews combined with comprehensive literature studies. Four scenarios illustrate how the Arctic might look in 2050 and what the implications might be for the sustainable development of the region from the economic, social and environmental perspectives.

Introduction

The Arctic has attracted a lot of research and media attention trying to shed light on the present and future state of the region as it is the one most affected by climate change and is of interest for resource extraction by the Arctic countries and international players. The Arctic region has become intensely geopolitical, affected by global interests and the narratives of business, national and regional governmental actors (Dodds & Woon 2020).

Exploring history to produce narratives about the future of the Arctic, the researchers agree that melting ice will lead to an increase in shipping and resource extraction (Wood-Donnelly, 2018).

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Scenarios for the future of the Arctic range from short to long time-horizons and portray an array of Arctic futures from the most pessimistic to the most optimistic (Arbo et al., 2012; Erokhin & Rovenskaya, 2020). Analysis of the media discourse demonstrates that whereas environmental organizations advocate better protection of the vulnerable Arctic, government actors stress the advantages of the new Arctic economy. Environmental sustainability and scientific knowledge are the most central justifications and are used by all actor types (academia, government, business). Ecological justifications, on the other hand, frequently conflict with market justifications (Kukkonen et al., 2020). Often the interests of different Arctic stakeholders are presented as being at odds with each other.

The purpose of this study is to construct scenarios for the future of the Arctic region until 2050 by identifying the driving forces and critical uncertainties of Arctic development. The time horizon of 2050 is a challenging one because the Arctic will be halfway through a transition from current structures to something different, approaching a tipping point. It will almost certainly contain elements of both the old and the new Arctic. The study involves multi-stakeholder dialogue and contributes to the previous literature by using the concept of the Triple Bottom Line whereby economic, social and environmental performance are equally important (Norman & MacDonald, 2004) and by applying the Oxford Scenario Planning Approach (Ramirez & Wilkinson, 2016). With our scenarios, we try to answer these questions: can Arctic development be both economically viable, socially and environmentally responsible and, if so, what is needed for that? Scenarios are aimed at showcasing a range of possible futures for the Arctic region, which provides a point of departure for leadership discussions.

The article proceeds as follows. Section 1 reviews previous research on the Arctic using scenario methodology. Section 2 discusses methodological choices and data. Section 3 presents development drivers and section 4 comments on critical uncertainties. These scenarios are elaborated on in Section 5. Finally, Section 6 presents the Conclusion.

Review of the Arctic studies using scenario methodology

The Arctic region has been a fertile field for researchers wanting to apply scenarios and future studies methods. A changing environment due to climatic warming, increased international political and business interest, and shifting geopolitics all offer a range of uncertainties for future Arctic trajectories. In the review article by Arbo et al. (2012), 50 studies concerning the future of the Arctic were analyzed in order to identify basic assumptions, analytical approaches, and future images that characterize current thinking about the Arctic. Major topics recurring in the studies include climate change and its social impacts, natural resources, economic activity (oil and gas, mining, shipping, fisheries) and changing Arctic governance (Arbo et al., 2012). The future of the Arctic is linked to the accessibility of the Arctic Ocean. In the report *Maritime Futures 2035*, the Arctic Region drivers such as geopolitical stability, global demand for Arctic resources and economic trends with the most influence and highest uncertainty are selected for twelve possible scenarios (Blair & Muller-Stoffels, 2018). A recent review of scenario studies by concepts used and methodologies applied can be found in Erokhin and Rovenskaya (2020).

Regional studies

Tsukerman & Ivanov (2013) discuss two scenarios of livelihood systems in the Arctic Zone of Russia. The first "*innovation scenario*" uses technology and scientific advances for the development

of natural resources in the Russian part of the Arctic. The second “*inertial scenario*” provides a conservative view with minimal projected growth in key socio-economic indicators of the Arctic zone. Regional studies applying scenario methodology for the Norwegian Arctic are to be found in studies by Blakkisrud (2008) and Olsen and Iversen (2009). Russian Arctic development to 2030 in three scenarios addressing the role of market forces and democracy can be found in Myllylä et al. (2016). Zaikov et al. (2019) looked at ways in which the Russian Federation’s Arctic region might develop until 2035, including physical and geographical features, the world economy, and demand for hydrocarbon resources. They outlined three distinct but overlapping scenarios: an optimistic one, a negative one, and a moderate one.

Comprehensive long-range horizon studies

Some studies like “The New North: The World in 2050” by Smith (2011) take global warming, resource scarcity and population expansion as the major drivers for global development. In the new world, Arctic countries – Canada, Greenland, Norway, Sweden, Iceland, Finland and the northern regions of Russia and the United States – will become zones of rapid economic growth and increasing strategic importance. Population movements and increased urbanization already influence the pace of development in the area. In the context of global megatrends, Rasmussen (2011) sees the Arctic as a part of global society and often at the centre of global attention.

Brigham (2007) presents four broad scenarios for the future of the entire Arctic until 2040. In these scenarios, global climate change results in significant regional warming. Other drivers include changing transportation systems, especially increases in marine and air access, resource development in oil and gas, minerals, fisheries, freshwater, and forestry. Moreover, it includes overall geopolitical issues, environmental degradation, Arctic Council cooperative arrangements and the role of Indigenous peoples. In the *Globalized Frontier* scenario, the Arctic in 2040 has become an integral component of the global economic system, in the *Adaptive Frontier* the Arctic in 2040 is being drawn into the globalization era much more slowly. In the third, the *Fortress Frontier* Scenario, the Arctic is viewed as a storehouse of natural riches that are being guarded and developed by a handful of wealthy circumpolar nations. In the fourth scenario *Equitable Frontier* the Arctic is integrated with the global economic system in 2040 with an evolving international sustainability paradigm that has been implemented for Arctic development.

Socio-economic scenarios for the Eurasian Arctic by 2040 are discussed in the report by Haavisto et al. (2016). The study takes a long-range horizon (to 2040) and builds up scenarios on three dichotomous axes (open – closed; public – private; and dirty – clean) to explain the political, economic, social, technological, and environmental characteristics of many futures. Altogether, six socioeconomic possibilities for the Eurasian Arctic, named *Wild West*, *Silicon Valley*, *Exploited Colony*, *Shangri-La*, *Conflict Zone*, and *the Antarctic*, are presented as a framework for discussing the development of the maritime, resource extraction, and tourism industries.

The Arctic Marine Shipping Assessment Report (AMSA) by the Arctic Council (2009) presented four scenarios for Arctic marine navigation until 2050. In the *Arctic race*, high demand and unstable governance set the stage for an economic rush for Arctic wealth and resources. In the *Polar Lows*, low demand and unstable governance bring a murky and underdeveloped future for the Arctic. In *Polar preserve*, demand is low and governance is stable. Arctic development should be slowed while establishing a vast eco-reserve with strict “no shipping zones”. The *Arctic Saga* scenario features a

healthy rate of development involving the conservation of Arctic ecosystems and cultures, leading to strong demand and stable governance.

Participatory

More and more scenarios are now being created with a participatory methodology for new developments in the Arctic. They have the potential to contribute to several Arctic research priorities, including integrating Indigenous and local knowledge into futures studies. Participatory approaches provide a platform for the local population to participate in identifying Arctic-relevant drivers and indicators for sustainable development (Cost & Lovecraft, 2019).

For instance, in Arctic Futures Makers (AFM) a two-day workshop was organized bringing together 22 Alaska Indigenous high school students to discuss the resilience of the Northwest Arctic Borough's communities in the face of climate and development change. The scenarios workshop's objective was to identify factors that students believed were critical to the future of healthy and sustainable communities (Cost & Lovecraft, 2019). Following the participatory approach, Falardeau et al. (2018) present four scenarios in the Canadian Arctic mobilizing Indigenous and local knowledge in scenarios constructing positive futures.

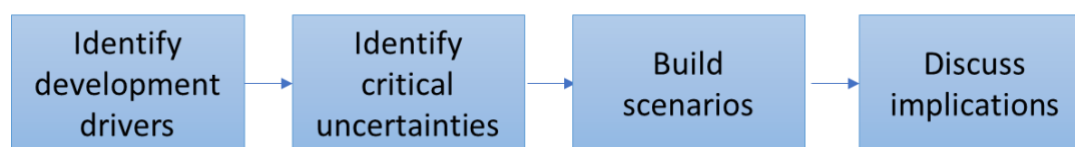
The reviewed studies demonstrate that the future of the Arctic has been and is becoming even more prominent on the wider research agenda. Studies vary by scope, by time-horizon and with the involvement of stakeholders in the futures scenario building process, while not being mutually exclusive. Our study contributes to the literature using a triple-bottom line approach, using a long-range horizon until 2050 and building scenarios for the entire Arctic region.

Methodology and data

Our study uses a scenario methodology (Schoemaker, 1991; Schoemaker, 1993; Ramirez & Wilkinson, 2016) that involves identifying uncertainties and building plausible future paths. Scenario methodology allows for questioning the prevailing mindset to consider shifting away from status quo positions and policies (Schoemaker, 1991). In our study we use the Oxford Scenario Planning Approach (OSPA) methodology (Ramirez & Wilkinson, 2016), which has been applied to an examination of the future of global shipping (Wärtsilä, 2010) and the future role of the European Patent Office (Elahi & Ramirez, 2016). The OSPA procedures focus on understanding conceivable rather than probable scenarios. Unlike probabilistic (making percentage predictions or best-case/worst-case scenarios) or normative (imagining a future) approach, Oxford scenario planning is based on plausibility. The goal is to generate new knowledge and insights iteratively and interactively, because assigning probability to probable situations is impossible in turbulent and uncertain environments. The Oxford scenario planning approach focuses on identifying and designing scenarios that the group considers realistic, challenging, and beneficial. Each scenario tells a story about a probable shift in the wider context within which the change is happening.

The scenarios were built as part of the cooperation of the Arctic 2050 initiative, between Nord University and Skolkovo Moscow School of Management, studying possible futures of the Arctic Development until 2050. The team leading the project consisted of diverse Arctic experts that identified the scope of the research. Figure 1 summarizes stages of the scenario building process, consisting of four blocks (identifying development drivers, identifying critical uncertainties, building scenarios and discussing their implications).

Figure 1. Scenario process



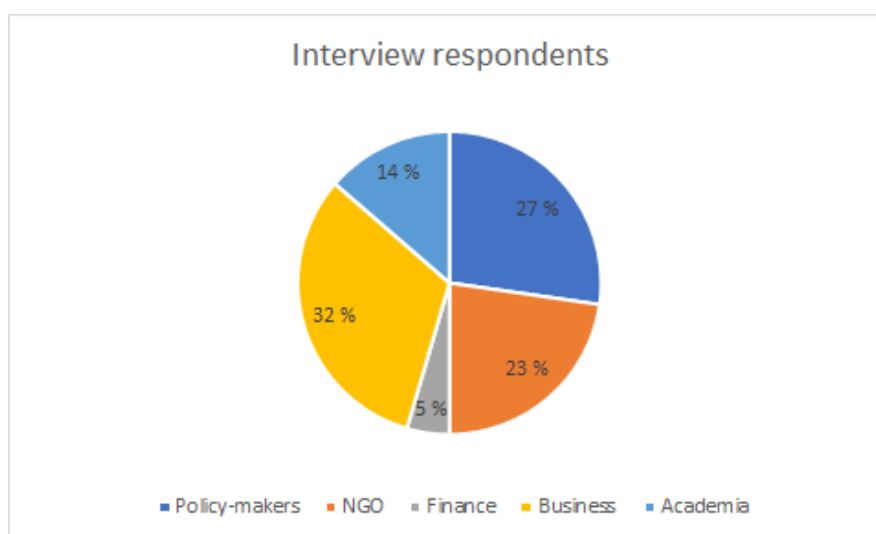
The Arctic 2050 Scenario planning process began with the identification of Arctic development drivers. Researchers working on methodology, data collection, analysis and scenario building were from Nord University, Skolkovo Moscow School of Management and the University of Oulu. The core research team established ongoing meetings between active participants. Additionally, there were several meetings with a larger group of participants and stakeholders, including EY and the World Energy Council, that contributed their unique expertise in scenario building. The large group meetings included members of the small group as well as senior-level staff to assist at critical decision points, such as ranking development drivers and identifying the most significant uncertainties affecting the scenario matrix design.

Mutual understanding is a primary goal of scenario planning, so as part of refining scenarios we included a multi-stakeholder process. As a result, stakeholders retained both their voice and their anonymity throughout. We also ensured that the data collection process was secure. Interview participants felt comfortable sharing their views since no direct and attributable quotations were ever used. Generalized data from the interviews were used for prioritizing uncertainties.

Data

Data for the scenario building process included published data from the previous Arctic scenario building studies reviewed. Furthermore, the data were collected via 22 interviews with a diverse base of Arctic stakeholders including NGOs, financial institutions, business, non-Arctic actors, academia, Indigenous peoples, government representatives and the media (see breakdown of interview respondents in Figure 2).

Figure 2. Interview respondents by stakeholder type.



We used an open-ended questionnaire that included questions on the Arctic's historic development and the most important indicators of change on the Arctic agenda currently. For the future, questions also concerned Arctic-related technological innovations, key stakeholders and uncertainties for Arctic development.

Identifying and mapping development drivers

In choosing development drivers, we used both previous scenario studies and data gathered through interviews. Altogether, seven drivers were identified: the climate crisis, social development, demographic changes, the economic value of the Arctic region, technologies and innovations, the institutional landscape and the enabling environment

Pace of climate change

The climate crisis is reflected in the increased pace of change in the Arctic. Warming is occurring three times faster than anywhere else in the world (AMAP, 2021). Its effects are being felt locally, with the melting of ice and permafrost, and throughout the world with global warming. Researchers previously predicted that the Arctic Ocean could be completely ice free by the year 2100, but more recent estimates suggest that might happen in 20 to 30 years' time (Guarino et al., 2019). *Key factors to watch:* rising sea levels, melting ice and permafrost, infrastructure degradation, transformation of the natural environment, physical accessibility of resources and routes.

Social development

Social development is connected to the Arctic region's overall economic well-being. It will depend on future solutions that enable Arctic people to break free from the "Arctic paradox", in which local and Indigenous people are left behind because of their lack of benefits from economic development (Nymand Larsen et al., 2013). While GDP per capita is at a high level in the Arctic, disposable income per capita is significantly lower and poverty rates are far higher than national averages. Projections indicate that, at most, a 1% population increase will take place in the Arctic until 2055 (Heleniak, 2020). However, significant regional differences are expected to persist, with some experiencing positive, and others negative, trends. There will be more urbanization and multiculturalism in the Arctic in the future. Arctic cities are at risk from climate change, and need to adopt climate change adaptation policies. The Arctic is becoming more multicultural, so cities will need policies that integrate Indigenous, local and migrant populations. *Key factors to watch:* population dynamic and outmigration, changing labor migration pattern, Indigenous peoples urbanization, increasing social disparities ("Arctic paradox").

Economic development

Although the Arctic is remote, it is a crucial part of the global economy. Arctic regions with only 0.1% of the world population produced 0.5% of global GDP (ECONOR, 2015). Over 70% of the Arctic economy was attributable to the Russian Gross Regional Product (GPR). Currently, the Arctic economy is dominated by industrial activities such as fishing, mining and quarrying, manufacturing, electricity, gas, heat and air-conditioning distribution, water distribution, sewage, waste management and remediation, and construction. The second-largest sector comprises public sector activities (which include public administration and defence, education, human health, social work, and so on) and services, which include wholesale and retail. (Nordregio, 2019). *Key factors to*

watch: level of knowledge generation, intensifying race for Arctic resources, pace of economic diversification, and freight traffic activities.

Pace of technological development and innovation

Several facets of *technology and innovation development* particularly relate to the Arctic: transportation technologies and infrastructure, connectivity, space technologies, renewable energy, and climate-resistant technologies. However, the level of innovation and R&D, and the integration of innovations with Indigenous knowledge varies across the Arctic and will require investment in the future. *Key factors to watch*: pace of digitization and connectivity of Arctic, energy transition in Arctic, commercialization of sustainable shipping technologies, advancement in extraction technologies, and the cost of doing business in Arctic.

Governance of geopolitics and international consensus

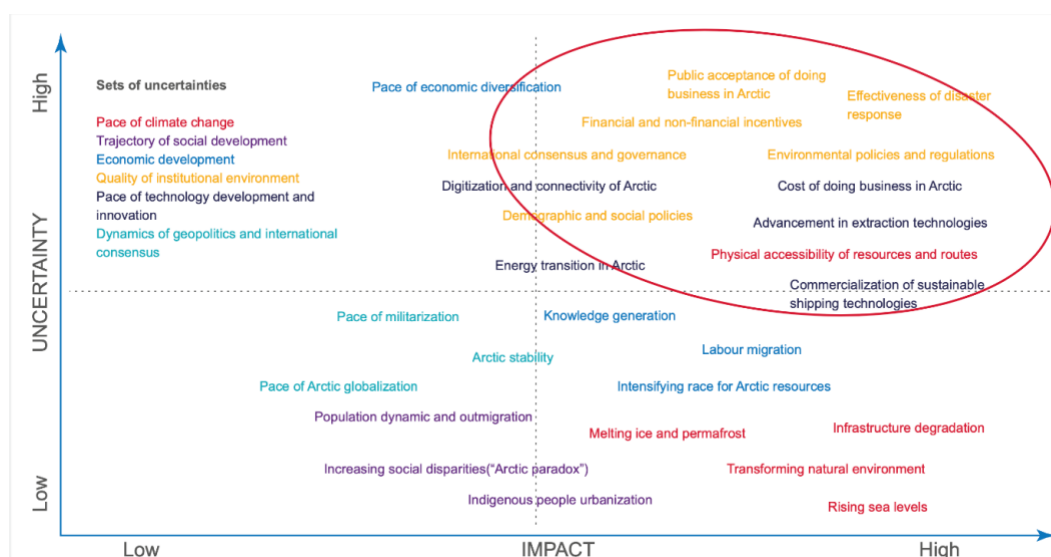
For decades, the geopolitical situation in the Arctic region was characterized by a degree of stability and peace due to a common interest in economic growth and a drop in military tensions following the Cold War. *Key factors to watch*: Arctic stability, pace of militarization, and the pace of Arctic globalization.

Quality of institutional environment

The *institutionalization of Arctic cooperation* was marked by the formation of the Arctic Council (AC) in 1996 with a focus on climate change, the environment, and sustainable development. Associated with this was the Arctic Economic Council (AEC) which was formed to encourage sustainable business development. While the Arctic remains one of the world's most stable regions, the revival of great power competition has affected the geopolitical environment. With the increased pace of change in the Arctic, the limits of the cooperation through the AC and AEC are highlighted by the need to create "the rules of the game" to provide standards for sustainable business development in the Arctic, transport, R&D and other economic activities. *Key factors to watch*: environmental policies and regulations, effectiveness of disaster response, demographic and social policies, financial and non-financial incentives, public acceptance of business in the Arctic, international consensus and governance. Any initiatives for the development of the Arctic, including shipping, require paying special attention to public acceptance, both in the Arctic itself and in the world as a whole. Public opinion is becoming a key factor in the development of the regulatory framework, as well in as corporate strategies and the policies of local administrations.

Next, we mapped all key factors by the uncertainty and impact (see Figure 3). The Impact/Uncertainty Grid is a two-dimensional matrix with an x-axis for uncertainty and a y-axis for potential impact (on future performance). Critical uncertainties are those that will have a significant impact on the future development of the Arctic. They are marked on Graph 2 by an ellipse. For mapping, we used data collected during interviews with different stakeholders. We developed a special interview protocol to reveal key developments factors for the region and their uncertain pace and impact using the Oxford Scenario Planning Approach (OSPA) methodology (Ramirez & Wilkinson, 2016).

Figure 3 Mapping Arctic development drivers (Source: Belostotskaya et al. (2021:44))



Identifying critical uncertainties

A critical step in the scenario planning process was to identify the two or three drivers with the greatest impact and uncertainty on the Arctic's likely future development from among the critically-ranked factors. After many meetings and rounds of deliberation with stakeholders and interview respondents, a consensus was reached on the two most significant and uncertain scenario drivers.

Based on a two-by-two impact vs. uncertainty matrix (see Figure 3) two uncertainties stood out as having the greatest magnitude and impact. Table 1 presents these two: (1) the quality of the institutional environment pertaining to the Arctic; and (2) the rate of technological development and innovation. The quality of the institutional environment will be critical in defining economic and social development and determining the effectiveness of mitigation and adaptation measures in the face of accelerating climate change. The rate of technological development and innovation will be critical in achieving economic intensification while remaining environmentally sustainable and socially just.

Table 1 Critical uncertainties (Source: Arctic 2050 report (2020). (Source: Belostotskaya et al. (2021:44))

UNCERTAINTY	DIMENSIONS
Quality of institutional environment	<ul style="list-style-type: none"> • Disaster response – effective vs non-effective • Environmental policies and regulations – effective vs non-effective • Demographic and social policies – effective vs non-effective • Financial and non-financial incentives – sufficient vs non-sufficient • International consensus and governance – strong vs weak • Public acceptance of doing business in Arctic – high vs low
Pace of technology development and innovations	<ul style="list-style-type: none"> • Digitization and connectivity of Arctic – strong vs weak • Energy transition in Arctic – fast vs slow • Advancement in extraction technologies – high vs low • Cost of doing business in Arctic – high vs low • Commercialization of sustainable shipping technologies – high vs low

Quality of institutional environment

The Arctic region requires a comprehensive and coordinated enabling environment – a suite of laws, regulations, policies, international trade agreements, and other elements of soft infrastructure, such as public awareness and acceptance – that will facilitate progressive but sustainable development in the Arctic region. However, looking ahead to 2050, it is unclear how adequate and balanced these institutions will be. Will stakeholders agree?

Will a collaborative Arctic investment platform be established? What if one of the most powerful Arctic states were to abandon economic activity in the Arctic due to environmental and social concerns? What if, over the next 30 years, Russia, for example, ceased exploitative activities in the Arctic? Environmental policies and regulations, disaster response effectiveness, demographic and social policies, financial and non-financial incentives, public acceptance of business in the Arctic, international consensus and governance are all critical factors to monitor.

Pace of technology development and innovation

In the Arctic, extreme weather conditions necessitate the development of specialized technologies for each industry and sector. Social and environmental considerations place additional demands on new technologies. Those required for Arctic development will need significant funding, political will, and acceptance of entrepreneurial risk to implement.

Will innovation in the Arctic catalyze economic development? Or will innovation be stagnant, impeding progress? The pace of digitization and connectivity, the energy transition, the commercialization of sustainable shipping technologies, the advancement of extraction technologies, and the cost of doing business in the Arctic are all critical factors to monitor.

Apart from the two critical uncertainties, the *dynamics of geopolitics and international consensus have been raised by the experts as an important factor*. Arctic stability is defined by shifting geopolitics, which will remain a critical uncertainty in the region's development. Geopolitical intensification, fueled by the Arctic states' national interests as well as those of non-regional actors, has the potential to transform current models of cooperation. It is unknown whether the quality of consensus will

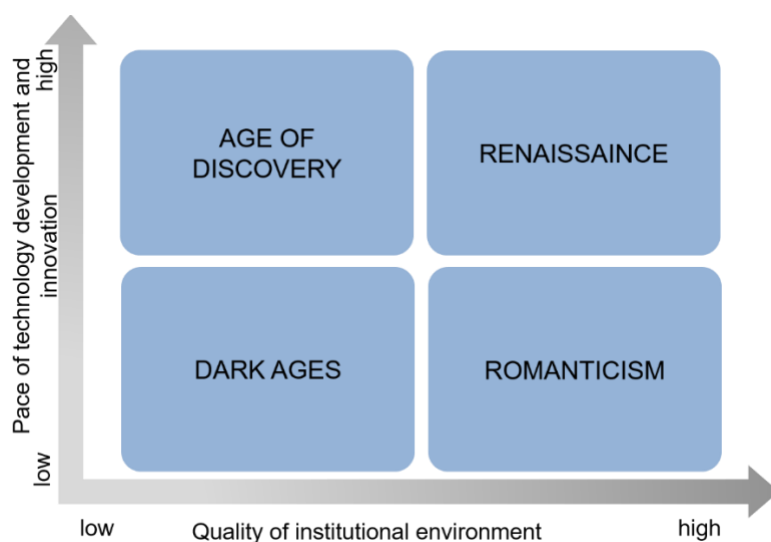
improve or deteriorate, and how this will affect the regional landscape in terms of political cooperation and economic development. What will be the nature of international cooperation in the Arctic? Will geopolitical competition make economic development and trade in the Arctic easier or more difficult? Will stakeholder tensions over resource capture result in (hybrid) armed conflict? The Arctic's stability, rate of militarization, and the pace of globalization are all critical factors to monitor.

Results and discussion

Based on these critical uncertainties influencing how the Arctic region could evolve up to 2050, four scenarios were constructed. Each one reflects the strength or weakness of the quality of the institutional environment, and the pace of technological development and innovation (see Figure 4).

Figure 4 illustrates the scenarios followed by details of how the region might evolve to 2050. From multiple futures that can be created in an interplay of critical uncertainties, we selected four mutually exclusive and collectively exhaustive (MECE) scenarios (Minto, 1985, Chevallier, 2016) to explore. These plausible futures help create a safe space for strategic leadership dialogue and could drive joint action. The Oxford Scenario Planning Approach is particularly suitable for building scenarios during periods of turbulence, unpredictability, innovation and ambiguity.

Figure 4. Scenario matrix



Dark ages

The slow pace of change and the lack of coordinated national and international structures and governance, plus the absence of new technological development and deployment, all combine to halt the development of the Arctic. For a decade, the Arctic region remains stagnant, before rapidly deteriorating. In the Dark Ages scenario, the only driver of economic growth is exploitation of natural resources. This is conducted irresponsibly, which in turn has severe climatic consequences and results in the overall degradation of the Arctic ecosystem, making it uninhabitable.

The Arctic becomes depopulated and devastated by the merciless exploitation of the environment. National states and corporations, whether state- or privately-owned, continue to dominate the Arctic economy.

In this scenario, the GDP grows for about 10-15 years (until 2030-2035), driven by accelerated exploitation of natural resources. Then it declines sharply so that by 2050 it is half of what it was in 2020. The reason is that the environmental degradation in the Arctic makes it impossible to continue exploitation projects. They are therefore abandoned, which not only slows GDP growth, but ultimately halts the Arctic economy. The extractive sectors prevail, avoiding diversification and new market development opportunities. That reduces global Arctic GDP by half from its current volume to near \$220 billion. Economic activity and rapid climate change continue to harm the natural ecosystem. Melting permafrost causes natural and technological disasters, destroying biodiversity and Indigenous peoples' traditional ways of life. These people either integrate or migrate. By 2050, the population will have decreased by 60%. Most of those remaining will be shift workers from the world's southern areas. In this scenario all dimensions of sustainability (social, environmental and economic) perform badly.

The Age of Discovery

Competition for the Arctic's resources, fueled by state-funded innovation, results in exploration of the Arctic's riches, boosting the economy and attracting opportunity seekers to the region. Both environmental regulation and disaster response are fragmented and inadequate, failing to halt the deterioration of the ecosystem. Indigenous people's natural habitats and livelihoods deteriorate as the climate crisis intensifies. In the Age of Discovery scenario, we are mostly referring to the disproportionate prioritization of economic dimension over the environmental and, especially, the social ones in the Triple Bottom Line concept.

The Arctic states are unable to agree on how to protect the region, which has developed into a global battleground for superpowers. Global competition is perpetually on the verge of escalating into confrontation. The region's increasing militarization is a new reality. Without effective governance and without platforms for dialogue, the situation becomes increasingly precarious. Some have referred to the Arctic as the 'new Middle East', meaning that any spark could cause an explosion.

The race for Arctic dominance motivates governments to invest in research and development. Rapid technological advancement and the increasing availability of diverse, innovative solutions improve access to Arctic resources and thus create new business opportunities. This boost to innovation drives modern economic activity. In 2050 the Arctic is becoming increasingly profitable and appealing to private investors. Massive government guarantees insure against all risks. While the Arctic economy remains largely resource-based, it has become as hi-tech and digitally loaded as possible. Economic considerations take precedence over environmental concerns, with the result that extractive practices continue to be detrimental to the Arctic ecosystem. Natural disasters occur more frequently, but the ongoing global climate crisis compels regional actors to consider whether they cause the Arctic's deterioration or whether the Arctic is merely one component of a much more general deterioration.

Arctic society is fragmented to the extent that urban communities and job seekers prosper, while Indigenous peoples suffer. Social and environmental organizations continue to raise concerns on global platforms, but their voices are ignored. Greenwashing and "bribing" the local people to keep silent in exchange for short-term economic gains are tactics which are tacitly accepted by the region's major actors. Bribery implies the irresponsible short-term practice of giving back in an unsustainable way, like offering financial or other material support for the local communities

without making sure that these have a positive long-term impact. Hence business practices in the Arctic are not ESG¹ compliant and businesses do not have a proper engagement with the local population.

Global public acceptance of Arctic exploitation is at an all-time low, and many consumer and financial brands not only avoid doing business with companies engaged in Arctic-related activities but also support a growing global consumer/citizen activist movement. The emphasis on the economic dimension means that ESG practices are ignored, which eventually leads to the shrinking of the companies' access to markets and capital. Specifically, we are talking about the most 'reputation obsessed' category, consumer brands, which reacts first to any interruption in the supply chain. In this scenario, the economic dimension is emphasized at the expense of the social and environmental ones.

Romanticism

The Arctic becomes a showcase for all things beneficial to the ecosystem – only sustainable energy and transportation, no mining or extraction, and the reintroduction of natural processes. Money is withdrawn from the Arctic. What was once a global magnet for business has developed into something akin to a film set for the *National Geographic*.

The Paris Agreement, followed by the New Green Deal, established a strong precedent for prioritizing long-term environmental benefits over immediate economic gains. Global agreement on preserving the Arctic's unique ecosystem has resulted in the development of what are possibly the world's strictest environmental regulatory framework and enforcement mechanisms. Social and environmental non-governmental organizations collaborate with academia to advance our understanding of the Arctic ecosystem and to develop guidelines for all human activity in the region. Climate change is being closely monitored to mitigate potential risks to the natural environment. The Arctic Council has developed into one of the most powerful supranational organizations in the region, with full legislative and regulatory authority.

In the Arctic, economic activity has been restricted to sustainable fishing and herding, Indigenous crafts, and sustainable tourism. Indigenous peoples keep their traditional ways of life and receive government assistance. All extraction activity has ceased, and Arctic GDP has fallen by 80 per cent from its 2020 level to around \$88 billion. The primary driver of innovation has been the tightening of sustainability standards. This has been heavily subsidized by governments and international development agencies. The Northern Sea Route is operated exclusively by green fuel-powered vessels. Local energy needs are met entirely through CO₂-free technologies.

Global public support is strong, as other countries regard the Arctic as the world's largest national park. While it benefits the natural environment and Indigenous peoples, the Arctic cities have been abandoned, and local infrastructure has deteriorated. Because no major companies operate in the Arctic anymore, all social and infrastructure responsibilities have been transferred to governments, which are struggling to justify ever-increasing expenditure. Economic stagnation and deteriorating living standards have accelerated the outmigration of professionals and the urban population. Apart from scientists and environmentalists who work in shifts, the region attracts no talent. The Indigenous peoples' natural decline has slowed but not ceased so that, by 2050, the Arctic population is less than 20% of what it was in 2020. In this scenario, the environmental dimension of sustainability displaces the social and economic ones.

Renaissance

Nations agree to make Arctic exploration a symbol of international cooperation and humanity's eternal striving for progress and invention. Many governments agree on standards for doing business in the Arctic, hoping to encourage the use of the most up-to-date and innovative technologies.

Arctic business development has been enabled by a worldwide consensus on the importance of economic prosperity and environmental sustainability. Previously inaccessible Arctic resources have now become both physically and institutionally available. As one element of a business development strategy, governments help businesses make long-term investments in R&D to produce an Arctic technological platform that is unique, like the Arctic ecosystem. Due to advances in technology and new industry creation, businesses have established advanced extraction and construction techniques, sustainable energy, shipping and digital technologies, and other new industries in the Arctic. These advances reinforce economic growth and allow businesses to mitigate many of the impacts of climate change. The Arctic is becoming an example of economic growth with a decreasing environmental footprint.

Even the Arctic cannot escape global warming, but some measures have helped slow this process down, giving habitats time to adapt to the new circumstances. Using a framework of regulations, behavioral changes, and cutting-edge technologies, the environment has been restored. Increases in public acceptance of economic activity in the Arctic have been observed. As demand for creative and innovative products increases in the Arctic, people move there to meet these needs. Sustainable construction, energy, transport and community areas all contribute to Arctic cities' growing prosperity. People throughout the area not only preserve their traditional ways of life and native languages, they also take part in civic life and decision-making processes. In this scenario, all social, economic and environmental dimensions of sustainability perform equally well.

These four scenarios share similarities with previous work. For instance, the Dark Ages shares the most pessimistic Arctic futures as in *Polar Lows* (AMSA 2009) and in *Exploited Colony* by Haavisto et al. (2016). What sets our scenarios apart from previous ones is the consideration of the social, economic and environmental dimensions of sustainable development and our focus on the institutional environment and on technology and innovation. In the most favourable scenario *Renaissance*, all social, economic and environmental aspects are equally important and supported by a strong institutional environment with agreed standards for doing business in the Arctic in the most responsible manner. Moreover, sustainable development in *Renaissance* relies on technologies and innovations targeted to specific Arctic needs.

Conclusions

Simulations of the global Arctic predict what will happen by mid-century. The Arctic will be much different, Arctic ecosystems will be hard to recognise, with less snow and sea ice, greater warming, more vegetation, and an average temperature increase of 4 °C. Future Arctic changes could have even more far-reaching impacts elsewhere through the release of greenhouse gases from the tundra and changes in both oceanic and atmospheric circulation (Overland et al., 2019).

While scientists have clear projections of the impacts of climate change in the Arctic, the future for economic and social development is less certain. In this work, we present four scenarios of Arctic development until 2050 that are built on assessments of how uncertainties such as the quality

of the institutional environment and the pace of technology and innovation might to play out. Our study takes into consideration changing geopolitics, turbulence, unpredictability, innovation and ambiguity in the future of Arctic development. The study contributes to a plethora of future studies on the Arctic (Arbo et al., 2012; ASMA, 2009; Brigham, 2007) by using the Oxford Scenario Approach and focusing on three pillars of sustainability (economic, environmental and social). Our scenarios are not predictions; rather, they are tools for imagining the future and detecting key turning points, emerging opportunities, and potential threats.

Scenarios developed as part of the Arctic 2050 initiative provide a starting point for discussion. While it is important to develop scenarios in a participatory manner, including Arctic stakeholders, it is equally important to engage in dialogue with policymakers, NGOs, and the local Arctic population in the post-scenario development period if we are to create realistic awareness and facilitate the design of the currently missing elements that will be needed for sustainable Arctic development.

Notes

1. Sustainable finance refers to the process of taking environmental, social and governance (ESG) considerations into account when making investment decisions in the financial sector, leading to more long-term investments in sustainable economic activities and projects. (Source: European Commission)

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