

Working paper

Regional scenarios of the Arctic futures:

A review

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Abstract

The future of the Arctic region is a subject of heated debates in both scientific and policy circles. The region has an enormous economic potential as a storehouse of mineral resources and as a provider of shorter and more cost-effective transportation between Europe and Asia. The Arctic is therefore an essential strategic element of the domestic and foreign policies of all Arctic states. In addition, there is an increasing economic interest in the region on the part of non-Arctic states. However, at present, the future of the Arctic region development remains highly uncertain. Scenario building is a suitable methodology to imagine alternative plausible futures of such a complex and multi-dimensional process and to elaborate successful and robust development strategies. This paper provides an overview of the scenario frameworks of Arctic futures presented in the literature and analyses key factors that determine these scenarios. Overall, we find a growing interest of the international foresight research community in the Arctic region that is evident from a number of thorough scenario-building exercises published recently. At the same time, we observe two drawbacks. First, the existing studies lack a numerical element, that is, the overwhelming majority of the scenario frameworks that can be found in the literature are fully qualitative. Quantitative estimates would strengthen the scenario narratives and enrich communication, which make them a useful addition to support a qualitative scenario framework. Second, the existing studies use a mixture of both internal and external factors to describe the underlying uncertainty. This limits the number of factors that can be taken into consideration and may be confusing for a potential user of these scenario frameworks due to the lack of a systemic view. Such a confusion can happen, for example, if some of the external factors underpinning a particular scenario suddenly develop in a direction that was not anticipated within the scenario framework. The effect of such a change on the set of scenarios and the validity of the scenarios despite this change will be of interest to the user, and a clear systems perspective would be conducive to address these questions. Separating internal and external factors in a scenario building exercise is particularly useful given that the volatility of the global geopolitical, geoeconomic and environmental dynamics is only increasing. It is our intention to address these two drawbacks in a scenario building exercise within the [“Emerging trade routes between Europe and Asia” scenario-building project](#) led by IIASA within the Northern Dimension Institute (NDI) Think Tank Action co-funded by the European Union and coordinated by Aalto University, Finland.

Introduction

Scenarios have been widely used by decision makers in business, industry, and government for over 50 years as an unequalled method to study the future before it happens (Ratcliffe, 2000). The idea of a scenario building exercise is to think about different futures to “minimize surprises” and “broaden the span ... of ... possibilities” (Mietzner & Reger, 2005).

The Arctic as an emerging region of geopolitical, geoeconomic and geocological interest (Federal Ministry, n.d.) brings about not only opportunities, but also risks. Stakes are high, and to deal with inherent uncertainties concerning the development of the Arctic in the future one has to work out multiple development options to be able to create a robust portfolio. Exploratory scenarios is a suitable methodology to describe delineate future uncertainties (Maier et al., 2016; Höjer et al., 2008).

Motivated by this reasoning, the “Emerging trade routes between Europe and Asia” project aims to bring into a dialogue representatives of academia, policy community, business, and civil society in order to look into plausible long-term futures of shipping in the Arctic. We focus on shipping as a promising economic activity that can develop vigorously as a consequence of climate change and ice melting (Ng et al., 2018; Smith & Stephenson, 2013; Ho, 2010). The aim of this project is to co-create several plausible scenarios of how commercial shipping can develop in the Arctic given the uncertainty in the global demands, other major transportation routes, climate change and technological development.

To position the to-be-developed scenarios in the context of the state-of-the-art literature and to concretize a knowledge gap to fill in, this paper undertakes the task to review scenario frameworks of Arctic futures published in the literature. In addition, to inform our scenario building process, we analyse the key factors of the Arctic futures scenarios from the literature.

Review of Arctic futures scenario frameworks

One of the first scenario frameworks for the Arctic was produced by Brigham (2007) who suggested four scenarios over the 2040 horizon. Overall, he expects this once-remote area to rise to a globally important region. Catalysts for this change include a rapid climate change and an increasing natural-resource extraction activity. Further key factors cover the transportation systems, indigenous Arctic people, governance in the Arctic and geopolitical issues. Based on these, the study proposes four scenarios: *Globalized Frontier* in which the Arctic is an integral part of the global economy, *Adaptive Frontier* in which globalization in the Arctic is slower than expected, *Fortress Frontier* in which international tension and resource exploitation in the Arctic increase, and *Equitable Frontier* in which the Arctic develops sustainably as an integral part of the global economy. See Table 1 for the summary of these four scenarios.

Table 1: Four scenarios for the Arctic by 2040 (Brigham, 2007)

	Globalized Frontier	Adaptive Frontier	Fortress Frontier	Equitable Frontier
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Transportation	Earlier and longer navigation seasons throughout Arctic Ocean increase commercial shipping. New polar air routes dramatically increase cargo and passenger loads.	Air and marine transportation have greatly expanded but under stricter international regulation for environmental protection and safety.	Marine and air access through the Arctic is tightly controlled and periodically suspended for foreign ships and aircraft, partly in retaliation against other non-Arctic states' actions elsewhere in the world. Cargo movement is disrupted.	Transportation is a key Arctic industry, and a fivefold increase in regional marine commerce offsets a modest reduction in air freight on polar routes. Stringent regulation emphasizes environmental protection of key routes.
Resource Development	Rising prices globally for commodities increase exploitation of Arctic resources such as nickel, copper, coal, and freshwater, as well as oil and gas. Overfishing is serious problem.	"Assault" on Arctic resources has not materialized, constrained by international agreements such as strict harvesting quotas for fisheries. Sustainable development is widely embraced by most stakeholders.	Arctic states "jealously" guard natural resources to prevent uncontrolled access by global community; e.g., fishing rights to all but the Arctic states have been suspended.	Sustainable practices benefit fishing, forestry, and reindeer herding, while oil production plummets. Clean freshwater from the Arctic has become a valuable global commodity.
Well-Being of Indigenous Population	While global warming has caused some coastal communities to wash away, commercial opportunities brighten prospects for Arctic indigenous workers, reversing exodus of Arctic workers following the collapse of the Soviet Union.	Indigenous organizations have a greater say in environmental and economic development decision making. Flourishing year-round tourism industry expands opportunities.	Many indigenous peoples are displaced from their traditional homelands due to extreme environmental events. Though economically improved, life is unstable as illegal immigration becomes a major problem.	Poverty among indigenous peoples has been reduced due to revenue sharing from industries such as tourism, transportation, and minerals extraction.
Regional Environmental Protection	Increased industrial activity puts the Arctic region as a whole at greater risk for major environmental catastrophe, such as spills and leaks from aging oil and gas pipelines. Ice damage to ships reawakens public interest in marine environmental protection.	Environmental protection as an imperative is widely held among all stakeholders, and emergency planning is proactive. The Arctic region has become a model for habitat protection.	Sustainable development has largely disappeared as economic and security concerns take precedence.	New areas are added to existing Arctic national parks, enhancing both the environment and the tourism industry.
Regional Governance and Cooperation	Economic interests related to industrialization have become more compelling – and contentious – and have put environmental issues on the back burner for the Arctic Council.	Private-public sponsorship aims to protect unique natural resources and to balance economic and environmental needs.	The Arctic Council remains strong but focused on making the region more independent and exclusionary – a position largely unchallenged by the global community due to the Arctic's collective economic and military strength.	The Arctic Council promotes a vision of social equity and environmental well-being; military presence is low, yet security is high because tensions among the Arctic states are virtually nonexistent.

The Arctic Marine Shipping Assessment Report (AMSA) by the Arctic Council (2009) can be regarded as a coryphaeus among Arctic studies. More than 185 experts participated directly in the work underpinning the AMSA. Thirteen major AMSA workshops were held from July 2006

through October 2008 covering a broad range of relevant topics, including the future navigation, marine use by indigenous communities, marine incidents (including sinkings, groundings, pollution and other environmental violations, disabling by collision, fire and loss of propulsion), environmental impacts, marine infrastructure (including ice navigation training, navigational charts, communications systems, port services, reception facilities for ship-generated waste, accurate and timely ice information, places of refuge, icebreakers), shipping technologies and systems, as well as the future of the Northern Sea Route and the adjacent seas. Scenario workshops identified total 120 factors and forces that could shape the future of the Arctic marine activity by 2050, including the global trade dynamics and the world trade patterns, the severity of climate change, the global oil price, the marine insurance industry, the legal stability and governance of marine use in the Arctic Ocean, safety of other global trade routes (notably, the Suez Canal and Panama Canal), agreements on the Arctic ship construction rules and global operational standards (International Maritime Organization), shipping disasters in the Arctic, limited windows of operation for Arctic shipping (the economics of seasonal versus year-round Arctic operations), the emergence of China, Japan and Korea as Arctic maritime nations, transit fees, conflicts between indigenous and commercial uses of Arctic waterways, new resource discoveries, escalation of Arctic maritime disputes, global shift to nuclear energy, socio-economic impacts of global weather changes etc. Three issues were identified as playing a key role in the development of the Arctic: the ongoing globalization of the Arctic through the development of the natural resource extraction and resulting destination marine traffic, the arrival of the global maritime industry in the Arctic Ocean, and the lack of international policies in the form of maritime governance to respond to this arrival.

As a result, four plausible scenarios of the Arctic marine navigation until 2050 were put forward. In the *Arctic Race* scenario, a rapid market development characterized by high commodity prices, high demand for Arctic natural resources, and active marine tourism are combined with a lack of an integrated set of maritime rules and regulations, and insufficient infrastructure to support such a high level of marine activity. In the *Polar Lows* scenario, a low demand for natural resources and minimal marine traffic in the Arctic Ocean are combined with the unstable governance, weak and undeveloped regulations and standards. Scenario *Polar Preserve* assumes a low demand for natural resources, Arctic oil and gas, while the governance systems regulating the marine use respect the environmental concerns focusing on a systemic preservation of the Arctic. Scenario *Arctic Saga* assumes a high demand for natural resources and high trade levels combined with the stable governance of marine use, shared economic and political interests of the Arctic states and improved marine infrastructure; concern for the preservation of Arctic ecosystems and cultures implies systematic and safe development of oil, gas and hard minerals. Table 2 summarizes these four scenarios.

Table 2: Four futures for Arctic marine navigation by 2050 (Arctic Council, 2009)

	Arctic Race	Polar Lows	Polar Preserve	Arctic Saga
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Framing uncertainties	More Demand for Resources and Trade Less Stable Governance	Less Demand for Resources and Trade Less Stable Governance	Less Demand for Resources and Trade More Stable Governance	More Demand for Resources and Trade More Stable Governance
High concept	High demand and unstable governance set the stage for an economic rush for Arctic wealth and resources. This is a world in which many international players anxiously move to outwit competitors and secure tomorrow's resources today. Intense interest in Arctic natural resources.	Low demand and unstable governance bring a murky and underdeveloped future for the Arctic. This is a world in which domestic disturbances divert attention from global issues, and simmering frictions cause prolonged divisiveness. Global financial tensions are prevalent.	Low demand and stable governance slow Arctic development while introducing an extensive eco-preserve with stringent "no-shipping zones." This is a world where concern about the environment, coupled with geopolitical and economic interests elsewhere, drives a movement toward a systematic preservation of the Arctic Ocean.	High demand and stable governance lead to a healthy rate of development that includes concern for the preservation of Arctic ecosystems and cultures. This is a world largely driven by business pragmatism that balances global collaboration and compromise with successful development of the resources of the Arctic.
Primary drivers of change	<ul style="list-style-type: none"> • Global competition among many nations for future rights to resources intensified by rise of Asia; new oil and gas discoveries; • Acute demand for water worldwide; continuing Middle East tensions; • Climate warms faster than models predicted; tourism expands. 	<ul style="list-style-type: none"> • Global economic downturn and increasing national protectionism; • Increased domestic troubles worldwide, including regional outbreaks of new-generation Avian flu; • Recession of Arctic ice slower than models projected. 	<ul style="list-style-type: none"> • Arctic oil and gas reserves disappointing; • Alternative energy emerges as viable source for global growth; • Public concern about climate change and conservation, especially impacts to the Arctic. 	<ul style="list-style-type: none"> • Expanded global economic prosperity; • Systematic development of oil, gas and hard mineral resources; • Shared economic and political interests of Arctic states; • Climate warms as expected.
Implications for Arctic Marine Navigation	<ul style="list-style-type: none"> • Much activity dominated by destination traffic supporting resource development; • Unilateral governance regimes lead to inconsistent infrastructure with incompatible standards; • Seasonal trans-Arctic passage possible, but not economical. 	<ul style="list-style-type: none"> • Minimal Arctic marine traffic, consisting of government re-supply and research, with periodic disruptions; • Market for ice-class ships cools, reducing R&D and shipbuilding; • Low attention to regulations, with unenforced and mismatched standards, and no new infrastructure. 	<ul style="list-style-type: none"> • Harmonized rules for Arctic ship design and mariner training; • Seasonal trans-Arctic shipping possible but proves prohibitively expensive due to environmental restrictions, frequent patrols and aggressive enforcement; • Growth of Arctic marine tourism allowed through limited numbers of "use permits". 	<ul style="list-style-type: none"> • Wide range and variety of marine activity; • Navigational infrastructure and aids expanded, making marine transport safer and more efficient; • Comprehensive international Arctic ship rules; • New technologies make seasonal trans-Arctic shipping a possibility.

Arbo et al. (2013) conducted an extensive literature review that summarized the insights of more than 50 future-oriented Arctic studies. Their paper did not develop own scenarios, but systematically analysed the factors that are key for the Arctic future, which makes it relevant to our review. Arbo et al. found that climate change and its social impacts, the demand for Arctic resources, economic activities, politics, governance, security, and geopolitical circumstances

are major factors for the Arctic development. All the reviewed studies expect the Arctic as well as the politics and other activities around the region to develop into a very different state in the future than it is now.

Arbo et al. distinguished two scenario focuses. The first one is around climate change and the receding sea ice cover which allow for expanding economic activity in the Arctic. The most frequently mentioned driving forces are population growth, globalization, demand for natural resources, technology development, regulatory frameworks, and the search for new shipping lanes. The second focus is around politics, governance, and security. Driving forces here include the end of the Cold war, economic and political interests of the Arctic states and other global players, the United Nations Convention on Law of the Sea, and disputed boundaries.

All in all, according to this study, the Arctic is expected to become a region of a greater economic and political importance in the future. Maritime activities are expected to grow as the ice is melting. The region is anticipated to exploit its great resource potential through an increase in oil and gas development, shipping, and other commercial activities – although their scale and content are uncertain. Challenges include drifting ice, scattered population, distance to the main markets, high costs of infrastructure and transportation, lack of trustable assessments of oil and gas production, mining, fisheries and tourism, and limited and highly uncertain quantitative estimates of the container trade between Asia and Europe.

A report by Haavisto et. al (2016) presents six socio-economic scenarios for the Eurasian Arctic by 2040, which focus on the development of shipping, resource extraction and tourism industries: *Wild West*, *Silicon Valley*, *Exploited Colony*, *Shangri La*, *Conflict Zone* and *Antarctic*. Each scenario is a result of a particular combination of binary states of three dimensions: possible future political and economic development (open – closed), initiating force of the development of the Arctic (public – private) and the environmental status of the Arctic region (dirty – clean), which describe the political, economic, social, technological, and environmental aspects of different alternative futures. Table 3 summarizes the six scenarios.

Table 3: Six socio-economic scenarios for the Eurasian Arctic by 2040 (Haavisto et. al, 2016)

Private – Open – Dirty: Wild West	Private – Open – Clean: Silicon Valley	Public – Open – Dirty: Exploited Colony
<ul style="list-style-type: none"> The Arctic area in 2040 is described by a laissez-faire economic development driven by the private sector and economic development is 	<ul style="list-style-type: none"> Society in 2040 has realized the natural carrying capacity of the Arctic through extensive R&D and communication thereof to society through strong science- 	<ul style="list-style-type: none"> In 2040, the development of the Arctic region is heavily guided by short-term profit seeking behavior where only immediate benefits count. Public debates

<p>prioritized over social and environmental concerns. This leads to haphazard growth and problems in maintaining infrastructure and basic services (such as health care, education). Land use is uncontrolled and transitions haphazard. Development is in the hands of investors and large/multi-national corporations and Arctic resources are mostly privatized. Common property rights are either non-regulated or based on too loose quotas compared to the environmental carrying capacity, and therefore natural resources (e.g. fish) are overharvested and ecosystems will degrade.</p> <ul style="list-style-type: none"> • Sea ice retreat is used as an excuse to enter the area, which creates a snowball effect in which new actors start exploiting activities in an accelerating pace as they rapidly follow the successful first movers. This leads to a rise in economic activities (oil, gas, tourism). Since the risk of accidents is high, accidents of varying severity occur, such as oil spills, shipwrecks and ballast water discharges from ships. This increases the need for search and rescue operations. • Technological development is making geoen지니어ing a viable way to mitigate climate change which in long term will slow down the progress of sea ice retreat. However, it affects the global climate and generates new ecological and social impacts. Thus, there is discussion on the rules of geoen지니어ing, and it is not in large-scale use yet. • Clean technology will lose its competitiveness due to lack of regulative incentives and the development of the Arctic relies on environmentally unsustainable technologies, such as fossil fuels or bottom trawling. There is insufficient or no (international) regulations and law enforcement to guide exploration and exploitation, which will lead to little investment in safety technologies and it is not 	<p>policy dialogues. Climate change has progressed as projected and society has had time to adapt to the changes. Awareness raising, education and global environmental awakening have created generally accepted sustainability standards and guidelines to comply with the carrying capacity of the Arctic. This gives more power to NGOs and creates sufficient trust between various stake- and rights-holders.</p> <ul style="list-style-type: none"> • Clean technologies boom and are competitive. New and sufficient funding forms (e.g. crowdsourcing) enable innovations and breakthroughs in technology. • Green and clean entrepreneurship dominate the economy and firms compete actively for the best environmental performance. The scientific community is actively involved in product development and innovation. Product certification and reward-fine systems communicate the environmental performance of economic activities and products. • New international organizations and mechanisms emerge to resolve domestic and international conflicts and to monitor activities in the Arctic. However, responsibility in case of accidents and everyday life relies on private insurances. • Regardless of good economic and environmental performance, social well-being in many Arctic regions lags. Corporations lack social integrity inside the Arctic, which is why social infrastructure is not as developed as other infrastructure and high welfare and health care services are not universally available. Work-related immigration to the Arctic creates large differences in the wealth of people, and the economy relies largely on a “fly in fly out” work force. 	<p>are focused on economic issues, resulting in public acceptance to the short-term utilization of Arctic resources. Oil and gas resources are heavily exploited by companies which are largely publicly owned and operate in close guidance and collaboration with the public sector. The companies are seen as important pillars of national economies, yet there are high corruption rates.</p> <ul style="list-style-type: none"> • Climate change has progressed faster than expected, which incites selfish behavior among countries and companies. There is no scientific or political agreement on the natural carrying capacity of the Arctic, and the global climate system is thus not considered a constraining factor for Arctic development. • Rules and regulations, including taxes/fines, are too weak to lead to a balanced sustainable development where social and environmental concerns are on equal footing with economic targets. The area is developed at any cost. • The area is exploited with insufficient safety standards due to lacking safety technologies. • Deep sea mining is permitted and practiced also in the high seas’ areas of the Arctic. • There is a high influx of workers to the area because of increased employment possibilities in ports, construction, other infrastructure, tourism and services. This leads to hub-based development, which attracts also local communities resulting in major changes in land use, for example increased urbanization. The areas outside the hubs remain short of any progress. • Socio-economic inequalities in the area are pronounced and conflicts arise between native people, immigrant workers and public authorities.
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<p>required by rules and regulations.</p> <ul style="list-style-type: none"> • Non-Arctic nations will have increased access to Arctic resources leading to their increased economic, military, cultural and political power in the Arctic. • Indigenous peoples and their claims are ignored, and their subsistence is at risk. Hunting and reindeer herding are close to vanishing. 		
<p>Public – Open – Clean: Shangri La</p>	<p>Closed – Dirty: Conflict Zone</p>	<p>Close – Clean: Antarctic</p>
<ul style="list-style-type: none"> • The Arctic area in 2040 has established a sustainable balance between environmental, social and economic conditions. Natural resources are managed sustainably and there are strong health policies resulting in improved physical and mental health as well as improved wellbeing of Arctic inhabitants. • Regulation is based on public deliberation, accurate climate and nature’s carrying capacity information, and sustainability considerations. All land claim agreements (between the indigenous population and other Arctic citizens) have been settled. • Economic actors have a strong bias for Arctic environmental protection and conservation, which encourages investments in R&D of clean technology. As one result, tourism causes limited stress for the Arctic environment. • Extensive shipping takes place and wide cooperation on navigation is practiced. Further cooperation takes place in searching new technological solutions for navigating in ice conditions, combating oil spills in icy conditions, construction work in permafrost areas and harnessing renewable energy potential under Arctic conditions. • Overall, national, regional and international regulation is clear and precise and is practiced from a responsible and equalized viewpoint. Regulation consists of incentive-based policies and license systems, which are a 	<ul style="list-style-type: none"> • In 2040, political instability is high, and the Arctic is riddled by political conflicts and non-secure conditions. Also global instability prevails because of unbalanced distribution of resources, such as clean water. Conflicts about, for instance, land rights and livelihood activities between states and the native people occur. Arctic countries have permanent and large-scale military presence in the area and military conflicts are taking place. • International and Pan-Arctic organizations have no mandate in regulating the area and Arctic states lack sufficient enforcement capability. • Environmental and other safety issues are considered secondary to national security, which leads to high risk operations and several environmental disasters taking place. • The uncertain and unstable conditions together with the lack of infrastructure hinder long-term private investments. 	<ul style="list-style-type: none"> • In 2040, an international Arctic Treaty is adopted supported by strong climate policy. The international community desires that uncertainty and risks related to the impacts of Arctic resource exploitation on climate change and environmental degradation are too high, and it is safer to turn the Arctic into a sanctuary. • The global economy is decarbonized, and renewable resources are politically fostered. • Based on the treaty, the Arctic area is regulated so that there is loss of extractive economic interest resulting in a cleaner environment. Some small-scale economic activities are sustained, such as limited eco- and scientific tourism. Stakeholders and rightsholders are committed to preserving natural habitats with instruments such as land trusts. The few private tourism companies concentrate on minimizing their environmental impact. The companies fear loss of reputation. • Indigenous people gain strong land rights and strong constituencies. Also other residents enjoy stable, yet economically less developed living conditions. Any infrastructure is run by decentralized renewable energy. Heavy regulation limits activities in the Arctic, which in turn decreases demand for new technological solutions. Thus, innovations in Arctic technology are slow. • Scientific, exclusive, (self-) regulated tourism to the unique

<p>result of awareness raising, public information sharing and exchange delivered by media campaigns.</p> <ul style="list-style-type: none"> • A global consensus of a conflict-free Arctic prevails, and new cooperative Arctic institutions emerge. These institutions possess mechanisms for domestic and international conflict resolution. High trust in compliance is achieved by intergovernmental surveillance and monitoring. • Regulated, small-scale aquaculture provides sustainable livelihood to local communities. 		<p>areas (North Pole, Northern Sea Route) takes place.</p>
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Myllylä et. al (2016) identified strong prospective trends for the Arctic and assessed their impact on the development of the Russian Arctic toward 2030. According to their study, the most important trend variables include the prices of natural resources, climate change and its impacts on the economy, economic structures and consumption patterns, resource-smart and eco-efficient technologies and their growing importance, the rise of importance of the bioeconomy and biotechnologies, new transport corridors to the North and strengthening logistic flows in the North, globalization and corresponding power decentralization, developments towards a multi-polar global economy, suitable technological solutions for the Arctic environment and their growing demand, digital evolution and ubiquitous technology revolution, the growing importance of the Northern Dimension and the Arctic regions for the European Union and international development, increasing environmental consciousness in the world, the global population growth, and the demographic shift towards an ageing society. Based on this, three scenarios were proposed: scenario 1 in which the market forces and democracy are strengthening, scenario 2 in which authoritarianism is increasing and a regulated economy prevails, and scenario 3 in which the problems are accumulating, and the oil, gas and other raw material prices are sinking. Table 4 summarizes these three scenarios.

Table 4: Russian Arctic development under three different scenarios by 2030 (Myllylä et. al, 2016)

	Scenario 1 The market forces and democracy are strengthening	Scenario 2 Authoritarianism is increasing and a regulated economy prevails	Scenario 3 The problems are accumulating, and the oil, gas and other raw material prices are sinking
Key drivers	Resource-smart and eco-efficient technologies and their growing importance, suitable technological solutions for the Arctic environment and their growing need, increasing prices of natural resources, climate change and its impacts on energy economy, economic structures and consumption patterns.	Resource-smart and eco-efficient technologies and their growing importance, suitable technological solutions for the Arctic environment and their growing need, increasing prices of natural resources.	Wild card happened, such as decreasing prices of natural resources, environmental catastrophe, war, Ukraine crisis and economic sanctions, broader crisis of world economy.
Clusters	Oil, gas, mining. Stronger positions for energy and logistic clusters, mining industry modernized through investments. Military structures directed towards prevention of terrorism. Western Europe is the most important energy market for Russia.	Oil, gas, mining. Energy, mining, and metal refining as well as logistic clusters essential. Military structures strengthened. Asia is a more important energy market for Russia than in scenario 1.	Mining, tourism, gas, oil. Weakening positions for energy and mining clusters. Attempts to develop the environmental cluster, information and communication technology and tourism. Inability to strengthen Russian military structures.
Levels of decision-making in Russia	Market and federal level.	Federal level most important.	Exits from crises are sought by increasing regional and local decision-making power.
Development of logistics	NSR (Northern Sea Route) is an international trade route year-round. Ports and railways, power transmissions networks, IT networks, roads and air traffic are important targets for logistic development. Innovative transport solutions actively developed and implemented in cooperation between Russia and international partners.	NSR mainly Russia's own raw materials exporting use year-round. Ports and railways, power transmission networks are important targets for logistic development. Innovative transport solutions and technology bought from foreign enterprises.	No year-round use of whole NSR. Infrastructure investments put on hold. IT infrastructure developed to start a new wave of economic development.

Haavisto et al. (2017) built on Arbo et al. (2013) and reviewed ten socio-economic scenarios developed for the Arctic region selected from the earlier literature. They considered the following key uncertainties: governance, resources and trade, economic growth of the EU, the resource efficiency in the EU, climate change in the Arctic, management of environmental pressures in the Arctic, resource development, human factor, land use, changing ecological-social interactions, perception of the Arctic as open or closed, initiating force of actions (private or public sector), and the state of the environment (dirty or clean). The study found that governance and natural resources are the main factors, which supports a rather traditional view

on the Arctic. However, the authors emphasized that since 2015, political factors as a key uncertainty have also been gaining importance. As for the climate change, different studies present different views of how certain the future global warming projections are (from treating global warming as a rather certain trend to considering a large uncertainty around it).

In the Strategic Foresight Analysis Report, NATO (2017) presented two views on the Arctic development. The first view foresees an increased range of activities in the Arctic due to the growing accessibility of the region. The second view expects that the Arctic region will not be exploited as anticipated. Table 5 summarizes the two scenarios.

Table 5: Two views on the Arctic (NATO, 2017)

Increased range of activities in the Arctic due to growing accessibility	Arctic region not exploited as anticipated
The Arctic region will increasingly open to a range of activities such as oil, gas and mineral exploration and exploitation, fishing and tourism by Arctic and non-Arctic nations, increased military use of the High North and Arctic regions due to growing accessibility.	There are factors which may inhibit commercial expansion in the region such as the economic balance of reduced fuel cost and transit-times due to shorter passage routes, against increased costs for ship strengthening, equipping, operating and insurance; the high costs and difficulties of maintaining infrastructure on thawing permafrost; the risk of environmental damage, and the massive clean-up costs and litigation that would be levied against those responsible for incidents and the license-issuing states. The Arctic will still be an exceptionally unforgiving operating environment, made worse by increased severe storm conditions as a result of climate change effects.

Zaikov et. al (2019) considered scenarios for the development of the Arctic, including the Arctic zone of the Russian Federation, in the long-term perspective (until 2035). They asserted that several factors influence the Arctic development scenarios, including the physical and geographical features of the region, the world economy and demand for hydrocarbon resources, technology status and its possession by a limited number of countries, the state of international relations, and the role of Russia. The authors distinguished an optimistic scenario, a pessimistic scenario, and a moderate scenario. The *optimistic* scenario implies an improvement in the multilateral relationships in the Arctic region. In contrast, the *pessimistic* scenario expects a deterioration of these relationships. The *moderate* scenario is in between the two extreme scenarios. Table 6 summarizes these three scenarios.

Table 6: Three socio-economic scenarios for the Arctic by 2035 (Zaikov et. al, 2019)

Pessimistic	Moderate	Optimistic
<ul style="list-style-type: none"> • Tense nature of interstate cooperation due to territorial disputes (incl. the “Spitzbergen issue”); the willingness of countries to protect their interests outside the national Arctic areas; promotion of the idea of free borders in the Arctic; seeking a UN ban on exploration and extraction of minerals in the Arctic; defending the right to free navigation in the Arctic Ocean; • Growth of the military presence; involvement of the foreign Arctic states via NATO. Militarization does not meet the interests of Russia in the Arctic region; • The Arctic Council like a discussion club; its role in solving the problems of the Arctic is declining; • Cyclical moderate growth of the world economy replaced by stagnation; the demand for the Arctic oil and natural gas decreases against the development of shale energy; production at developed fields in the Arctic is falling; geological exploration rates are declining; transportation along the NSR remains uncompetitive; North-West passage is increasingly free of ice during the period of navigation; • Against international isolation, Russia is searching for new partners in the development of hydrocarbon deposits among Asian companies; anxiety of environmental organizations associated with the exacerbation of the ecological situation in the Arctic due to poor readiness of fields for development; the activity of ecological organizations near mining sites and transportation routes for natural resources is interpreted as environmental terrorism. 	<ul style="list-style-type: none"> • Balance between optimistic and pessimistic scenarios; • Territorial disagreements and the desire to control shipping routes remain, but these processes are not sharp with the expressed desire of states to find a solution based on international law; • The state of bilateral relations with the participation of the Russian Federation and Western states remains tense. Sanctions pressure from European and North American states continues; Asian countries are key partners in the Arctic projects; • The risk of losing control of shipping routes in the Indian Ocean and representation in the scientific community in Svalbard make India promoting its interests in the Arctic carefully with a steady interest in the region; • The development of the world economy stimulates economic activity in the Arctic, which contributes to maintaining attention to the region from international environmental organizations; • North American oil and gas companies, combining the technology and financial resources, actively pursue their interests in the exploration and extraction of mineral resources on land and the shelf of the Arctic Ocean; • Implicit factors (unpredictable aspects of development dependent on events that do not directly affect the Arctic) as the successes of the oil shale revolution and, in the long-term perspective, of hydrogen energy, albeit for a short time, can change the attitude towards the Arctic resources. Signs of negative consequences include conserving Arctic projects for the development of natural resources and their export to foreign markets, a decline in the standard of living of the local population and, as a result, the desertion of the Arctic spaces. 	<ul style="list-style-type: none"> • Progressive (despite cyclical) development of the global economy; the demand for natural resources of the Arctic and transport routes of the Arctic Ocean (primarily the NSR, although it remains low compared to the Suez Canal). All this and international participation help to continue the geological exploration of hydrocarbons in new areas of the Arctic; • Rallying the international community around the values of the Arctic region (territorial integrity, respect for the norms of international law, sustainable socioeconomic growth, the well-being of the population, high quality of the environment, production of new knowledge and joint scientific research — these postulates are in every Arctic strategy of Europe and North America); • Development of public diplomacy – cooperation between municipalities in the Barents Euro-Arctic Region and the transfer of knowledge and experience; • Increasing the role of the Arctic Council, which takes binding decisions for other countries, invites new states interested in the use of resources and sustainable development of the Arctic region to its work; • The United States ratify the United Nations Convention on the Law of the Sea and, as a result, prepare an application for an increase in the Exclusive Economic Zone; growing activities of American corporations in the Arctic; • Mutual understanding between the Russian Federation and the principal countries of the region – the United States, Canada, and Norway – in subsoil use and transport routes reduces the political and military tension in the area; • Russia's initiatives to find new partners for the environmentally safe and economically profitable

	<p>The positive significance lies in the conservation of resources for future generations, the reduction of anthropogenic pressure on ecosystems, and the preservation of a favorable environment;</p> <ul style="list-style-type: none"> • Random factors that can influence the choice of scenarios are natural disasters, technological accidents, acute and protracted financial crises, arms race, information wars, terrorist attacks, the discovery of new deposits, unexpected technological innovations, increasing market volatility, or increase in the rate of climate change. 	<p>development of natural resources in the Arctic among non-Arctic states, primarily Asian and Latin American ones through public-private partnerships.</p>
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Blair & Müller-Stoffels (2019) built on the workshop “Maritime Futures 2035: The Arctic Region” and presented three scenarios for the Arctic development: the most plausible scenario *Growing Pains*, the most consistent scenario *The Winner Takes It All*, and the most robust scenario *All Aboard the Arctic Express*. They relied on twelve key factors: geopolitical stability, accessibility of Arctic sea routes, user-centric information infrastructures and data, global economic trends, demand for Arctic resources, regulations and policy affecting Arctic operations, major incidents and critical events, predictability of sea ice variability, fluctuating energy prices, China’s strategic plan, sustainable and resilient local communities, and the trajectory of technological development in marine technologies. Table 7 summarizes these three scenarios.

Table 7: Three maritime futures scenarios for the Arctic by 2035 (Blair & Müller-Stoffels, 2019)

Factor\Scenario	Most Plausible Scenario: Growing Pains	Most Consistent Scenario: The Winner Takes It All	Most Robust: All Aboard the Arctic Express
Geopolitical stability	Status quo (occasional bullying): <ul style="list-style-type: none"> • Current trends continue • Showmanship: showing off military might • Trying to out-muscle without using muscle Mainly verbal threats with occasional cyber and electronic attacks		
Accessibility of Arctic sea routes	Difficult access: <ul style="list-style-type: none"> • Persistent sea ice • Unreliable predictive models • More regulatory barriers • No new resource developments 	Easy access: <ul style="list-style-type: none"> • Less sea ice • Reliable predictive models • Increasing global agreement, collaboration due to collaborative leadership as well as efficient coordination • New icebreakers Strengthened Search and Rescue operational networks and infrastructure	
User-centric information infrastructures and data	Few specialized, big actors (data and service providers): <ul style="list-style-type: none"> • Portfolio of regular, public services remains similar to now Increase in specialized, commercial, subscription-based services		
Global economic trends	Arctic rush:		

	<ul style="list-style-type: none"> • Rising global commodity prices provide incentives for natural development resources and destination shipping, fishing, and marine tourism • Influx of people increases need for shipping supplies to remote Arctic communities • More mineral exploration and cruise tourism leading to increased infrastructure needs, overwhelming local users / communities • More tourism results in more development, increasing the complexity of port logistics <p>Increased traffic leads to moving traffic into shoulder season, thereby increasing high risk operations</p>		
Demand for Arctic resources	<p>Tourism first:</p> <ul style="list-style-type: none"> • People with disposable income eager to spend on exotic experiences • Accessibility of Arctic destinations increases as does the portfolio of metocean services needed • Adventure tourism grows • Straining resources and cultural values of communities 	<p>Fossil futures:</p> <ul style="list-style-type: none"> • Conflict in the Middle East increases • Alternatives to fossil fuel are not viable • Rising oil prices • Oil crisis creates higher demand for Arctic fossil fuel 	<p>Seafood first:</p> <ul style="list-style-type: none"> • More processing and transport of seafood products (increased fishing traffic) • Global food demand grows • Global demand for eco-friendly protein grows • Seafood is an increasingly valuable export commodity from Arctic region
Regulations and policies affecting Arctic operations	<p>Economic and commercial uses dominate:</p> <ul style="list-style-type: none"> • Regulations determined by industry (industry writes code) • Environmental requirements take a backseat to economic efficiency • Ice class and search and rescue requirements may ease • Traffic may increase if cost of operations decreases sufficiently 		
Major incidents and critical events	<p>Ship crash (medium-to-large event):</p> <ul style="list-style-type: none"> • More Arctic ship traffic increases chances for major incidents • Incidents are on the rise • Major incident occurs slowing down shipping • A lack of search and rescue response capacity combined with regulations designed to facilitate merchant necessities and not the luxury cruise industry leaves major marks on the cruise sector 	<p>Status quo:</p> <ul style="list-style-type: none"> • Good record of marine operations • Industry reputation is good, slightly blemished at times of minor incidents <p>Traffic expands in linear relation with local trade</p>	
Predictability of sea ice variability	<p>Gradual improvement of predictive models:</p> <ul style="list-style-type: none"> • Sea ice prediction improves gradually over time 	<p>Breakthrough:</p> <ul style="list-style-type: none"> • Breakthrough in sea ice prediction beyond weeks, observational models 	<p>Gradual improvement of predictive models:</p> <ul style="list-style-type: none"> • Sea ice prediction improves gradually over time
Fluctuating energy prices	<p>Northern push:</p> <ul style="list-style-type: none"> • Increased bunker fuel prices • Increased replacement of inefficient ships, and building of fuel-efficient ships • High fuel costs result in preference toward shorter Arctic route • Some sectors hard-hit by large fuel price fluctuations (e.g. cruise industry when price is high, extractive industries when prices are low) • Industry-friendly regulations are likely in areas that profit from the fossil industry • Profitable Arctic operations in extractive industries, increased revenue for fossil industry (potential for benefit sharing with communities) 		

	<ul style="list-style-type: none"> • Supply chain decision making possible due to predictability or operations and contingency planning • Increase in Arctic exports <p>Insurance availability widens, cost decreases</p>		
China's strategic plans	<p>Chinese finger cuffs:</p> <ul style="list-style-type: none"> • China's strategic plans provoke preemptive developments and increase in investments by Arctic nations (control remains within the Arctic) • China's and Korea's strategic plans are controlled via proactive action by Arctic states • China's strategic investment plans are scrutinized and rejected to thwart outside geopolitical leverage 	<p>Mad Max:</p> <ul style="list-style-type: none"> • Heavy critical infrastructure investments • Shipping shares shift toward state-owned companies • Mining and fishing rights shift toward Chinese ownership • China follows their own strategic plans for Arctic development • Increased demands on local resources and communities • Increase in shared liabilities and responsibilities of information provision • Potential for growth in joint information hubs and cooperative solutions (price of information may decrease) 	<p>Chinese finger cuffs:</p> <ul style="list-style-type: none"> • China's strategic plans provoke preemptive developments and increase in investments by Arctic nations (control remains within the Arctic) • China's and Korea's strategic plans are controlled via proactive action by Arctic states • China's strategic investment plans are scrutinized and rejected to thwart outside geopolitical leverage
Sustainable and resilient local communities	<p>Expat haven:</p> <ul style="list-style-type: none"> • Increased influx of people from outside the Arctic region • Increase in labor force <p>Increasingly mixed cultural identity</p>		
Trajectory of development in marine technologies	<p>Techno-utopia for some, stormy seas for others:</p> <ul style="list-style-type: none"> • Favorable regulatory frameworks and intense competition for smart marine technologies speed up worldwide technical standardization and cooperation • Portfolio of technologies supporting electromagnetic stealth and resilience to electromagnetic attacks increases • Private sector is confident to invest • Big-data analytics advance coupled models' ground-truthing forecast information with in-situ data • Robotics, advanced materials and new communication technologies increasingly saturate marine operations • These new, expensive technologies will require changes in supply chain management and likely adopted quicker by larger corporates • The speed of green development picks up due to policies incentivizing cleaner, more efficient vessels • New build orders based on clean, efficient propulsion and powering increase • Onboard energy management increases in efficiency, marine fuels focus on novel technologies • Environmental regulations play catch-up with intensifying activities and new places of exploration, increased focus phasing out heavy fuels and search-and-rescue capacities • Increasing complexity of technologies and speed of development requires new skills and training from people operating systems and equipment • Growing demand for highly qualified sea-going staff • Increasing deployment of sensors in remote locations to support users and decisionmakers in decision making, and a better understanding of environmental preservation needs 		

	<ul style="list-style-type: none"> • Unprecedented amount of data available to users aids those with access to big data analytics, while those without struggle to translate complex data sets for use • Demand for increased portfolio of metocean services continues to rise rapidly: increasing demand for data transfer services, public services struggle to keep up to finance growing service demands, private subscription-based providers grows
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Lovecraft (2019) summarized the results of the workshop “Arctic Futures 2050: Scenarios Narratives” and presented seven scenarios. The future scenarios are based on sixteen key factors: cryosphere climate change, atmosphere climate change, terrestrial biosphere climate change, marine systems climate change, Arctic regional collaboration, Arctic regional security, global policy, international security, status of Indigenous peoples, access to markets, extraction of renewable resources, extraction of non-renewable resources, Arctic energy systems, public health, community sustainability, and science advancement and communication. Table 8 summarizes these seven scenarios.

Table 8: Seven Arctic futures scenarios by 2050 (Lovecraft, 2019)

Factor\Scenario	An insecure Arctic in a warmer world with high resource demand – most consistent results	Slowly rising emissions where atmosphere and marine changes are transformative as incremental social changes trend for the worse – high robustness	Lowered emissions and harmonious regional and global relations – forced Representative Concentration Pathway (RCP) 2.6
Climate Change – Cryosphere	Slight melt and thaw increase in the Arctic	Substantial melt and thaw in the Arctic	Little melt or thaw in the Arctic
Climate Change – Atmosphere	Mid-21 st century decline in greenhouse gas emissions	Rising greenhouse gas emissions throughout the 21 st century	Early-21 st century decline in greenhouse gas emissions
Climate change – Terrestrial Biosphere	Slight change to biomass, fire, and biodiversity	Substantial change to temperature and biodiversity	Little or no change to terrestrial flora and fauna
Marine Systems Change	Slightly warmer oceans and more coastal erosion	Complete transformation to ice-free marine ecosystem	Oceans absorb only a little heat
Arctic Regional Collaborations	Collaboration in the Arctic decreases		Harmony between national, Indigenous, and business stakeholders in the Arctic
Arctic Regional Security	Arctic is insecure	Insecure relations between Arctic and non-Arctic interests	Arctic interests are secure globally
Global Policy	International cooperation breaks down globally	Global policy remains as is	Arctic Council as government
International Security	International security does not exist	International relations characterized by distrust	Interests around the globe are secure
Status of Arctic Indigenous People	Decreased self-determination for Indigenous Peoples	Governance by and of Indigenous peoples remains as is	Increased self-determination for Indigenous Peoples
Access to Markets	Decreased development in the Arctic	Boom-bust nature of arctic markets remains as is	Local planning for sustainable markets

Economic Development: Renewable Resource Extraction	Increased development of renewable resources in the Arctic		U.N. establishes an Arctic Development Bank	
Economic Development: Non-Resource Extraction	Rapid and unregulated resource extraction		Collaborative development of the Arctic	
Arctic Energy Systems	Insecure and costly energy resources and development		Increased energy security and independence	
Public Health	Public health crises	Public health for those who can pay for it	Responsive public health and greater well-being	
Community Sustainability	Some communities adapt, innovate, or develop		Arctic communities adapt and innovative for self-benefit	
Science Advancement and Communication	The globe's wealthiest corporations wield control over science		Co-production of knowledge increases	
	On track for late century decline in emissions with little change in governance systems – most plausible	Low emissions and an isolated but internally collaborative Arctic – best emissions, but inward looking Arctic	Emissions reduced in an insecure world and depopulating Arctic – best emissions “worst world”	Significant global collaboration for adaptation to, not mitigation of, rising greenhouse gas emissions – high emissions, high collaboration, no results
Climate Change – Cryosphere	Substantial melt and thaw of the cryosphere	Little melt or thaw in the Arctic		Complete melt and thaw of the Arctic
Climate Change – Atmosphere	Late-21 st century decline in greenhouse gas emissions	Early-21 st century decline in greenhouse gas emissions		Rising greenhouse gas emissions throughout the 21 st century
Climate change – Terrestrial Biosphere	Substantial change to temperature and biodiversity	Little or no change to terrestrial flora and fauna		Complete transformation to a green, wet Arctic
Marine Systems Change	Substantial temperature, flora, and fauna shifts in the ocean	Oceans absorb only a little heat		Complete transformation to ice-free marine ecosystem
Arctic Regional Collaborations	Regional collaboration in the Arctic remains as is	Arctic stakeholders collaborate with each other and not with outside interests	Collaboration in the Arctic decreases	Harmony between national, Indigenous, and business stakeholders in the Arctic
Arctic Regional Security	Arctic security remains as is	Arctic remains secure amongst world-order collapse	Arctic is insecure	Arctic interests are secure globally
Global Policy	Global policy remains as is	International policy fully addresses arctic interests and concerns	International cooperation breaks down globally	International policy fully addresses

				arctic interests and concerns
International Security	International relations are characterized by distrust	Arctic security through isolation	International security does not exist	Interests around the globe are secure
Status of Arctic Indigenous People	Governance by and of Indigenous peoples remains as is	Autonomous Indigenous Peoples	Increased self-determination for Indigenous Peoples	
Access to Markets	Boom-bust nature of Arctic markets remains as is	Local planning for sustainable markets	Decreased development in the Arctic	Arctic development boom
Economic Development Renewable Resource Extraction	Increased development of renewable resources in the Arctic	U.N. establishes Arctic Development Bank	Decreased development of renewable resources in the Arctic	Increased development of renewable resources in the Arctic
Economic Development Non-Resource Extraction	Rapid and unregulated resource extraction	Collaborative development of the Arctic	Decreased investment in the Arctic	Collaborative development of the Arctic
Arctic Energy Systems	Insecure and costly energy resources and development	Increased energy security and independence	Insecure and costly energy resources and development	Increased energy security and independence
Public Health	Public health for those who can pay for it	Responsive public health and greater well-being	Decreased well-being, large disease outbreaks	
Community Sustainability	Some communities adapt, innovate, or develop	Reactionary development, adaptation, and innovation	Outmigration outpaces adaptation	
Science Advancement and Communication	Co-production of knowledge increases	Scientists engage increasing number of citizen scientists	Scientists as geoengineers	Scientists rekindle public trust

Key factors

In the context of scenario analysis, factors are defined as “aspects of a social or natural system around which there are broad policy issues of particular interest” (Kok et al., 2006). In our paper, these are uncertain issues with several distinctly different possible development paths that are expected to have a major direct or indirect impact on the future of the Arctic region.

Based on the studies reviewed above, the key factors for the Arctic can be grouped into several broad categories:

- Climate and environment
- Resource extraction
- Demand for and supply of resources
- Trade and economic issues
- Transportation, shipping and infrastructure
- (Indigenous) people
- Governance and geopolitical issues
- Technological development

The presence of these key factors and their more specific components in each scenario framework reviewed in the previous section are summarized in Table 9, which constitutes the main result of our analysis presented in this paper. The presence of factors from a given category, the number of factors included, and the role these factors play in defining scenarios across the reviewed studies are indicators of the importance of a factor category for the Arctic region. Based on this, governance and geopolitical issues appear to be the most important group of factors, followed by resource extraction and climate and environment. Trade and economic issues as well as transportation, shipping and infrastructure are the least presented categories. Let us point out that these factor categories contain both global and regional, i.e., Arctic-specific, factors (see Table 9 for details).

Conclusion

This paper reviews the scenarios of the development of the Arctic region presented in the literature. The analysis reveals a growing attention of the international foresight research community to the Arctic region in the recent years, which can be attributed to the increasing geopolitical importance of the Arctic.

By scanning through the existing scenarios for the Arctic development, we have summarized the key factors that are expected to have a major direct or indirect impact on the future of the Arctic region, of which governance-, resource- and environment-related issues appear to be most frequently used. Trade- and transport-related issues are underrepresented in the reviewed studies.

The reviewed studies employed both regional and global factors to construct scenarios. Mixing two scales in one scenario-building effort limits the number of factors that can be considered and complicates assessment of the plausibility of the scenarios. A scenario framework that separates two scales would complement and enrich the already existing scenarios of the future development of the Arctic.

Another weakness of the existing regional scenarios of the development of the Arctic region is that they are all qualitative in nature and lack quantification of the major trends. The foresight community recognizes the value of complementing the qualitative scenarios by quantitative elements. However, to the best of our knowledge, such an effort has not yet been conducted for the Arctic region.

The “Emerging trade routes between Europe and Asia” scenario-building project intends to address these two weaknesses. We will build on a global scenario framework and construct regional scenarios that will combine qualitative and quantitative elements. This will provide an enriched and systemic view on the plausible futures of the region and set the stage for the

development of robust win-win strategies to boost the economic potential of the Arctic in a sustainable manner.

Table 9: Key factors for the Arctic

Authors and year	Brigham 2007	Arctic Council 2009	Arbo et al. 2013	Haavisto et al. 2016	Myllylä et al. 2016	Haavisto et al. 2017	Blair & Müller-Stoffels 2019	Lovecraft 2019	Zaikov et. al 2019		
Type of study/Key factors	<i>4 scenarios of Arctic futures by 2040</i>	<i>4 futures for Arctic marine navigation by 2050, workshop outcome</i>	<i>Literature review of 50 studies on the future of the Arctic</i>	<i>6 socio-economic scenarios for the Eurasian Arctic by 2040, workshop outcome</i>	<i>12 most important strong prospective trends in the Arctic by 2030, workshop outcome</i>	<i>Literature review of 10 socio-economic scenarios in the Arctic</i>	<i>3 scenarios for the Arctic development by 2035, workshop outcome</i>	<i>7 scenario narratives for the Arctic by 2050, workshop outcome</i>	<i>3 scenarios for the development of the Arctic by 2035</i>		
Climate and environment	Global climate change (regional warming)	Climate change	Climate change	Extreme natural conditions and their variability	Climate change	Climate change in the Arctic	Predictability of sea ice variability	Climate change: cryosphere	Physical and geographical features of the region		
	Regional environmental degradation and environmental protection schemes			Risks of natural and manmade hazards		Dirty or clean environment				Climate change: atmosphere	
				Receding sea ice cover		Climate change				Ecological-social interactions	Climate change: terrestrial biosphere
						Management of environmental pressures in the Arctic				Climate change: marine systems	
Resource extraction, demand and supply	Resource development – for example, oil and gas, minerals, fisheries, freshwater, and forestry	Oil prices	Demand for Arctic resources	Utilization and accessibility of mineral resources	Prices of natural resources	Resources	Demand for Arctic resources	Arctic energy systems	Demand for hydrocarbon resources		
		Shift to nuclear energy	Demand for oil, gas and other natural resources	Utilization and accessibility of fossil fuel reserves		Resource development					
		New resource discoveries		Global demand of fossil fuels		Land use				Energy prices	
				Global demand of minerals							Extraction of renewable resources

				Fossil fuel price levels in global market				Extraction of non-renewable resources	
				Mineral price levels in global market					
				Marine fisheries					
Trade and economic issues		Change in global trade dynamics		Tourism	Climate change impacts (pressures) on energy economy, economic structures, and consumption patterns	Trade	Global economic trends	Access to markets	World economy
		Socio-economic impact of global weather changes		Global economy		EU economic growth			
		World trade patterns							
Transportation, shipping, infrastructure	Transportation systems, especially marine and air access	Safety of other routes	Search for new shipping lanes	Development/ coverage/ distribution of infrastructure	New transport corridors to the North and logistic flows in the North		Accessibility of Arctic sea routes		
		Loss of Suez or Panama canals							
		Maritime insurance industry engagement							
		Transit fees		Competitiveness of the Northern Sea Route compared to other trade routes					
		Limited windows of operation (economics)							
		Major Arctic shipping disaster							
(Indigenous) people	Indigenous Arctic peoples – their economic status and the	Conflict between indigenous and commercial use	Population growth	Livelihoods of Indigenous peoples	World population growth	Human factor	Sustainable and resilient local communities	Status of indigenous peoples	
								Public health	

	impacts of change on their well-being			Environmental awareness	Demographic shift towards an ageing society			Community sustainability	
					Environmental consciousness in the world				
Governance and geopolitical issues	The Arctic Council and other cooperative arrangements of the Arctic states and those of the regional and local governments	Global agreements on construction rules and standards	Regulatory frameworks	Arctic treaties (navigation and environmental)	Globalization and corresponding power decentralization, developments towards a multi-polar global economy	Governance	Regulations and policy affecting Arctic operations	Arctic regional collaboration	State of international relations and the role of Russia
		Legal climate		National climate policy					
	Overall geopolitical issues facing the region, such as the Law of the Sea and boundary disputes	Arctic maritime enforcement	Increasing globalization	Geopolitical situation (tense vs. cooperative)	Growing importance of the Northern Dimension and the Arctic regions for the European Union and international development	Perception of the Arctic as open or closed	China's strategic plan	Arctic regional security	
		China, Japan and Korea become Arctic maritime nations	Economic and political interests of the Arctic states and other global players	Common Arctic security policy				Initiator of actions being private or public	Major incidents and critical events
		Escalation of Arctic maritime disputes	United Nations Convention on the Law of the Sea	Land rights (not including the off-shore locations)		Global climate policy	Geopolitical stability		Global policy
			Disputed boundaries	Level of international cooperation					
			Geopolitical circumstances	International cooperation in the Arctic					
			End of the Cold War	Emphasizing territorial presence (e.g. by					

				keeping areas populated)					
Technological development			Technology development	Development of Arctic engineering (including control of extreme conditions)	Rise of importance of bioeconomy and biotechnologies	EU resource efficiency	Trajectory of technological development in marine technologies	Science advancement and communication	Technology status and its possession by a limited number of countries
				Certification of Arctic products and services (greentech and cleantech)	Digital evolution and ubiquitous technology revolution				
				Developments in shipbuilding technology and winter navigation technology	Suitable technological solutions for the Arctic environment and their growing need		User-centric information infrastructures and data		
				Development in satellite technology	Resource-smart and eco-efficient technologies and their growing importance				

References

- Arbo, P., Iversen, A., Knol, M., Ringholm, T., & Sander, G. (2013). Arctic futures: Conceptualizations and images of a changing Arctic. *Polar Geography*, 36(3), 163-182. Retrieved from <https://www.tandfonline.com/doi/full/10.1080/1088937X.2012.724462>.
- Arctic Council. (2009). Arctic marine shipping assessment 2009 report. Retrieved from https://www.researchgate.net/profile/Hajo_Eicken/publication/255891922_Arctic_Marine_Shipping_Assessment_2009_Report/links/5ad39ab30f7e9b2859360173/Arctic-Marine-Shipping-Assessment-2009-Report.pdf.
- Blair, B., & Müller-Stoffels, M. (2019). Maritime Futures 2035: The Arctic Region: Workshop Report & Technical Documentation. Retrieved from <https://library.wur.nl/WebQuery/wurpubs/fulltext/497386>.
- Brigham, L. W. (2007). Thinking about the Arctic's Future. *Futur Sept–Oct*, 27-34. Retrieved from https://lisd.princeton.edu/sites/lisd/files/brigham_sept2007.pdf.
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (n.d.). The economic importance of the Arctic. Retrieved from <https://www.bmu.de/en/topics/sustainability-international/international-environmental-policy/multilateral-cooperation/the-arctic/the-economic-importance-of-the-arctic/>.
- Haavisto, R., Pilli-Sihvola, K., Harjanne, A., & Perrels, A. (2016). Socio-economic scenarios for the Eurasian Arctic by 2040. *Finish Meteorological Institute*, 1, 1-65. Retrieved from https://www.researchgate.net/profile/Karoliina_Pilli-Sihvola/publication/303026020_Socio-economic_Scenarios_for_the_Eurasian_Arctic_by_2040/links/5735d93408ae298602e09216/Socio-economic-Scenarios-for-the-Eurasian-Arctic-by-2040.pdf.
- Haavisto, R., Pilli-Sihvola, K., & Harjanne, A. (2017). Uncertainties in Arctic socio-economic scenarios. In *The Interconnected Arctic—UArctic Congress 2016* (pp. 115-125). Springer, Cham. Retrieved from <https://www.oapen.org/download?type=document&docid=1002221#page=120>.
- Ho, J. (2010). The implications of Arctic sea ice decline on shipping. *Marine Policy*, 34(3), 713-715. Retrieved from <https://www.sciencedirect.com/science/article/pii/S0308597X09001717>.
- Höjer, M., Ahlroth, S., Dreborg, K. H., Ekvall, T., Finnveden, G., Hjelm, O., ... & Palm, V. (2008). Scenarios in selected tools for environmental systems analysis. *Journal of Cleaner Production*, 16(18), 1958-1970. Retrieved from <https://www.sciencedirect.com/science/article/pii/S0959652608000188>.
- Kok, K., Rothman, D. S., & Patel, M. (2006). Multi-scale narratives from an IA perspective: Part I. European and Mediterranean scenario development. *Futures*, 38(3), 261-284. Retrieved from <https://www.sciencedirect.com/science/article/pii/S001632870500128X>.

- Lovecraft, A. L. 2019. Arctic Futures 2050: Scenarios Narratives. Report on the SEARCH Scenarios Project. Study of Environmental Arctic Change. Retrieved from https://www.searcharcticsscience.org/files/page/documents/29247/arcticfutures_scenariosnarrativereport_ed_1.pdf.
- Maier, H. R., Guillaume, J. H., van Delden, H., Riddell, G. A., Haasnoot, M., & Kwakkel, J. H. (2016). An uncertain future, deep uncertainty, scenarios, robustness and adaptation: How do they fit together?. *Environmental Modelling & Software*, 81, 154-164. Retrieved from <https://www.sciencedirect.com/science/article/abs/pii/S1364815216300780>.
- Mietzner, D., & Reger, G. (2005). Advantages and disadvantages of scenario approaches for strategic foresight. *International Journal of Technology Intelligence and Planning*, 1(2), 220-239. Retrieved from <https://www.inderscienceonline.com/doi/abs/10.1504/IJTIP.2005.006516>.
- Myllylä, Y., Kaivo-oja, J., & Juga, J. (2016). Strong prospective trends in the Arctic and future opportunities in logistics. *Polar Geography*, 39(3), 145-164. Retrieved from <https://www.tandfonline.com/doi/pdf/10.1080/1088937X.2016.1184723>.
- NATO. (2017). Strategic Foresight Analysis 2017 Report. Retrieved from https://www.act.nato.int/images/stories/media/doclibrary/171004_sfa_2017_report_hr.pdf.
- Ng, A. K., Andrews, J., Babb, D., Lin, Y., & Becker, A. (2018). Implications of climate change for shipping: Opening the Arctic seas. *Wiley Interdisciplinary Reviews: Climate Change*, 9(2), e507. Retrieved from <https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.507>.
- Ratcliffe, J. (2000). Scenario building: a suitable method for strategic property planning?. *Property management*. Retrieved from <https://www.emerald.com/insight/content/doi/10.1108/02637470010328322/>.
- Smith, L. C., & Stephenson, S. R. (2013). New Trans-Arctic shipping routes navigable by midcentury. *Proceedings of the National Academy of Sciences*, 110(13), E1191-E1195. Retrieved from <https://www.pnas.org/content/110/13/E1191.short>.
- Zaikov, K. S., Kondratov, N. A., Kudryashova, E. V., Lipina, S. A., & Chistobaev, A. I. (2019). Scenarios for the development of the Arctic region (2020–2035). *Social and Economic Development*, (35), 4. Retrieved from http://www.arcticandnorth.ru/upload/iblock/f66/01_Zaikov_et_al.pdf.