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SOCIO-ECONOMIC SCENARIOS FOR THE EURASIAN ARCTIC BY 2040

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Abstract

Improved weather and marine services (WMS) can have a role to play in the safe and secure development of the Arctic region through either a demand-pull (enhanced by growth in activity) or a supply-push (enhances growth in activity) process. To analyse the nature of the process and the future use and benefits of WMS, a better understanding of possible future developments in the Eurasian Arctic is needed. This report presents six socio-economic scenarios for the Eurasian Arctic by 2040, and a brief synopsis of the implications of each scenario for WMS. The scenarios focus on the development of shipping, resource extraction and tourism industries.

The scenario futures, called *Wild West*, *Silicon Valley*, *Exploited Colony*, *Shangri La*, *Conflict Zone* and *Antarctic*, describe the scale and scope of activities in the Eurasian Arctic by 2040. The scenarios have three dimensions: *open – closed*, *public - private* and *dirty – clean,* which describe the political, economic, social, technological and environmental aspects of different futures.

The scenarios are based on a literature review, pre-survey, expert workshop and restructuring and analysis of this material. The methodology used for scenario construction is described in detail and may be used widely by other scenario developers.

Our analysis shows that plenty of potential pressures for major changes in the Eurasian Arctic exist. Environmental changes, political shifts and technological development can all push forward drastic new developments in the region. Then again, it is possible that despite all the hype and interest, the Eurasian Arctic remains backwater areas in the global economy. This emphasizes the need for any decision-maker to be able to respond to very different futures. Therefore, robust decision making, a good eye for weak signals and tipping points, and the ability to prepare for risks and seize opportunities as they emerge is required in the Eurasian Arctic. The development of WMS is important in ensuring the safe and secure development of the Eurasian Arctic, unless the development follows the path of “Antarctica” with tourism and research as main activities in the marine regions.

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Tiivistelmä

Paremmat sää- ja meripalvelut voivat vaikuttaa Arktisen alueen turvalliseen kehitykseen joko kysyntävetoisesti (toiminnan kasvu lisää aiempaa parempien sää- ja meripalvelujen kysyntää) tai tarjontavetoisesti (parantuneet sää- ja meripapalvelut lisäävät toimintaa). Tulevaisuuden sää- ja meripalveluiden kysynnän taustalla olevan prosessin ymmärtäminen ja palveluiden tuottamien hyötyjen analysointi tarvitsevat tuekseen ymmärryksen siitä, millainen Euraasian arktinen alue tulevaisuudessa voi olla. Tämä raportti esittelee kuusi sosioekonomista skenaariota Euraasian arktiselle alueelle vuodelle 2040 ja kuvailee lyhyesti, kuinka kukin skenaario vaikuttaa sää- ja meripalveluihin.

Kuudelle eri tulevaisuudelle annetut nimet *Wild West, Silicon Valley, Exploited Colony, Shangri La, Conflict Zone ja Antarctic,* kuvaavat Euraasian arktisella alueella olevan toiminnan mittasuhteita ja laajuutta vuodelle 2040. Skenaarioilla on kolme ulottuvuutta: *avoin – suljettu, julkinen – yksityinen* ja *likainen – puhdas*. Nämä ulottuvuudet kuvaavat skenaarioiden poliittisia, taloudellisia, sosiaalisia, teknologisia ja ympäristöllisiä lähtökohtia.

Skenaariot perustuvat kirjallisuuskatsauksen, ennakkokyselyn ja asiantuntijatyöpajan tuottaman materiaalin perusteelliseen analysointiin. Skenaarioiden tuottamiseen käytetty menetelmä on kuvattu raportissa ja sitä voivat käyttää muut skenaarioiden kehittäjät.

Analyysimme osoittaa, että Euraasian arktinen alue kohtaa monia mahdollisia muutospaineita. Ympäristömuutokset, poliittinen tahtotila ja teknologian kehittyminen voivat kaikki viedä eteenpäin jopa dramaattisia uusia kehityssuuntia. Toisaalta, huolimatta suuresta innostuksesta ja kiinnostuksesta minkä arktinen alue on saanut osakseen, Euraasian arktinen alue voi mahdollisesti pysyä syrjäseutuna globaalissa maailmantaloudessa. Tämä korostaa jokaisen päätöksentekijän tarvetta pystyä reagoimaan hyvin erilaisten tulevaisuuksien toteutumiseen. Siksi vakaa ja kestävä päätöksenteko, heikkojen signaalien ja kriittisten pisteiden havaitseminen sekä kyky valmistautua riskeihin ja tarttua tilaisuuksiin niiden ilmaantuessa ovat Euraasian arktisella alueella tarpeen. Sää- ja meripalveluiden kehittäminen on tärkeässä osassa mahdollistamassa alueen turvallisen kehityksen, paitsi silloin jos kehitys seuraa ”*Antarctic*” kehityspolkua, jossa matkailu ja tutkimus ovat alueen keskeisimmät toimintamuodot.

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Glossary

AACA	Adaptation Actions for a Changing Arctic, a project by AMAP
ACIA	Arctic Climate Impact Assessment, a project by AMAP
AMAP	Arctic Monitoring and Assessment Programme, an Arctic Council Working Group
AMSA	Arctic Marine Shipping Assessment
BBOE	Billion Barrels of Oil Equivalent
CAFF	Conservation of Arctic Flora and Fauna, an Arctic Council Working Group
IIASA	The International Institute for Applied Systems Analysis
ILO	International Labour Organization
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
LOSC	The Law of the Sea Convention
NEP	Northeast Passage
NSR	Northern Sea Route
NWP	Northwest Passage
OPEC	Organization of the Petroleum Exporting Countries
PAME	Protection of the Arctic Marine Environment, an Arctic Council Working Group
RCP	Representative Concentration Pathway
SPA	Shared Climate Policy Assumption
SSP	Shared Socioeconomic Pathway
TEU	Unit of cargo (twenty-foot equivalent units)
TSR	Trans-Siberian Railroad
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
USGS	The United States Geological Survey
WMS	Weather and Marine Services

1 Introduction

The world is changing, and so is the Arctic. The Arctic has already witnessed the impacts of climate change and with fullest force. At the same time, the changes in northern latitudes are often brought up as an example of possible positive impacts of the changing climate, with new trade routes, resources and economic opportunities emerging. Different nations, corporations and interest groups are now reforming their Arctic plans and strategies. The extent of activities in the area remains to be seen, but it is clear that any actions should be based on reliable information. The conditions in the Arctic are both changing and challenging, and the capability to produce information about these conditions is currently limited compared to most of the world.

TWASE is a research project funded by the Academy of Finland and aims ***T****owards better tailored* ***W****eather and marine forecasts in the* ***A****rctic to serve* ***S****ustainable* ***E****conomic activities and infrastructure*[1]. The project started in September 2014 and will finish in August 2018. TWASE will identify the emerging needs for Weather and Marine Services (WMS) in the Eurasian Arctic and develop these services in collaboration with relevant stakeholders. In addition to everyday weather forecasts, WMS include ice charts, warnings, and satellite-based observations. These are needed for economic activities such as navigation, aviation, fishing, energy production, manufacturing, and tourism due to their weather sensitivity. After identifying the needs for WMS, the project will estimate the future economic value of WMS.

To obtain an understanding of the emerging needs for WMS, the project team and a set of Arctic experts, mainly through input obtained in a two-day workshop (see Appendix 1 for participant list), have constructed a set of socio-economic scenarios by 2040 for the Eurasian Arctic[2]. The timeframe for the scenarios was set by the project team to reflect a relevant time horizon for the development of the WMSs; not too close to the present to allow for potential

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[1] http://polar-meteorology.fmi.fi/projects/twase.html

[2] The Eurasian Arctic covers the Northern Sea Route from the Norwegian Sea to the Bering Sea (both the coastal version and the straight crossing version) and the land areas nearby (mainly Northern Fennoscandia and Northern Russia).

development of economic activities and WMSs, but not too far in the future as this entails too large uncertainties for strategic decision making on WMS. Development paths of the drivers that result in the scenarios were not analysed, as this is not needed for the assessment of the future need and value of WMS.

The first step in the process was a literature review on existing Arctic scenarios, underlying driving forces and other relevant issues related to the Eurasian Arctic. To obtain an understanding of the importance and relevance of these drivers, an online pre-survey was sent out to the Arctic experts participating in the workshop, held on the 30th and 31st March, 2015 at the Finnish Meteorological Institute (FMI) in Helsinki, Finland. This report describes the process and discussions undertaken prior (Section 2.3 of this report) and during the workshop (Sections 3.1 and 3.2), presents the results of the workshop and the scenarios constructed based on the workshop results (Sections 3.3 and 4). The emphasis is on the Eurasian Arctic but, where relevant, the Arctic as a whole is discussed as well.

2 Literature review – the Arctic now and in the future

The aim of the literature review was to collect a diverse set of relevant background material and identify key development drivers to be used in the expert workshop, with a focus on socio-economic literature concerning Arctic development. To start, we explored reports by the Nordic Council of Ministers (e.g. Nordregio 2011), the Arctic Human Development Report II (eds. Larsen & Fondahl, 2014a) and reports by the Arctic Council and its working groups (e.g. Andrew 2014, PAME 2013, AMAP 2010, AMSA 2009, ACIA 2004, CAFF 2001). To gain a further understanding of the development trends mentioned in these reports, we searched for scientific papers dealing with issues such as oil and gas exploration and shipping in the Arctic. In addition, we explored existing socio-economic scenarios for the Arctic presented in the academic and grey literature. The report was written prior to the global climate negotiations in Paris, December 2015 (UNFCCC, 2015). Therefore, the anticipated phase-out from coal and oil use and its impact on Arctic resource extraction have not been discussed in this report.

2.1 The Arctic now

"The Arctic" can be defined in many ways. Perhaps the most common understanding of the Arctic is to define the area geographically as the polar regions that are located north of the Arctic Circle (66° 33'N). Arctic countries are then the eight countries that possess land areas within this region: Canada, Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, Russia, Sweden and the United States. These countries form the Arctic Council together with permanent representatives of Indigenous peoples and selected observer organizations. The Arctic is a diverse and heterogeneous area in many respects: different cultures, nationalities, economies and ecosystems coexist and interact together.

The population estimates for the Arctic vary between 4 to 10 million depending on what is considered as the Arctic area (Andrew, 2014). According to Heleniak and Bogoyavlensky (2014), the population has stabilized at just over 4 million and is not projected to increase much further. The number of Indigenous people has been growing annually by 1.5 % (Nordregio, 2011). Currently, over 5 million tourists visits the Arctic and sub-Arctic regions annually (Hall & Saarinen, 2010).

The Arctic population embraces different ethnicities, and many different identities and cultures exist, having major differences between them. The Indigenous peoples have lived in the area for millennia and non-Indigenous peoples have arrived through migration. Nowadays, the awareness of “mixed” identities in Arctic communities has increased. Contemporary Indigenous peoples try to find a liveable combination of “modernity” and “unchanging tradition”, but the official policies and legislation tend to rely on old-fashioned identity categories. However, a trend towards cultural focus can be seen both in sense of commodity and external recognition, which can be an asset in the future. (Schweitzer, et al., 2014).

Increased access and a longer navigation season have already had an impact on Arctic shipping and transportation. There are two major sea routes in the Arctic: the Northwest Passage (NWP) at the American side and the Northeast Passage (NEP) at the Eurasian side of the Arctic (see Figure 1). The Northern Sea Route (NSR), is a shipping line in the NEP, from the port of Dudinka to Murmansk. (AMSA, 2009).

In the NSR, an increase in the ship size and a change in the shipping season has been observed (PAME, 2013). Overall, Arctic shipping activities have increased since 2000 partly due to reduced sea ice; hence a growing interest in future ice conditions exists (Rogers, et al. 2013). Northern Sea Route Information Office (2016) provides transit statistics to NSR since 2011: 41 vessels entered NSR in 2011, 46 in 2012, 71 in 2013 and 53 in 2014 (of which 31 travelled the entire length). In 2013, the shipping season in the NSR lasted for 154 days and a total of 49 vessels transported 1.35 million tons of cargo, mainly oil products (911 000 tons = 67 % of the total cargo). 203 000 tons of iron ore (15 %) and some coal (5.5 %) and general cargo (7.4 %) were also carried. Of the total of 71 entries to NSR, only 41 vessels travelled the entire length. (Humpert, 2014).

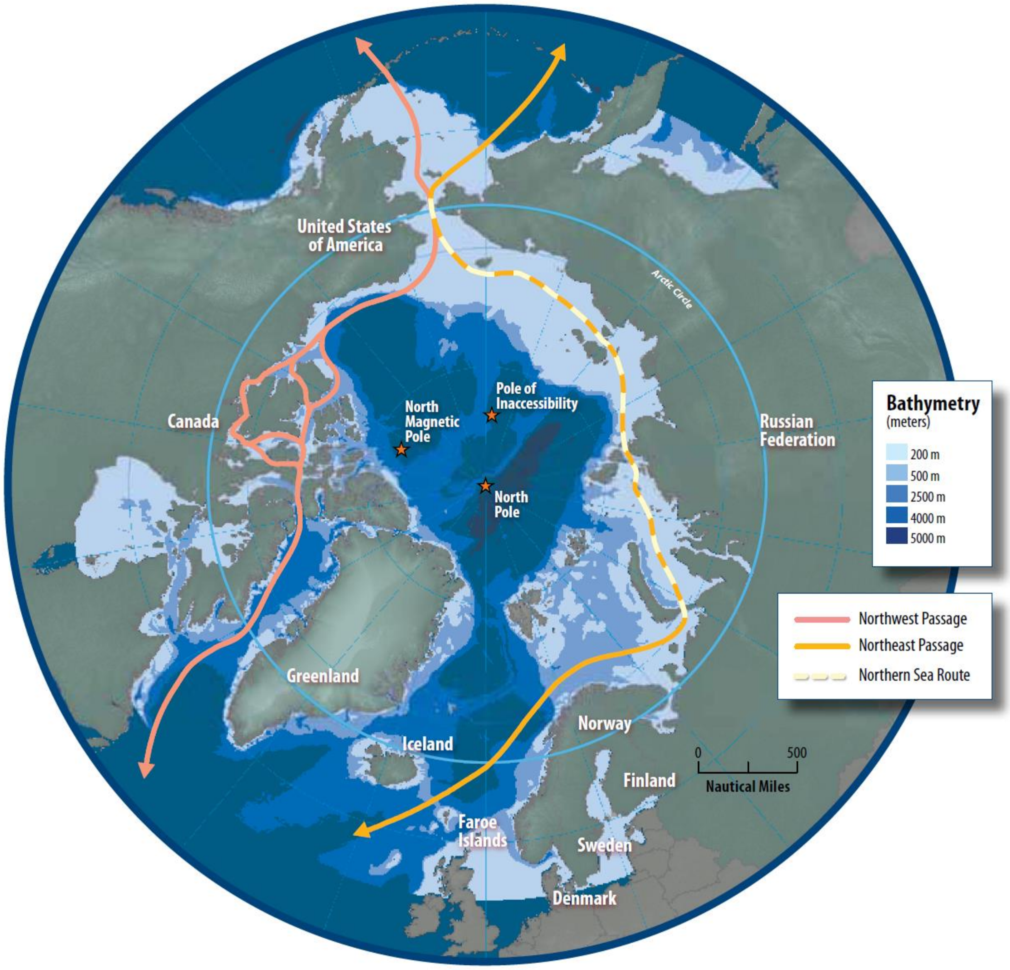

Figure 1. Sea routes in the Arctic. (AMSA, 2009).

The United States Geological Survey (2008) estimates the total amount of undiscovered petroleum resources in the Arctic at about 413 billion barrels of oil equivalent (bboe); 134 oil and 279 gas (Lindholt & Glomsrod, 2011). Over 70 % of the undiscovered oil reserves are estimated to occur in 5 provinces: Arctic Alaska, the Amerasia Basin, the East Greenland Rift Basins, the East Barents Basins, and in West Greenland-East Canada, whereas the gas reserves occur in 3 provinces: the West Siberian Basin, the East Barents Basin, and Arctic Alaska. 84 % of the resources occur offshore (USGS, 2008).

Harsem et al. (2011) conclude that Arctic oil and gas production is dependent on a complex set of variables including three key characteristics. First, the Arctic environment is difficult to operate in. Long term plans and predictions become difficult to make under a changing climate where historical data might not support cost effective investment decisions in the future. Second, extreme conditions imply high production costs compared to other regions. Hence, a sudden shift in price or demand may have a great effect on Arctic production. Third, high costs drive governments to take the lead, which might lead to colliding policies across different political levels.

The Arctic environment consists of fragile marine and terrestrial ecosystems, which are under pressure due to human influence. Because of air and water circulation patterns, local climates in Eurasian Arctic and American side of the Arctic differ, but in general the Arctic has cold winters, cool summers and low humidity (CAFF, 2001). Over the past decades, Arctic climate has been warming rapidly and the average temperature has increased twice the rate compared to rest of the world (ACIA, 2004). Still, climate creates harsh conditions for species to survive. Permafrost is an important element in the Eurasian Arctic land areas, which are mainly covered by taiga, forest tundra and tundra, and even polar deserts in the Arctic Ocean islands (CAFF, 2001). For instance, the Arctic vegetation is a home for reindeers, caribous, mountain hares and various birds. Arctic fish populations, marine mammals such as walruses and seals, and seabirds are prominent elements of Arctic marine ecosystems (PAME, 2013), but the diversity, ranges and distribution of populations are projected to change with proceeding climate change (ACIA, 2004).

2.2 The Arctic in the future?

The expected rapid environmental changes and potential geopolitical and economic significance have encouraged many authors and organizations to anticipate, predict or analyse the trends and future development of the Arctic region. Some concentrate on the key shaping forces while others go further into constructing conditional scenarios for the area as a whole or for certain activities.

One exercise identifying the key trends in the area is the *Megatrends* report published by the Nordic Council of Ministers (Nordregio, 2011). It draws attention to the megatrends that shape the changes in the Arctic, but it also goes further in discussing the wishes and priorities of Arctic societies and secure development. The report presents nine overarching megatrends affecting all development in the Arctic:

1. “Increased urbanisation – a global trend also including the Arctic”
2. “Demographic challenges – the old stay while the young leave”
3. “Continued dependency on transfers [*from royalties and governments*] and the exploitation of natural resources will continue to dominate the Arctic economies”
4. “Continued pollution and ongoing climate change will have a significant impact on the nature and environment of the Arctic”
5. “The Arctic needs to generate more Human Capital by investing more in its people”
6. “Changes in the nature of interaction between the public and private spheres will impact development”
7. “Renewable energy will contribute to a ‘greening’ of the economy”
8. “Increased accessibility provide opportunities as well as new risks”
9. “The Arctic as a new player in the global game”

Due to the nature of the report, some of the megatrends seem to have a rather political tone. Furthermore, these megatrends do not describe scenarios as such but are meant to pave way for more detailed foresight analysis and scenario construction. However, we consider these as suitable basis for our work.

Table 1 lists selected socio-economic scenarios for the Arctic areas. Many of these have a special emphasis on the maritime industry, energy issues and environmental management. For instance, the Arctic Council’s Arctic Marine Shipping Assessment (AMSA) created scenarios for Arctic marine navigation in 2050 in two workshops during 2007. The 60 workshop participants agreed that governance and resources & trade are the most critical among the 120 uncertainties identified. These two critical uncertainties form the axes of the AMSA scenario matrix (Figure 2).

Table 1. Summary of literature of socio-economic scenarios in the Arctic

Reference	**Subject of scenarios (industry)**	**Key drivers or variables**	**Scenario development method**	**Geographic coverage**	**Time horizon**
AMSA (2009)	Arctic marine navigation	Development of Arctic natural resources (hydrocarbons, hard minerals and fisheries); Regional trade	Expert workshop	The Arctic	2050
Loe et al. (2014)	Arctic business (various sectors)	Energy developments; Climate change; Environmental regulation; China's growth; Russian domestic policies; International relations; Arctic cool[3]; Communication; Technology	Workshops and in-depth interviews with business leaders and Arctic experts	The Arctic	2020
Perrels et al. (2014)	Container shipping	Economic growth	Modelling exercise (World Container Model)	Northern Sea Route	2040
Cavalieri et al. (2010)	EU's environmental footprint	Climate change; Governance	Expert workshop	The Arctic	2030

[3] Arctic cool refers to perceptions of Arctic in the eyes of the public.

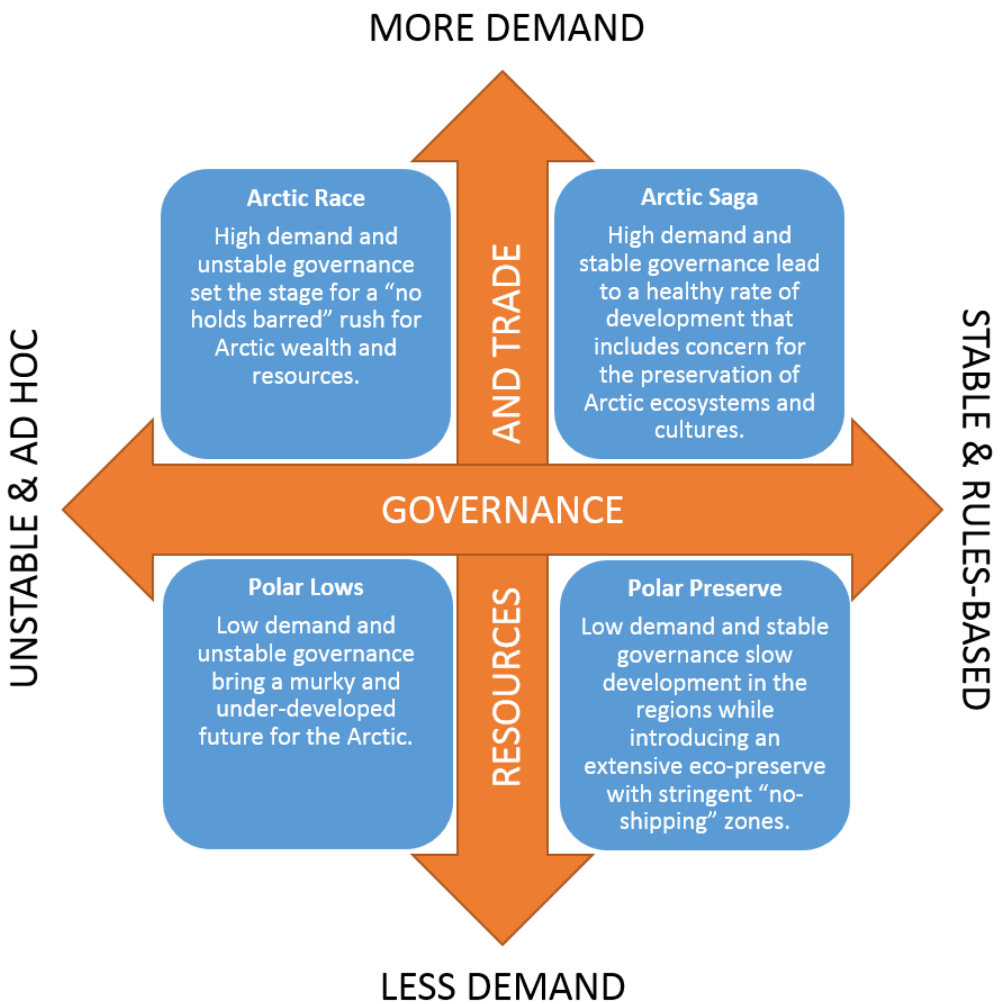

Figure 2. Scenario matrix for the AMSA scenarios for maritime industry. Modified from AMSA (2009).

Loe et al. (2014) present three scenarios for Arctic business towards 2020. The scenarios cover shipping, petroleum, mining and seafood industries, and business development opportunities in the Arctic. The first scenario is driven by oil demand, the second by adaptation to alternative energy sources and the third by increased regionalism. While the AMSA (2009) scenarios focus on maritime industry in general, the scenarios by Loe et al. (2014) focus on business activities. However, these scenarios have a rather short time horizon compared to the AMSA (2009) scenarios.

A more sector-specific scenario exercise was conducted as part of the FP7 ToPDAd project (Perrels, et al., 2014). In the "*Arctic Shipping case - theme 3*" in Perrels et al., 2014, container shipping on the NSR with a Polar Class 6 (PC-6) or Polar Class 7 (PC-7)[4] ship was compared to container shipping via the Suez Canal. PC-6 and PC-7 entail low cost adaptation to the existing container vessels (Perrels, et al., 2014). Container shipping constitutes more than 50 % (in value) of the maritime market (UNCTAD, 2012), and its share is growing. While referring to Bussiere and Schnatz (2006), the ToPDAd study assumes that the container based trade flows between Europe and East Asia will be 2 to 4 times larger in 2040 as compared to 2010-2011. From East Asia (Tokio, Pusan, Shanghai) the NSR is 10% to 30% shorter than the route via the Suez Canal. This means fuel savings and — depending on the ice conditions — time savings. Owing to the time saving potential, the NSR seems most competitive in the shipping of vehicles, machinery and other manufactured goods that take a 97% share of all container shipping, as these goods have a high value of time. In the most optimistic estimate (reached in the absence of large investments and high bunker fuel prices) the NSR traffic might expand up to 2.5 million TEU's (Twenty-foot equivalent unit). (Perrels, et al., 2014)

The Polar class ships have higher capital cost than normal ocean going ships and the size of ships using NSR is limited to 3800 TEU; the newest container ships have quadruple and even more capacity. The PC-6 and PC-7 ships' polar advantage can only be used from June – October. The rest of the year the ships need to use the Suez Canal at a cost disadvantage compared to standard container ships. As a consequence, the resulting container market niche for the NSR is quite sensitive to factors outside the control of the shipping companies and of the NSR manager (Russia), such as fuel prices and Suez Canal capacity and charges. Furthermore, enhancement of the Trans-Siberian Railroad (TSR), could add further competition to the NSR, as it can offer transport times of 15-25 days. As a result the more plausible projections for container shipping via the NSR up to around 2040 stay below the 1 million TEU per year. (Perrels, et al., 2014).

Due to the factors mentioned above, there seems to be little chance that the NSR becomes competitive year-round by 2040 (Perrels, et al., 2014). This is confirmed in Rogers et al.

[4] PC 7 vessel can operate summer and autumn in thin first-year ice, which may also include old ice, and it is the lowest type of polar class vessels (IACS, 2011).

(2013), which suggests that ice cover is reduced in the key access routes in the Arctic all the way through 2100 and the season for marine operations will lengthen by 1-3 months. Yet, unassisted access for the PC-7 vessel would occur only in the latter half of the century.

The EU Arctic Footprint –project (Cavalieri, et al., 2010) has created three scenarios for analysing the effectiveness of environmental and other policies in the Arctic in 2030. The scenarios are labelled Race for Resources, Business as Usual (BAU) and Eased by Efficiency. The scenario framework relies on four key parameters; climate change, efficacy of management of environmental pressures, economic growth in the EU, efficiency of resource use of EU actors, and different assumption of their state.

As shown by the examples above, Arctic development is tightly connected to the global climatic and socio-economic changes. Perhaps the most cited global climate scenarios are those developed for the Intergovernmental Panel on Climate Change (IPCC). The current scenario framework includes three components: Representative Concentration Pathways (RCPs) (van Vuuren, et al., 2011), Shared Socioeconomic Pathways (SSPs) (O´Neill, et al., 2014) and Shared Climate Policy Assumptions (SPAs) (Kriegler, et al., 2014). The four RCPs represent the changes in the greenhouse gas emissions, radiative forcing and climate and the five SSPs represent possible socio-economic development, such as population and economic productivity. SPAs refer to policies and measures that are needed to tie a certain socio-economic development into certain emission pathway; unlike RCPs and SSPs, there exists no predetermined set of SPAs (O´Neill, et al., 2014). Hence, SPAs could be considered as the global political attitude or will that is required to reach the climate target. The International Institute for Applied Systems Analysis (IIASA, 2015; IIASA, 2014) and Adaptation Actions for A Changing Arctic (AACA, 2016) in a project lead by AMAP, are currently developing Arctic scenarios under the RCP/SSP framework. At the moment in the TWASE project, the RCP/SSP framework is used as a general backdrop for the scenario development, but they have not been explicitly used behind the scenarios due to the interest toward aspects beyond the RCP/SSP framework.

2.3 Drivers of the Arctic change in PESTLE framework

Existing scenarios provide background for what has been considered as the key drivers and their trends in the Arctic. Complementing the top-down type of scenario literature overview with a bottom-up analysis, we searched for sources discussing individual drivers of the Arctic development. To categorise these drivers, the so called PESTLE[5] (Political, Economic, Social, Technological, Legal, Environmental) framework was used. This framework was later emphasised during the exchange with the workshop participants to ensure that the full range of factors in the development of the Arctic is considered. However, for that purpose the framework was slightly simplified by merging political and legal drivers, thereby the framework was a so-called PESTE framework.

2.3.1 Political

Geopolitics and power relations of the Arctic countries and others interested in the Arctic play a key role in Arctic development, as the Arctic countries already have competing interests concerning Arctic resources (Aaltola, et al., 2014). International cooperation and Arctic treaties create the rules of the game in the Eurasian Arctic, both in resource extraction and exploration, but also in shipping and other activities. Maritime boundaries that are diplomatically resolved reduce uncertainty in border areas and enable, for example, resource exploration (Andrew, 2014). Offshore petroleum and other resources are mainly governed by the states themselves, unlike shipping that is under international governance (PAME, 2013).

When it comes to energy and extractive resource issues, many countries emphasise their territorial presence in a resource abundant area. Sovereignty is found to be a major driver for exploring new resources in the Arctic, and therefore national interests shape development (Andrew, 2014). Another driver for Arctic resource exploration is the national interest to

[5] https://www.mindtools.com/pages/article/newTMC_09.htm

reduce dependence especially on energy imports. When fossil fuel reserves become more accessible, nations are tempted to utilize them (Andrew, 2014).

Global and national climate policies also shape the Arctic development by affecting the strictness of global emission pathway, which eventually has an impact on ice cover. According to Andrew (2014), Arctic shipping may potentially displace transit shipping elsewhere because of the reduced fuel consumption and expectation of reduced climate impacts. Climate policy may even incentivise Arctic shipping over other routes (Andrew, 2014). Climate agreements and regulations have political significance in developing the hydrocarbon sector in the Arctic as well (Strategic Assessment of Development of the Arctic, 2014).

2.3.2 Economic

The future of the Arctic and relevant economic activities are shaped by global economic development. For instance, the development of the shipping industry is driven by oil and iron ore prices, and oil and gas exploration and exploitation are driven by oil and gas prices and energy demand. The future energy supply systems need to respond to the increased demand for energy and electricity in the changing climatic conditions. The development of energy systems has an impact on the Arctic indirectly through climate change and directly through the exploration of resources. (Harsem, et al., 2011)

Arctic petroleum supply can be highly sensitive to development of petroleum prices (Lindholt & Glomsrod, 2011). High prices are a result of increasing demand for energy and declining production from existing conventional fields (Andrew, 2014). Increased demand for oil and gas will contribute to making previously marginal or unviable deposits competitive and exploitable in economic terms (Harsem, et al., 2011).

Historically, oil prices have been fluctuating and changing. A record oil price was reached in early 2008 (Figure 3). In general, crude oil prices may swing due to geopolitical events, changes in demand and supply (by OPEC and non-OPEC countries) and the emergence of new stocks[6]. However, peaks in oil prices have not been consistently followed by an increase in the number of licences issued by governments, seismic data acquisition, drilling and oil production because a complex relationship exists between all these factors (Crandall & Thurston, 2010).

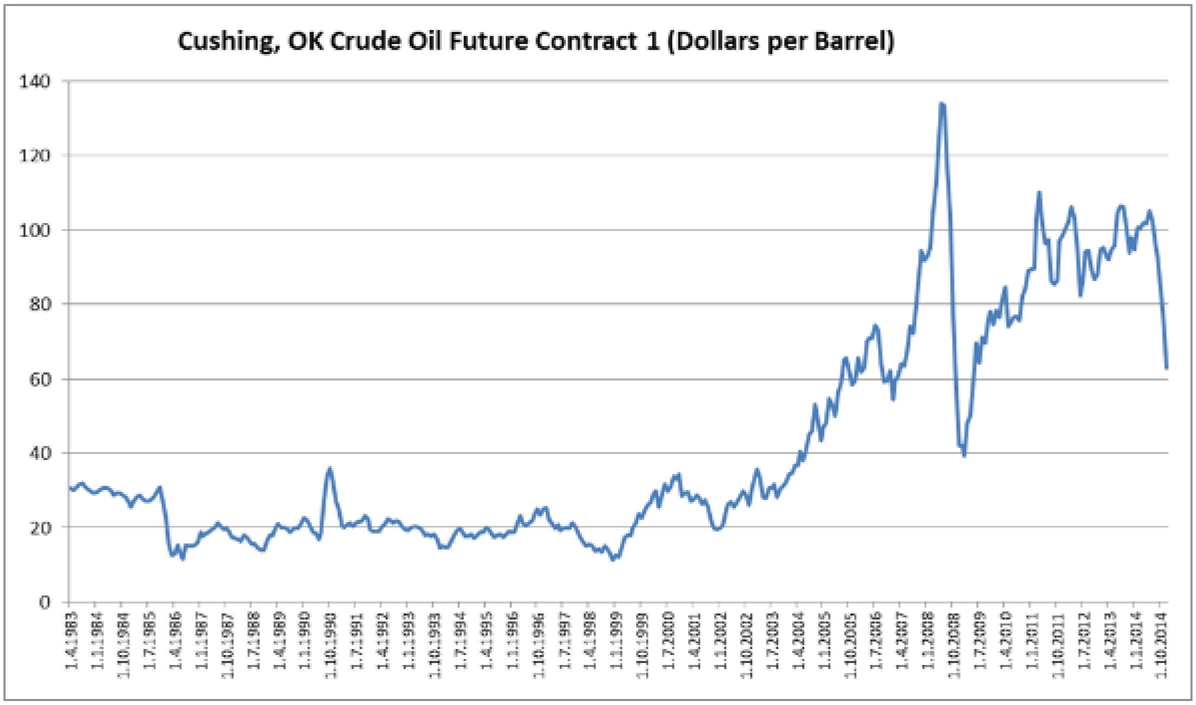

Figure 3. The development of crude oil price 1983-2014 (EIA, 2014b).

For the time being, the Arctic has more importance in supplying gas than oil. If the oil price is relatively high and producers acquire access, Arctic may gain importance as a global oil producer. 70% of undiscovered petroleum in the Arctic is natural gas, but the Arctic's share of global production is likely to decline by 2050 because of the new shale gas and oil sands reserves for example in Canada and USA (Lindholt & Glomsrod, 2011). U.S. Energy Information Administration projects that the crude oil price will be 92.93$ in 2020, 104.90$ in 2025, 114.69 in 2030, 125.59 in 2035 and 137.63$ in 2040 (EIA, 2014a). International

[6] http://www.wtrg.com/prices.htm

Energy Agency in turn estimates that the Arctic resources could be exploited at a cost of 35-100$ per barrel (IEA, 2008).

Petroleum production in the Arctic faces harsh weather conditions and high costs compared to other regions. Offshore and remote areas add to the challenges due to the lack of transportation infrastructure (Lindholt & Glomsrod, 2011). Large scale production plants have capital, technological and labour needs that are often brought from outside the Arctic, implying that much of the income that projects generate flow out of the region (Huskey, et al., 2014).

The oil price is one determining factor in the Arctic oil and gas exploration but it certainly is not the only one. Long-term price projection is important, because the discovery and exploration activities in the Arctic require a great deal of time (building infrastructure, ports, tankers etc.). Also even one large discovery or the depletion of old reserves may be drivers for further exploration. Trans-Alaska Pipeline System will potentially face prohibitive refit costs if certain threshold values of the throughput are reached (200000 barrels per day is technological limit and 400000 barrels per day economical limit), which also drives the exploration. In addition, incentives and public acceptance have an influence on exploration. (AMAP, 2010).

The shipping industry in the Arctic is also affected by the global economy, and, for example, changes in oil and iron ore prices. Shipping decisions are affected by the fee for the use of NSR and fuel costs (Perrels, et al., 2014). Furthermore, Arctic shipping routes may have reduced costs compared to other competing routes, which may attract shipping (Andrew, 2014).

According to Buixade Farre et al. (2014), NEP has the most potential of the Arctic shipping routes to enable economic activity in the area and shipping related to extraction of resources has the most immediate potential for expanding the activities along the route. More specifically, Lasserre and Pelletier (2011) looked only at NSR and found that the bulk sector (oil, gas and minerals), which does not rely on schedules so heavily, and vessels servicing local communities would benefit from the route. Container ships, on the other hand, rely on strict schedules, which might be difficult to hold in Arctic waters unlike the route via Suez

Canal. Hence, the Arctic conditions create challenges to the container sector. (Buixade Farre, et al., 2014). A theoretical potential assuming that the NSR is similar to Suez route in all ways but in distance, the trade volume of NSR could account a little less than 4 % of world trade (Morgenroth, 2014).

Despite the theoretical potential, there are many restricting factors:

- the route bathymetry is low restricting the size of cargo, (50 000 deadweight tons, or 2500-4500 TEU's) (Buixade Farre, et al., 2014);
- new routes have difficulty being established due to competition structure of the industry, as found in a survey among shipping companies (Lasserre & Pelletier, 2011);
- weather conditions, drifting ice and icebergs still cause risks (Perrels, et al., 2014; Lasserre & Pelletier, 2011);
- navigation aid and porting facilities are limited (Perrels, et al., 2014; Lasserre & Pelletier, 2011);
- other competing routes (e.g. Suez Canal) still hold a competitive advantage. They offer greater vessel capacity, predictability and access to multiple markets and ports offering maintenance and support. (Buixade Farre, et al., 2014).

In theory, NEP could save about 40 % of sailing distance from Asia to Europe. However, that does not correspond to equal savings in costs. For example, higher building costs for ice-classed ships, non-regularity and slower speeds, navigation difficulties and greater risks hinder the growth of shipping in the Arctic. From a single user's perspective, navigable time of the NEP, Russian NSR fees and bunker prices have the largest influence on the use of NEP, and competitiveness of NEP correlates with the ice-breaking fees. (Liu & Kronbak, 2010).

Tourism can also be seen as an economic driver for Arctic development. Yet, it is regarded as a benign development alternative compared to resource exploration and extraction (Hall & Saarinen, 2010). Major obstacles influencing future tourism in the Arctic are physical access, tourists' ability to pay, time and cost that is associated with traveling to remote areas, capacity and availability of infrastructure, environmental conditions and jurisdictional restraints (AMSA, 2009).

2.3.3 Social

The population projections in different parts of the Arctic region vary (see Figure 4). The societal development is to large extent driven by interlinked drivers of migration both in and out of the area (Andrew, 2014), increased urbanisation and demographic structure (Nordregio, 2011).

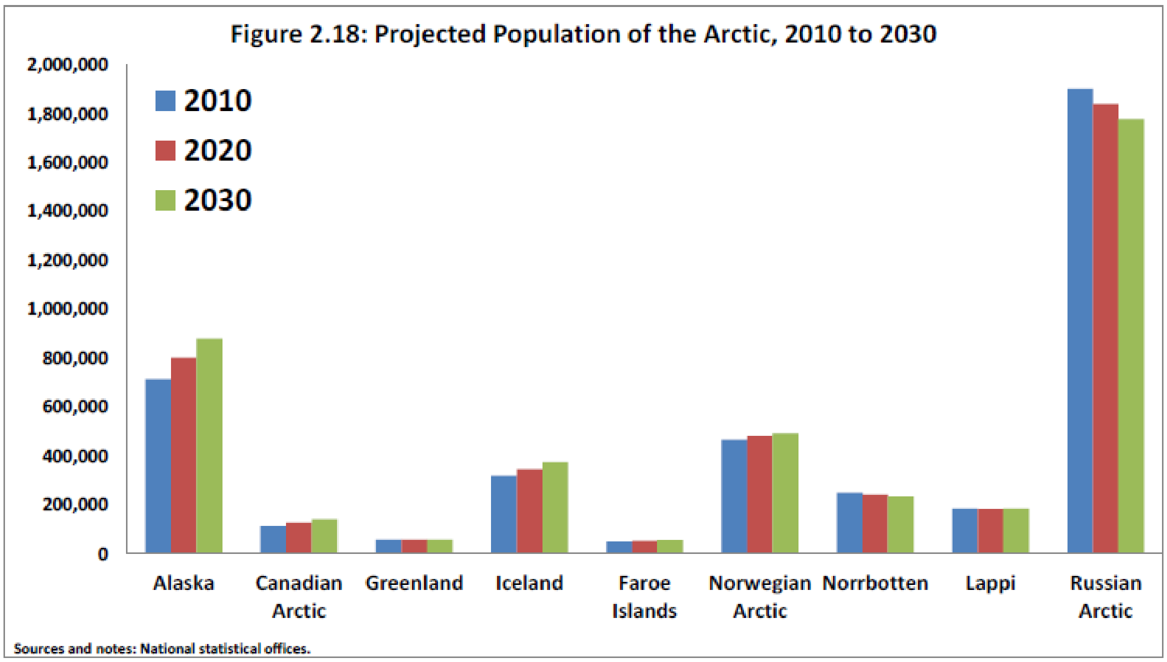

Figure 4. Projections for Arctic population by region in 2010, 2020 and 2030 (Heleniak & Bogoyalensky, 2014).

Despite the rather small population, demography is one key issue in societal development. Ageing of the population, on the one hand, and the decreasing youth, on the other hand, are important factors for the development of Arctic communities (Heleniak & Bogoyalensky, 2014). Urbanization is a global megatrend that is also seen in the Arctic. Especially the young migrate from the region due to, for example, the lack of education opportunities but the old remain (Nordregio, 2011). This has naturally implications for the service needs of Arctic societies.

Indigenous populations in the Arctic are, in general, in an earlier stage of demographic transition than non-Indigenous populations since many Indigenous populations have relatively young age structure (meaning there are relatively more young people than old people). Consequently, Indigenous peoples tend to make up an increasing share of the population (Heleniak & Bogoyalensky, 2014). However, this development varies between regions.

2.3.4 Technological

Technological advancements in all sectors and scales shape the development. In the Arctic, improved technologies regarding hydrocarbon production, shipping and transportation especially affect the future development (Andrew, 2014). For instance, the increase of interest in oil and gas activities in Arctic waters in the past years was also instigated by developments in offshore drilling technology and sea ice retention (PAME, 2013). The characteristics of the vessel (e.g. its carrying capacity and Polar Class[7]) are also important in Arctic waters. Innovations in shipbuilding technology play a part in the potential increase of Arctic container shipping (Perrels, et al., 2014). Particularly important is the vessel's ability to break the ice and make both narrow and wide channels. An example of such technology, the oblique icebreaker concept, has been developed in the mid 1990's by Aker Arctic (Hovilainen, et al., 2014).

Navigation technology is another factor affecting the extent of offshore activities and willingness to exploit the potentially shorter Arctic routes. Enhancements in weather and ice forecasting and nautical charts to aid navigation should also be of interest to Arctic states and individual Arctic mariners can receive this detailed and location-specific information when operating the sea (PAME, 2013). Navigation and extent of sea ice go hand in hand, but economics, infrastructure, bathymetry and weather have also a role in navigation related decision-making (Stephenson, et al., 2013). Hence, development or under-development of

[7] For more information on Polar Class categories see IACS (2011).

navigation technology and other supporting technologies and information does shape the scale of shipping and transportation activities in the Arctic.

Recently, monitoring and surveillance of ship traffic in the Arctic Ocean has progressed. Automatic identification systems for collision avoidance required by the International Maritime Organization (IMO; a UN agency), ground-based radars and satellite tracking of ships provide information on shipping routes, traffic and vessels (PAME, 2013). Utilizing and further developing satellite-based technology would enable safer passage. There are public and private plans to increase satellite coverage over the Arctic, improving communications, air and marine traffic management and environmental observations (Iceye Oy, 2015; Norwegian Space Center, 2015; Magnuson, 2014; Zeppenfeldt, 2009). Autonomous airships have also been proposed as another technological solution to improve these services, as well as hauling cargo (Sarkadi, 2012).

2.3.5 Legal

There are three federal states and five unitary states (including Greenland and Faroe Islands, the autonomous territories of Denmark) in the Arctic; each possessing their own formal legal systems. Furthermore, global and regional domains of international law apply in the Arctic and the European Union (EU) member countries and signatories of European Economic Area Agreement are committed to comply with the regulations of the EU. Customary norms of Indigenous peoples are less formal than legal systems, but in recent decades states have started to account for these traditional norms, habits and values in national and regional legislation. (Bankes et al., 2014).

In general, domestic laws have offered increased language rights to Indigenous peoples but the legislators have been reluctant to recognize their land ownership rights. However, international instruments that address the rights of Indigenous peoples are continuously being elaborated. Some examples of this type of development are the United Nations Declaration on the Rights of Indigenous Peoples and ILO Convention 169[8]. (Bankes et al., 2014)

The United Nations Convention on the Law of the Sea (UNCLOS) is of primary importance in the Arctic because of the vast maritime area the Arctic holds and the historical accessibility to the area. Land areas form the basis for national maritime zones but overlapping claims prevail in the crossroads of continents and countries. The claims are continuously under disputes, but the current development shows a trend towards delimitation (Bankes et al., 2014).

In addition to the territorial aspects, there are also an increasing amount of regulations guiding activities in Arctic waters. The Polar Code, a mandatory international code issued by IMO for ships operating in the Arctic and Antarctic waters has been adopted and will enter into force in 2017. The Polar Code applies to passenger and cargo ships above 500 tons gross tonnage and concerns a range of design, construction, equipment, operational, training, search and rescue, and environmental protection matters. The code will be legally binding for vessels operating in the Arctic. (UNCTAD, 2014, p. 84). Even though IMO is responsible for setting technology standards for ships operating in the Arctic, individual states can impose stricter standards (Buixade Farre, et al., 2014). High safety levels and strict standards help to avoid potential risks and adverse effects to the Arctic marine environment (PAME, 2013).

2.3.6 Environmental

Climate change, a global phenomenon that is changing the Earth system and societies, is shaping the Arctic environment by melting the sea ice cover, thereby creating both opportunities and threats to society and economic activities. The Arctic ecosystems have already experienced changes due to climate change, for example,

- warming of surface-water in mid and high latitudes,

[8] International Labor Organization's Convention concerning Indigenous and Tribal Peoples in Independent Countries

- decrease of the sea ice cover,
- spatial shifts of fish populations,
- earlier phytoplankton bloom, and
- changes in land cover (Larsen, et al., 2014).

These will drive changes in the economy as well. According to the Arctic Human Development Report (2014), the three pillars of the Arctic economy are large scale resource production, traditional and small scale resource production, and transfers from governments (public sector jobs, provision of services, direct payments to residents) (Larsen & Fondahl, 2014b). Sectors that exploit natural resources, such as agriculture, forestry and fisheries have already undergone changes relating to the timing of activities, management of the resource base and productivity. The transport sector has also benefited from climate change because navigation season is longer due to the decreased sea ice cover. As suggested in Mokhov & Khon (2008), ice free conditions have increased by 22 days in NSR between 1979-1988 and 1998-2007. By the end of the 21st century, NSR may be open for navigation about 4.5 months a year. In general, accessibility to the Arctic is the major environmental driver of Arctic development (Andrew, 2014).

Greater marine access and longer navigation seasons are expected due to the retreat of Arctic sea ice (PAME, 2013), which is caused by the proceeding climate change. The length of the navigation season depends on the timing, extent and thickness of the Arctic sea ice cover, which are also important from the shipping and transportation perspective (Buixade Farre, et al., 2014).

Overall, climate change and the changing Arctic environment can make offshore exploration, drilling and production of hydrocarbons easier. However, activities may also become more difficult, as experienced in recent years as the ice cover behaviour has become less predictable. This expectedly causes both risks and opportunities to the oil and gas industry (Harsem, et al., 2011).

3 The Scenario Construction Methodology

The scenario construction was completed in four major phases (Figure 5). The literature review (Chapter 2), pre-survey and workshop provided input to the final scenario construction work, conducted by the project team, and resulted in the final scenario narratives. This Chapter describes the pre-survey, workshop and restructuring and analysing processes.

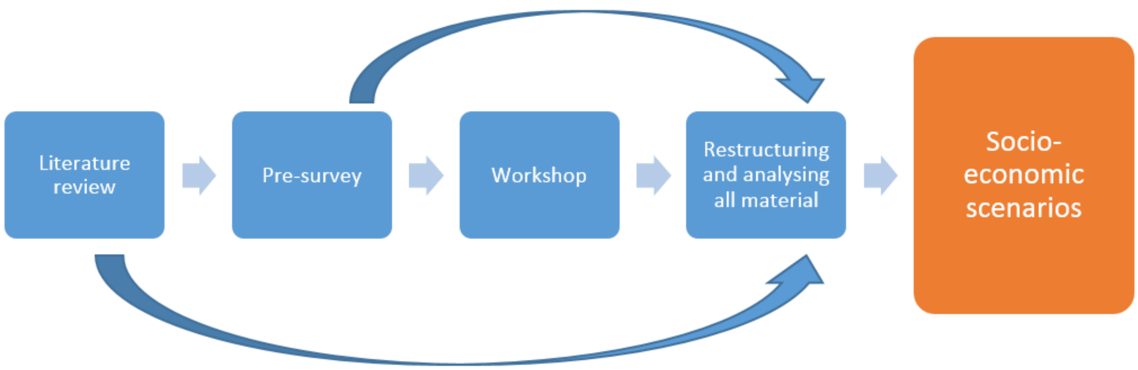

Figure 5. Process of scenario construction.

3.1 Pre-survey

Before the workshop, the participants were asked to rank a set of global and local drivers guiding Arctic development based on their perceived importance. The majority of the drivers were pre-defined based on literature (see Section 2.3). Some drivers were chosen based on the TWASE research plan and on expert opinions[9], and some impacts of the drivers were also added to the list (livelihoods of Indigenous peoples). Table 2 shows the list of drivers and impacts used in the pre-survey. The purpose of the pre-survey was also to collect background information about the expected participants.

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[9] Discussions with FMI research professors Adriaan Perrels and Timo Vihma (leader of TWASE project).

Table 2. List of the factors used in the pre-survey.

Factor	Reference
Climate change	Andrew (2014) (on accessibility)
Level of international co-operation	Modified from Aaltola et al. (2014) and Andrew 2014
Environmental awareness	Expert opinion
Global demand for fossil fuels	Harsem et al. (2011); Andrew (2014)
Global climate policy	Modified from Andrew (2014) and Strategic Assessment of Development of the Arctic (2014)
Global economy	Harsem et al. (2011)
Global demand of minerals	Modified from Andrew (2014)
Fossil fuel price levels in global market	Harsem et al. (2011); Lindholt & Glomsrod (2011)
Mineral price levels in global market	Andrew (2014); Harsem et al. (2011)
Development of Arctic engineering (including control of extreme conditions)	Modified from UNCTAD (2014) (IMO Polar Code)
Development/coverage/distribution of infrastructure	Modified from Lindholt & Glomsrod (2011)
Competitiveness of the Northern Sea Route compared to other trade routes	Modified from Andrew (2014); Morgenroth (2014); Liu & Kronbak (2010)
Arctic treaties (navigation and environmental)	Modified from PAME (2013)
Extreme natural conditions and their variability	Modified from Andrew (2014)
Developments in shipbuilding technology and winter navigation technology	Modified form Andrew (2014); Stephenson et al. (2013); Perrels et al. (2014)
International co-operation in the Arctic	Aaltola et al. (2014); Andrew (2014)
Minimizing risks of natural and manmade hazards	Modified from PAME (2013)
Development in satellite technology	Expert opinion
Geopolitical situation (tense vs. cooperative)	Aaltola et al. (2014)
Utilization and accessibility of mineral resources	Modified from AMAP (2010)
National climate policy	Modified from Andrew (2014) and Strategic Assessment of Development of the Arctic (2014)

Common Arctic security policy	Based on expert opinion
Tourism	Modified from AMSA (2009)
Land rights (not including the off-shore locations)	Based on expert opinion
Utilization and accessibility of fossil fuel reserves	Modified from Harsem et al. (2011); Lindholt & Glomsrod (2011); AMAP (2010)
Emphasizing territorial presence (e.g. by keeping areas populated)	Modified from Andrew (2014) (sovereignty and autonomy of resources)
Marine fisheries	Modified from Larsen et al. (2014)
Livelihoods of Indigenous peoples	Modified from Larsen et al. (2014) (an impact)
Certification of Arctic products and services (greentech and cleantech)	Expert opinion

Following the logic used in Andrew (2014), the drivers were divided into local and global drivers in order to separate the drivers emerging from within the Arctic and from global development. The results of the pre-survey are shown in Figure 6 for global drivers and Table 3 for local drivers. The drivers are listed in order of their perceived importance. The pre-survey results were presented in the workshop and used as a starting point for the workshop activities. Section 3.3.2 explains how the pre-survey is incorporated in the final scenarios.

Figure 6. Global drivers identified in the pre-survey in the order of importance. [10]

[10] Map credit to: http://ewgukraine.wikispaces.com/Earth+Day. Texts added.

Table 3. Local drivers identified in the pre-survey in the order of importance.

Local drivers
Development of Arctic engineering (including control of extreme conditions)
Development/coverage/distribution of infrastructure
Competitiveness of the Northern Sea Route compared to other trade routes
Arctic treaties (navigation and environmental)
Extreme natural conditions and their variability
Developments in shipbuilding technology and winter navigation technology
International co-operation in the Arctic
Minimizing risks of natural and manmade hazards
Development in satellite technology
Geopolitical situation (tense vs. cooperative)
Utilization and accessibility of mineral resources
National climate policy
Common Arctic security policy
Tourism
Land rights (not including the off-shore locations)
Utilization and accessibility of fossil fuel reserves
Emphasizing territorial presence (e.g. by keeping areas populated)
Marine fisheries
Livelihoods of Indigenous peoples
Certification of Arctic products and services (greentech and cleantech)

3.2 Workshop

3.2.1 Aim and Objectives

The purpose of the workshop was to collect expert input for scenario construction for the Eurasian Arctic by 2040 with the aim to collect the framework ("skeleton") for the socio-economic scenarios and to start putting "flesh on the bones" for the detailed scenario description with innovative workshop methods/techniques. A scenario development toolkit described in Wulf, Brands and Meissner (2010ab-2011ab) gave the inspiration for the approach and methods used.

The specific objectives of the workshop were to

- Identify factors that critically affect Eurasian Arctic development (day 1)
- Understand the causes and effects of development trends (day 1 and 2)
- Develop preliminary socio-economic scenarios for the Eurasian Arctic by 2040 (day 2)

The key sectors relevant for scenario-building emphasized during the workshop were natural resource extraction, tourism and shipping. These sectors were the primary focus of the workshop but any issues brought up or suggested by the workshop participants were also discussed.

Twelve experts participated in the workshop; of which five were from outside the Finnish Meteorological Institute. The workshop was facilitated by four members of the project team. The techniques used in the workshop were

- brainstorming and online voting to identify the axes for the scenario matrices,
- futures wheel to analyse primary and secondary impacts of the development trends, and
- backcasting to develop the preliminary scenario matrix.

The activities during day 1 were completed in one group and during day 2 the participants were divided into two separate groups until a joint discussion, which concluded the workshop. During the workshop, the participants were encouraged to frame the analysis of various factors and actors that drive the development of the Arctic under the PESTE-framework: political, economic, socio-cultural, technological and environmental factors and actors.

3.2.2 Day 1

Day 1 of the workshop started with the introduction to the TWASE project given by the project coordinator. The introduction was followed by general information about the workshop and a presentation on the pre-survey results, which was used as a starting point for the two-day discussion.

Activity 1: Brainstorming

The first activity of the workshop was to identify relevant factors and actors that have an impact on the development of the Eurasian Arctic by 2040. This was done in a brainstorming session followed by facilitated discussion. The factors were defined as development trends or processes that influence the activities or the environment in the Eurasian Arctic in some way. The actors were defined as organizations or parties that can actively influence or have a stake in the Arctic development. The PESTE-framework played a key role in this activity.

The results of the brainstorming were then clustered under themes. The clustering was done by the facilitators with active participation and commenting from the workshop participants. Emerging themes were: non-governmental organisations (NGOs), local inhabitants/communities, consumers, economics, business, resources, shipping, energy, technology, climate change, policy issues, non-Arctic interests, and surprises. These themes include both factors and actors.

Activity 2: Online voting, heat map and axis formation

During the brainstorming session, the project team identified important development trends, which arose from the discussions. These development trends were formulated by the project team into one or two statements for each actor and factor cluster themes and were used in the next step. The statements describe a possible development trend of each cluster identified during the brainstorming (Table 4). The idea was to formulate them into a declarative form to enable the voting process. The purpose of the statements was to find out and measure how the participants perceive the impact of the possible development trends or events on the Arctic by 2040 and the likelihood and related uncertainty of each trend or event.

Table 4. Statements formulated by the project team.

Actor / Factor	**Statement:** **Development trend of the actor/factor**
ENV. NGOs	Rise of environmental awareness
LOCAL COMMUNITIES	Increase in political power of local communities
CONSUMERS	Increase in Arctic tourism
ECONOMICS	Rise of Asian economies
BUSINESS	Increase in business activities in the Arctic
RESOURCES	Increased demand of non-fossil resources
SHIPPING	Major increase in Arctic shipping
ENERGY	Shift to post-petroleum age
TECHNOLOGY	Major improvements in (Arctic) technologies
CLIMATE CHANGE	Ice cover continues to retreat rapidly
POLICY ISSUES	Arctic treaties hold
	Tightening of global CC (climate change) policy
NON-ARCTIC INTEREST	Rise of global interest towards the Arctic
SURPRISES	Major environmental incident
	Destabilization of geopolitics in the area

The impact and uncertainty/likelihood of the statements were determined by anonymous online voting by using the PollEverywhere software[11], which the participants used with their mobile phones or computers. Each statement was first voted according to its impact on a five point scale and then according to its likelihood and uncertainty on a seven point scale. Before

[11] http://www.polleverywhere.com

and after each voting round, a short discussion was facilitated to make sure all the participants had a shared understanding of the statement and that everyone had been able to vote as they wanted.

The voting resulted in a heat map (see Figure 7), which shows the collective perception on the impact and uncertainty/likelihood of each trend or event. The horizontal axis describes the likelihood and certainty of the occurrence of the statements. The statements considered most certainly likely are on the right and most certainly unlikely on the left – the more perceived uncertainty there was, the closer to the centre the statement is. It should be noted that in this system, there are two sources for the perceived uncertainty: either the participants' views separated so that others considered a trend likely and other unlikely, or then many participants considered the trend to be uncertain. The vertical axis describes the impact of the statement on Arctic by 2040, ranging from low impact (at the lower end of the axis) to high impact (at the upper end of the axis).

The results of the heat map can be used to categorize the trends or events into "predetermined trends", "critical uncertainties" and "secondary elements". Predetermined trends will most likely happen and have a great impact on the Arctic. Critical uncertainties are those that have a high impact on the Arctic development by 2040, but their occurrence is highly uncertain. Secondary elements may be used for further differentiation in final scenario narratives but they are not important in developing the scenario frames. Eventually, the critical uncertainties form the basis of the choice for the axes in the scenario matrix.

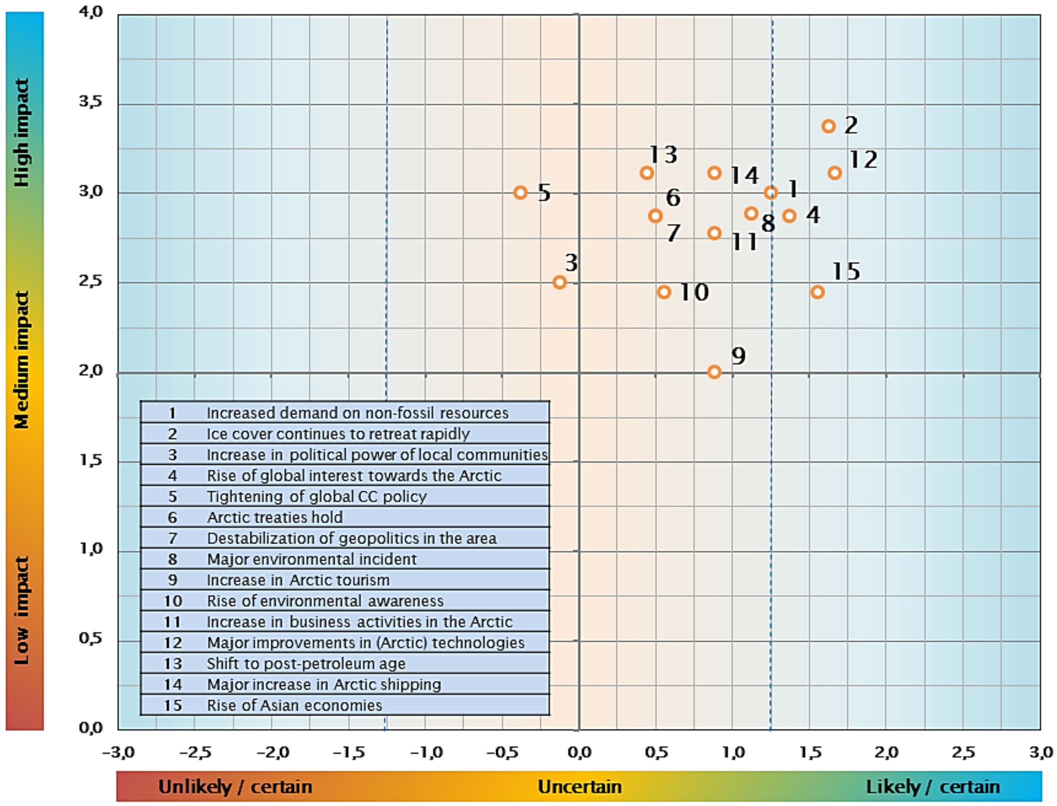

Figure 7. Heat map of the voting results. The horizontal axis corresponds with certainty and likelihood: the closer a point is to the centre, the more uncertain the trend is. Towards the borders, the trends are considered either more likely (to the right) or unlikely (to the left). Vertical axis corresponds to the estimated impact of the trend to the Arctic area. The likelihood was voted on a seven point scale and the impact on a five point scale.

The heat map shows, for instance, that the participants assigned relatively high certainty to the *Arctic ice cover continues to retreat rapidly* (2) and that it has the highest impact on Arctic development. Therefore, this can be considered a predetermined trend. The same goes for the *major improvements in (Arctic) technologies* (12), which was rated as having a slightly smaller impact, but with a bit higher certainty. *A shift to post-petroleum age* (13) and *a major increase in Arctic shipping* (14) also have a high impact on the Arctic, but were considered more uncertain. *Increased demand for non-fossil resources* (1) is also considered to have more uncertainty yet quite high impact. The most uncertain events were considered to be *tightening of global climate change policy* (5) and *increase in political power of local communities* (3). The former was considered to have quite a high impact on the Arctic and the latter medium impact. *Rise of Asian economies* (4) is very likely but it is not considered to have a very high impact; therefore, it can be considered a secondary element. The most critical uncertainties were: *Tightening of global CC policy* (5), *Shift to post-petroleum age* (13), *Major increase in Arctic shipping* (14), *Major environmental incident* (8), *Arctic treaties hold* (6), *Destabilisation of geopolitics in the area* (7), *Increase in business activities in the Arctic* (11), and *Increased demand of non-fossil fuel resources* (1).

The initial purpose of the heat map was to identify the critical uncertainties in order to construct the axes for the scenario matrix, as suggested in Wulf et al. (2010b). However, the critical uncertainties identified were thematically far apart from each other; therefore, the common features of all the statements (not necessarily the critical uncertainties, however) were discussed and the first suggested axes for the scenario matrices was *Institutional/immaterial - material and non-economic - economic*. In this matrix, the critical uncertainties would fall on the matrix as shown in Figure 8. The first suggestion was further elaborated in discussions.

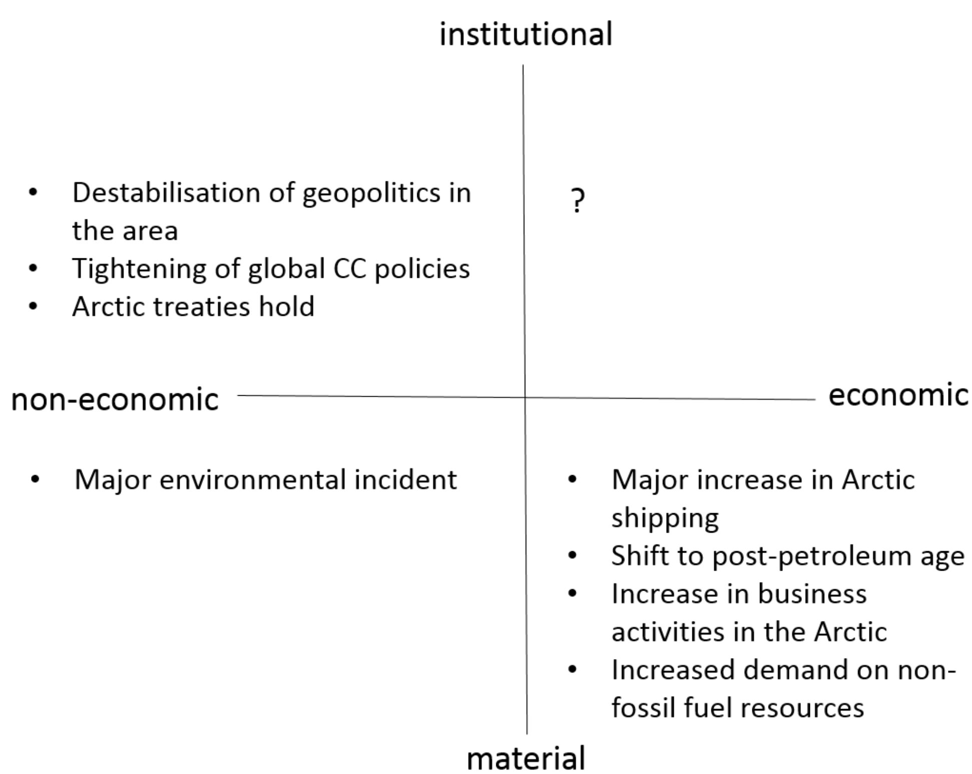

Figure 8. First suggestion for scenario matrix.

This received some criticism for instance due to the unclear definition of the dimension *institutional*. The group concluded that there should be more than one scenario matrix with two dimensions. This gave rise to two new suggestions: 1) open – closed and public – private; and 2) clean – dirty and regulated – unbounded. As the workshop participants considered all of these dimensions meaningful and were not able to reach an agreement regarding the dimensions for the final scenario matrix — a common step in scenario construction — it was decided that these four dimensions would form the basis for the construction of two scenario matrices and as background material for the project team in the final scenario construction. A third dimension - *business as usual* - *something else* – was added to both scenario matrices to provoke new ideas and stimulate out of the box–thinking of radically different future developments.

3.2.3 Day 2

On Day 2, the participants were divided into two groups, which worked separately until the final joint discussion.

Activity 3: Futures wheel

To obtain a better understanding of the complex feedback-systems and cause and effect - chains in the Eurasian Arctic, a method called *futures wheel*[12] was used. In the futures wheel, an initial, nearly certain predetermined trend is placed in the centre of a board. This can be, for instance, a trend which was perceived to have a high impact on the Arctic. First, the participants identify primary, first-order impacts of the trend, which is followed by identifying second-order impacts.

The two predetermined trends chosen for this activity were: "*Ice cover continues to retreat rapidly*" and "*Rise of global interest towards the Arctic*". These trends were chosen based on the voting and the project team's discussions. The Ice cover retention was voted as the trend

[12] See description of the Futures Wheel in https://www.mindtools.com/pages/article/futures-wheel.htm.

with the highest impact, and the rise of global interest was seen as a driving force to many other predetermined trends with high impact.

After the groups had identified the first and second-order impacts, the futures wheels were swopped and the groups were given a chance to comment on the work of the other group. The resulting futures wheels are depicted in Figure 9 and Figure 10. The pictures are transcribed from flap boards and post-it notes. Primary impacts are shown in green background, secondary impacts in yellow background and additions made by the second group in blue background.

Figure 9. Futures wheel: Rise of global interest in the Arctic.

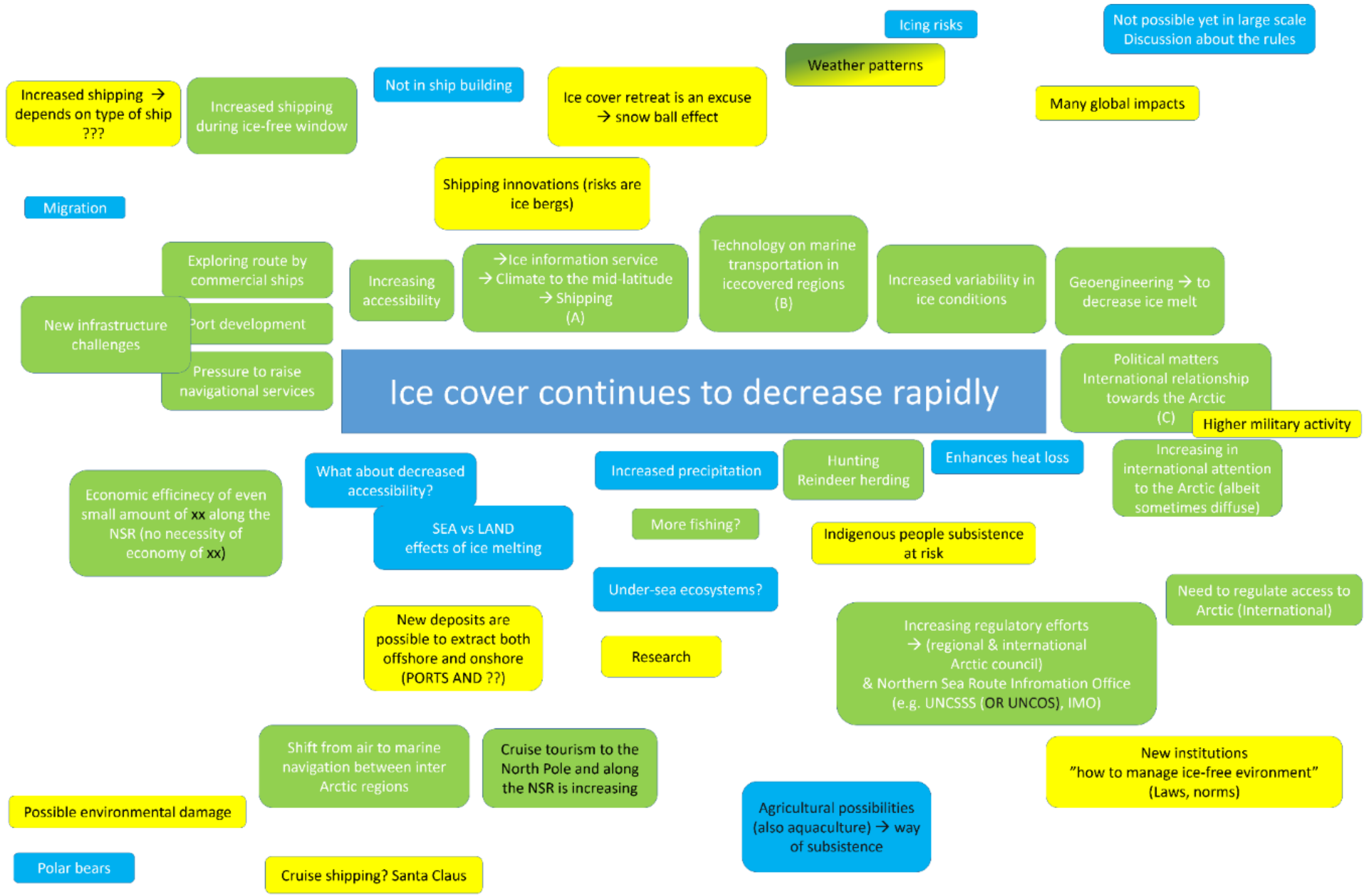

Figure 10. Futures wheel: Ice cover continues to retreat rapidly.

Activity 4: Scenario matrix construction

The last activity of Day 2 was to describe how the world looks like in each of the quadrants of the scenario matrix. One group worked with the axes *regulated* - *unbounded* and *dirty* - *clean*, and the other worked with the axes *public* - *private* and *open* - *close*. Again, the participants were instructed to think the world from the point of view of the PESTE-framework: what political, economic, socio-cultural, technological and environmental aspects prevail in the scenarios? This session resulted in preliminary scenario frameworks (Figure 11 and Figure 12). In the final discussion, the facilitators presented the scenarios, and the differences and similarities of the two different scenario sets were discussed.

The 4 scenarios in *regulated* - *unbounded* and *dirty – clean* matrix (Figure 11) were created by thinking dirty or clean environment as a result of dirty or clean intentions of the regulated or unbounded actors. In the dirty and regulated world, the proposed standards in technology are not sufficient to meet the criteria for clean environment, regulation is complex and not enforced properly with sufficient tax levels. Economic and political decision-making is rather short sighted. Military support is utilized in resource use and money flows to military technology instead of health or other wellbeing. In the regulated and clean world there is a clarity of natural carrying capacity which guides technological development. The Arctic is considered as a natural preserve due to social and environmental wellbeing and political will. Intergovernmental organisations have active role in supervising Arctic development. In the dirty and unbounded world the Arctic states rely on corporations and prioritize economic development over environmental concerns. The resources are depleted quickly due to the lack of enforcement capability and denial of common property rights. Extensive conflicts or even war occurs. Indigenous peoples are treated irresponsibly and people and workforce only fly in and out of the Arctic, with no intention to stay. The unbounded and clean world has a cleantech boom but a shortage in technology and infrastructure of wellbeing. In general, there is sufficient trust between actors and transparency and monitoring in economic activities gives more power to the stakeholders.

The 4 scenarios in *open – closed* and *private – public* matrix (Figure 12) were divided among the openness and the type of actor taking the initiative in the Arctic development. Openness refers to the region being seen as open for new expansive actions, with possibilities overshadowing the limits and barriers of various kinds. A closed Arctic refers to development where human activity is maintained at current levels at most or even reduced. Private-Public–axis refers to who has the initiative and active role in the development of the Arctic. In the public scenarios, the national governments and international organizations set the pace, whereas in private scenarios the initiative is on private actors and public measures lag behind. The resulting four scenarios were then described to follow these lines, with certain key assumptions and related controversies identified. In open-public world the economic activity in the Arctic increases within clear regulative boundaries set national and international bodies. Incentives and limits are based on environmental and social sustainability. The controversy in this development rises from the assumed benevolence of the states; if the governing bodies are not committed to sustainable goals, the outcomes can be very different. In open-private world the increasing economic activity is based on unregulated market incentives. Growth is fast but haphazard and risks, environmental and social problems accumulate. The controversy here is tied to subsidies; if all direct and indirect public support for large scale utilization ceased, the level of activity might be considerably lower. Thus, public initiatives still probably play a role in this world. Public-closed world sees development where public actors deliberately limit the activity in the Arctic, resulting in slow or non-existent development. The key controversy is whether this is driven by environmental, social or military politics. In the private-closed Arctic it is the private sector that decides to close the Arctic, although they are not forced to do so. This is either because barriers such as the harsh conditions and lack of demand result in decreasing interest or because the instruments of environmental protection rise from the private sector in the form of impact investing or benevolent investors.

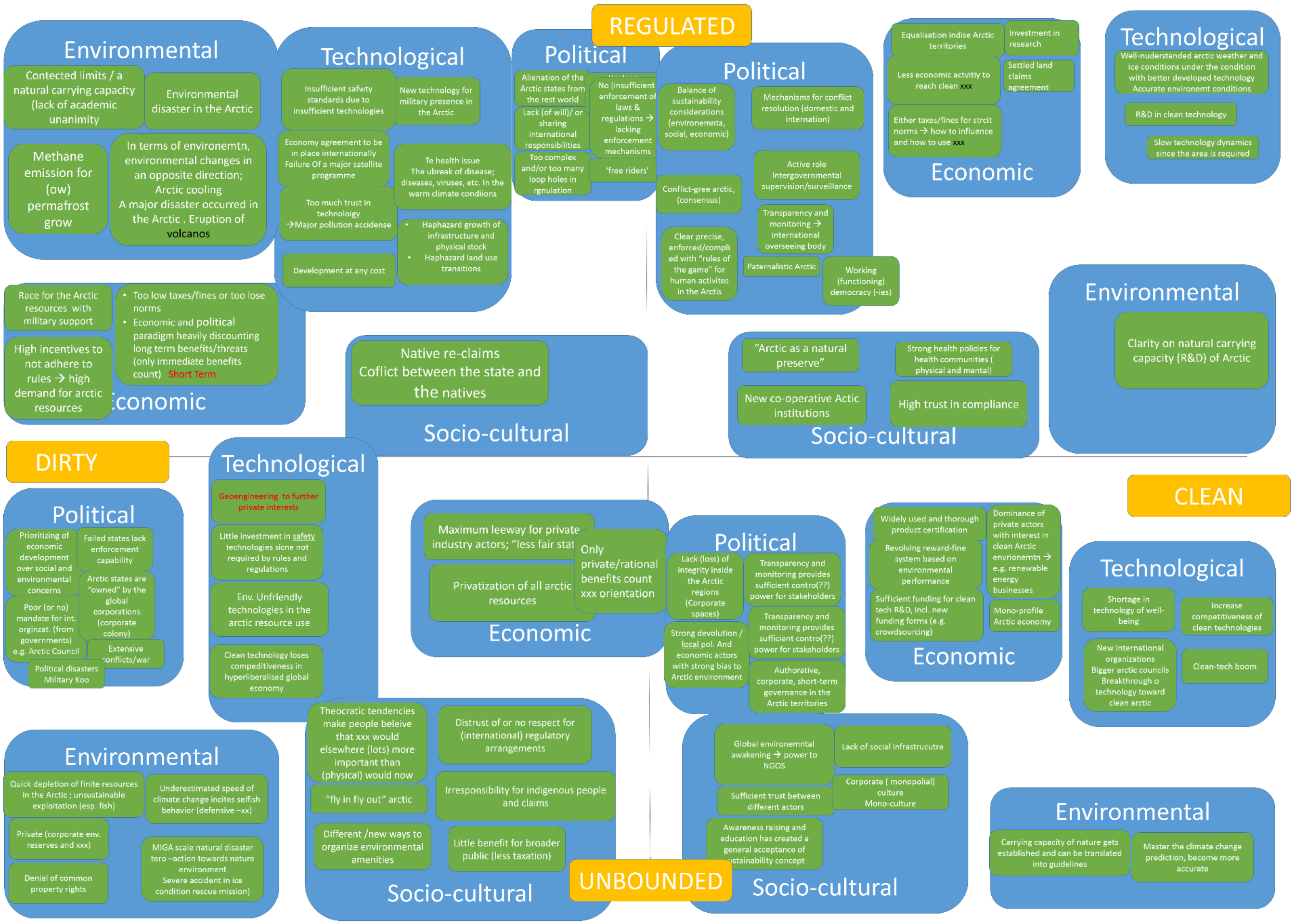

Figure 11. Scenario matrix A: unbounded - regulated and dirty - clean.

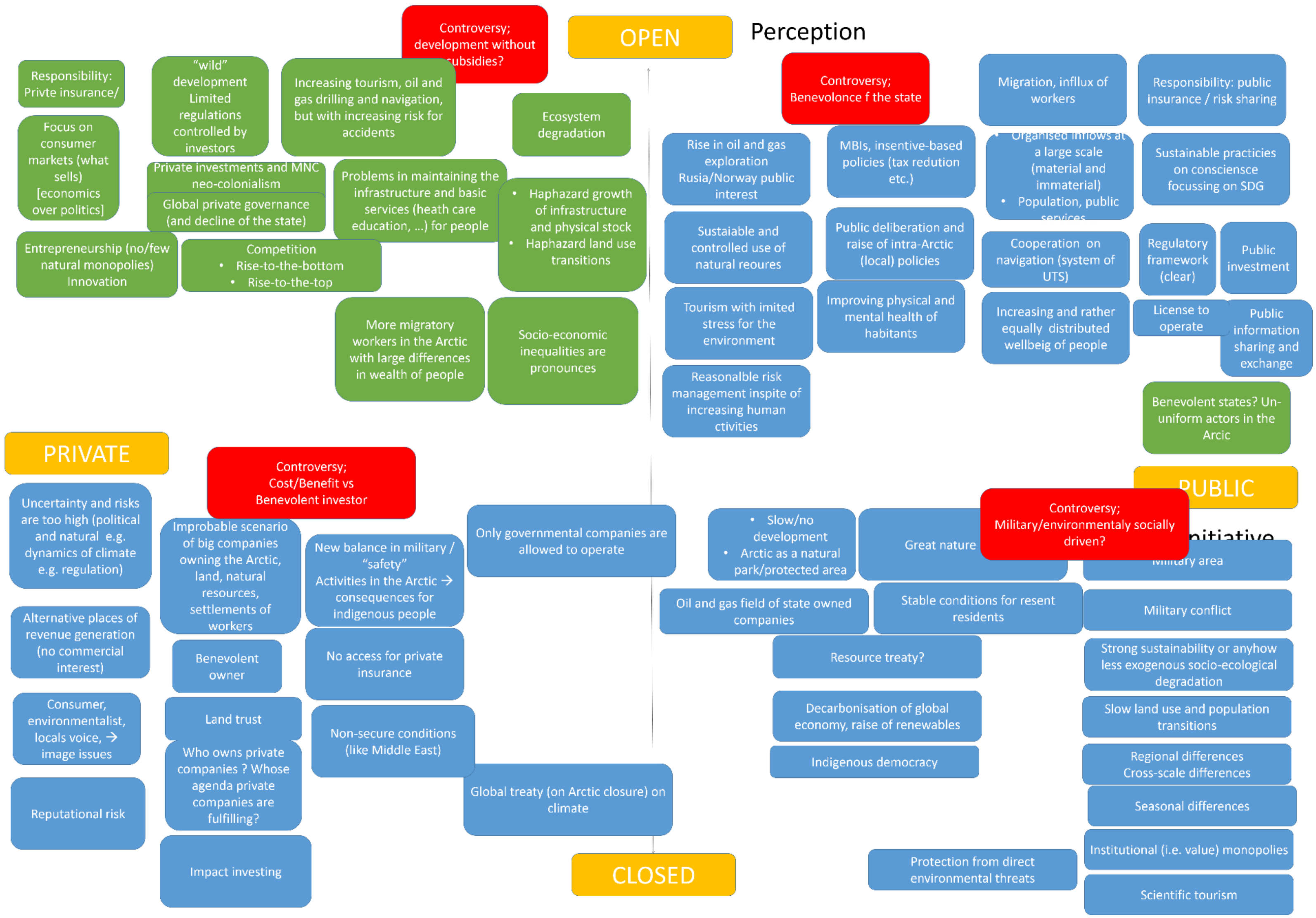

Figure 12. Scenario matrix B: closed- open and private - public.

3.3 The way forward

Due to the fact that the scenario workshop resulted in two separate scenario matrices, the final responsibility of the TWASE-scenario narratives was left to the project team. This was done in two phases: 1) Restructuring of the workshop scenario matrices into one scenario matrix, and 2) Considering the pre-survey results and futures wheels.

3.3.1 Restructuring the workshop scenario matrices

To obtain an understanding of the factors identified in the two groups, the first step in this process was to cluster all the factors of the two scenario matrices (Figure 11 and Figure 12). The emerging clusters, their description and two examples for each cluster are given in Table 5. By clustering the team aimed at identifying the common characteristics of the two scenario matrices, so that closely related factors would fall in the same quadrant in the final matrix.

Table 5. Emerging clusters, their descriptions and two examples of each cluster.

Cluster	**Description**	**Example**
Cooperation	Cooperation and diplomacy	Conflict-free Arctic
		Transparency and monitoring → international overseeing body
Conflict	Conflicts involving military	Military conflict
		New balance in the military activities in the Arctic → consequences for Indigenous people
Disaster	Natural and environmental disasters or accidents affecting people and the environment	Increasing tourism, oil and gas drilling and navigation, but with increasing risk for accidents
		Too much trust in technology → major pollution accident
(Green) innovations	Innovations, particularly cleantech and navigation	Dominance of private actors with interest in clean Arctic environment → e.g. renewable energy businesses

		Sufficient funding for clean tech R&D, including new funding forms (e.g. crowd-sourcing)
Bad regulation	Lack of regulation to control development	Little investment in safety technologies, since not required by rules and regulations
		Development at any cost
Good regulation	Enforced rules and regulations to control development	Carrying capacity of nature gets established and can be translated into guidelines
		License to operate
Privatization	Development and resources in the hands of private actors	Arctic states are “owned” by the global corporations (corporate colony)
		Denial of common property rights
National interest	Development and resources in the hands of public actors	Only governmental companies are allowed to operate
		Rise in oil and gas exploration Russia/Norway public interest
Wellbeing	Social wellbeing and health	Prioritizing of economic development over social and environmental concerns
		Improving physical and mental health of habitants
Environmental degradation	Decreasing quality of ecosystems and natural resources	Quick depletion of finite resources in the Arctic: unsustainable exploitation (especially fish)
		Ecosystem degradation
Influx	Influx of migrant workers and its consequences	More migratory workers in the Arctic with large differences in wealth of people
		Fly-in-fly-out Arctic

Poor infrastructure	Poor quality of physical and social infrastructure	Problems in maintaining the infrastructure and basic services (health care, education,..) for people
		Lack of social infrastructure
Risk management	Lack of or availability of risk management technologies	Transparency and monitoring provides sufficient control – power for stakeholders
		Insufficient safety standards due to insufficient technologies
Indigenous	Indigenous peoples	Settled land claims agreement
		Irresponsibility for Indigenous people and claims
Environmental awareness	Increased interest of the general public towards environmental sustainability	Awareness raising and education has created a general acceptance of sustainability concept
		Global environmental awakening → power to NGOs
Benevolence	Private interest towards environmental sustainability	Benevolent owner
		Land trust
Preserve	Arctic as a sanctuary	Arctic as a natural preserve
		Slow/no development
No commercial incentive	No commercial incentives to operate in the Arctic	Uncertainty and risks are too high (political and natural, e.g. dynamics of climate, regulation)
		Alternative places for revenue generation
Narrative	Outliers	Scientific tourism
		Seasonal differences

The second step was to determine a combined scenario matrix dimensions based on the two separate matrices constructed during the workshop. Since the dimension *Open-closed* describes an important dimension of the possible future political and economic development, it was chosen as one of the dimensions. Therefore, it was decided that the second dimension should be taken from the original matrix with the dimension *clean – dirty* reflecting the environmental status of the Arctic region, due to its major role in the future of the Arctic. Clean was also interpreted as decarbonised. A third dimension added to the scenario was the dimension of whom will take the initiative on the development of the Arctic: the private or the public sector. As *unbounded – regulated* and *private – public* were considered to be close to each other in terms of their content, it was decided that these should be combined in the final scenarios. After this, all the factors from the two original matrices were positioned in the new, final scenario space. Some of the factors were ambiguous on either of the dimensions *open – closed* / *clean – dirty,* and was therefore placed in the middle of the scale.

3.3.2 Incorporating pre-survey results and futures wheels

The last step was to ensure that the logics found in the futures wheel are considered in the narratives. This was done by checking that the narratives are consistent with the futures wheels. If new ideas arouse, they were added to the narratives.

The two most important global drivers according to the pre-survey (climate change and level of international co-operation) have been included in the narratives since they also came up extensively in the workshop. The following three most important global drivers (environmental awareness, global demand for fossil fuels and global climate policy) are included in the scenario dimension *dirty-clean*. The majority of the local drivers were also discussed in the workshop, but a few did not receive attention most likely due to the background of the participants. Therefore, for instance, competitiveness of the Northern Sea Route compared to other trade routes received less attention and has not been included consistently in the narratives.

Based on the new three-dimensional scenario space, a total of six short narratives were created (see Table 6). *Private - Closed- Clean* and *Public – Closed – Clean* were merged into one narrative, since they did not distinguish from each other clearly. The same applies to

Private- Dirty – Closed and *Public – Dirty – Closed*. In these scenarios, it was considered that the initiator (whether it is public or private) does not have a crucial role in the development from the WMS point of view.

Table 6. The dimensions and names of the six scenarios.

Scenario	Private-Public	Open-Closed	Clean-Dirty	Scenario name
1	Private	Open	Dirty	“Wild West”
2	Private	Open	Clean	“Silicon Valley”
3	Public	Open	Dirty	“Exploited Colony”
4	Public	Open	Clean	“Shangri La”
5	Private & Public	Closed	Dirty	“Conflict Zone”
6	Private & Public	Closed	Clean	“Antarctic”

4 Results: Six socio-economic scenarios for Eurasian Arctic by 2040

As described above, the process for scenario construction proceeded through various phases. All this input was refined in the form of six final narratives describing six plausible but different socio-economic scenarios for the development of the Eurasian Arctic by 2040. These final narratives (summarised in Table 7) are given below. The scenario participants were given a chance to comment on the final scenarios; the original scenario descriptions were modified based on the comments received. The final scenario descriptions are considered plausible by the experts who participated in the workshop.

4.1 Private – Open - Dirty: "Wild West"

- The Arctic area in 2040 is described by a laissez-faire economic development driven by the private sector and economic development is 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.
- Sea ice retreat is used as an excuse to enter the area, which creates a snow ball 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 & rescue operations.
- Technological development is making geoengineering a viable way to mitigate climate change which in the 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 geoengineering 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 as it is not required by rules and regulations.
- 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.

4.2 Private – Open – Clean: "Silicon Valley"

- Society in 2040 has realized the natural carrying capacity of the Arctic through extensive R&D and communication thereof to society through strong science-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 that comply with the carrying capacity of Arctic. This gives more power to NGOs and creates sufficient trust between various stake- and rights-holders.
- 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 events relies on private insurances.

- Regardless of good economic and environmental performance, social well-being in many Arctic regions lags behind. Corporations lack social integrity inside the Arctic, which is why social infrastructure is not as developed as other infrastructure and high level 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.

4.3 Public – Open - Dirty: "Exploited Colony"

- In 2040, the development of the Arctic region is heavily guided by short-term profit seeking behaviour where only immediate benefits count. Public debates 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.
- Climate change has progressed faster than expected, which incites selfish behaviour 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.

4.4 Public – Open – Clean: "Shangri La"

- 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, combatting 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 result of awareness raising, public information sharing and exchange delivered by media campaigns.
- A global consensus of a conflict-free Arctic prevails and new co-operative Arctic institutions emerge. These institutions possess mechanisms for domestic and international conflict resolution. High trust in compliance is achieved by inter-governmental surveillance and monitoring.
- Regulated, small-scale aquaculture provides sustainable livelihood to local communities.

4.5 Closed - Dirty: “Conflict Zone”

- 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.

4.6 Closed – Clean: “Antarctic”

- In 2040, an international Arctic Treaty is adopted supported by strong global climate policy. The international community decides 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 peoples gain strong land rights and strong constituencies. Also other residents enjoy stable, yet economically less developed living conditions. Any infrastructure is ran by de-centralized 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 areas (North Pole, Northern Sea Route) takes place.

Table 7 summarizes the narratives and provides a preliminary analysis for the sectors that are relevant for the TWASE project and Table 8 presents the implications of each scenario for WMS.

Table 7. Interpretation of the narratives for the WMS relevant sectors

	"Wild West"	**"Silicon Valley"**	**"Exploited Colony"**	**"Shangri La"**	**"Conflict Zone"**	**"Antarctic"**
Framing uncertainties	Private – open - dirty	Private – open - clean	Public – open - dirty	Public– open - clean	Closed -dirty	Closed -clean
Resource extraction	Low hanging fruits	Efficient; Respects carrying capacity	Inefficient, old technology	Regulated, Sustainable technologies	Causes conflicts	None
Tourism	Popular destination	Responsible tourism	Difficult access	Responsible tourism	None	Exclusive
Shipping	Traffic jams	Traffic with minimum environmental impact	Supports resource extraction	Traffic regulated by international bodies	Military	Tourism and research

Table 8. Implications of each scenario for Weather and Marine Services

Scenario	Implications for Weather and Marine Services
"Wild West"	High demand for sector specific situational information (from oil, gas and tourism sectors, Search and Rescue operations)
"Silicon Valley"	High demand; Open data; competitive market (from green and clean entrepreneurs, scientific community, NGOs, private insurances)
"Exploited Colony"	Medium demand both for situational information and more general observations (from oil, gas, construction, other infrastructure, tourism)
"Shangri La"	High demand; Tailored services (for shipping, clean technology, tourism)
"Conflict Zone"	Low demand for commercial services, high demand for situational awareness and strategically important observations (for military)
"Antarctic"	Low demand in general, mainly for scientific purposes (for eco- and scientific tourism)

5 Conclusions

This report has covered conditions, drivers and trends in the Arctic based on a diverse set of sources and methods. As we show, there is potentially a lot of pressure for major changes in the Eurasian Arctic. Among others, environmental changes, political shifts and technological development can all push forward drastic new developments. Then again, it is possible that despite all the hype and interest, the Arctic remains a backwater of the global economy. All this emphasizes the need for any decision-maker to be able to respond in very different futures. The Arctic calls for robust decision-making, a good eye for weak signals and tipping points and the ability to prepare for risks and seize opportunities as they emerge. The scenario work described in this report aims to serve these needs within the TWASE project and for a broader audience.

The six scenarios for Eurasian Arctic by 2040 anticipate changes of different scale and scope in society from three dimensions: *open – closed*, *public - private* and *dirty – clean*. The dimensions describe the state of the environment, political atmosphere, economic development and general ambience towards the Arctic. The scenarios also take a stand on social, technological and legal factors affecting the development of the Eurasian Arctic.

Overall, the scenarios aim at a holistic approach in anticipating the socio-economic developments in the Eurasian Arctic from the point of view of tourism, resource extraction and the shipping industries. In addition, the resulting six scenarios are the first scenarios for the Arctic that have also considered the future need for WMS. Only one out of the six scenarios shows low demand for WMS, which implies that it is highly recommended to develop WMSs.

Our methodology enables the construction of a comprehensive set of socio-economic scenarios when the participating expert pool is versatile enough; the resulting scenarios emphasise variety of alternative futures and choices inside the futures. However, a clear limitation of the scenario construction process is that the number of experts that participated in the workshop was rather modest. Yet, as a whole, the process resulted in a justified set of possible futures for the Eurasian Arctic by 2040. The scenarios provide an adequate outline of possible futures and consequences, and associations between trends and events.

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Appendix 1 Workshop Participants

Time: 30.-31.3.2015

Venue: Finnish Meteorological Institute, Helsinki

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Vihma, Timo	FMI
Votsis, Athanasios	FMI

Appendix 2 Pre-survey questions

BACKGROUND QUESTIONS

1. **Is your official work location in 2014 and 2015:**
    a. in Finland (please don't count short term assignments abroad)
    b. Outside Finland
    c. Alternatingly in Finland and elsewhere

2. **The sector in which you work is (NB if the public organisation in which you work has clearly a sector specific function you can tick 2 options, e.g. in case of a port authority (a. + d.)):**
    a. Public administration
    b. Research (University or other public sector)
    c. Natural resource extraction (oil, gas, mining)
    d. Marine transport
    e. Other transport
    f. Tourism
    g. Fisheries
    h. NGO
    i. other, being …..

3. **What part(s) of the Arctic are relevant for your organisation (more than 1 answer possible):**
    a. The entire Arctic
    b. The Eurasian Arctic (Kara Sea to Bering Strait)
    c. The North-American Arctic
    d. The Barents Sea
    e. The Arctic Ocean (core Arctic)
    f. Other, namely …

4. **How important are the development prospects of the Arctic (or parts thereof) for your organisation?**
    a. Crucial (i.e. can 'make or break' the organisation)
    b. Important (changed prospects affect the size and/or structure of the organisation)
    c. Somewhat important (some changes in the organisation and/or careers)
    d. Barely or not important

5. **When you think about prospects for the Arctic, the typical timeframe for you is:**
    a. Up to 2025

b. 2025 – 2040
c. 2040 – 2060
d. 2060 – 2100
e. Other, being ….

6. **Do you foresee that the organisation (or department) in which you work will become:**
    a. More engaged in Arctic activities in the next 10 years
    b. More or less continue at the current level of engagement
    c. Less engaged in Arctic activities in the next 10 years
    d. … additional comment / additional option

7. **What is the nature of your stake(s) in the Arctic (max. 3)**
    a. Environmental protection
    b. Livelihood of indigenous people
    c. Safety and security (of inhabitants and economic activities)
    d. Research
    e. Enabling or implementing natural resource extraction
    f. Enabling or implementing navigation
    g. Enabling or protecting something else, being: ….

QUESTIONS ON ARCTIC DRIVERS

8. **We list here a set of driving forces that drive the <u>global</u> development. How important are these drivers? Consider that the timeframe is up to 2050. Indicate the importance in scale of 1-5 (1=not important at all, 5=extremely important). You may also choose the option "no opinion/don't know":**
    a. Global demand of fossil fuels
    b. Global demand for minerals
    c. Fossil fuel price levels
    d. Mineral price levels
    e. Global economy
    f. Climate change
    g. Level of international co-operation
    h. Environmental awareness
    i. Other, namely

9. **We list here a set of driving forces that drive the <u>local</u> development of the Arctic. How important are these drivers? Consider that the timeframe is up to 2050.**

Indicate the importance in scale of 1-5 (1=not important at all, 5=extremely important). You may also choose the option "no opinion/don't know":

a. Arctic treaties (navigation and environmental)
b. International co-operation in the Arctic
c. National climate policy
d. Common Arctic security policy
e. Geopolitical situation (tense vs. cooperative)
f. Emphasizing territorial presence (e.g. by keeping areas populated)
g. Utilization and accessibility of mineral resources
h. Utilization and accessibility of fossil fuel reserves
i. The prices of minerals and fossil fuels
j. Competitiveness of the Northern Sea Route compared to other trade routes
k. Tourism
l. Marine fisheries
m. Extreme natural conditions and their variability
n. Minimizing risks of natural and manmade hazards
o. Development of Arctic engineering (including control of extreme conditions)
p. Development/coverage/distribution of infrastructure
q. Development in satellite technology
r. Developments in shipbuilding technology and winter navigation technology
s. Land rights (not including the off-shore locations)
t. Certification of Arctic products and services (greentech and cleantech)
u. Livelihoods of indigenous peoples
v. Perspective of sustainable development
w. Other, namely

QUESTIONS ABOUT THE WORKSHOP

10. What do you expect from the workshop?

a. Free word

11. Do you wish to receive the results of this questionnaire and of the summary report of the workshop of 30/31 March?

a. YES
b. NO

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