Actor-network services in the Arctic
–
Development of a theoretical and methodological concept to assess interdependencies between nature and society

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Zusammenfassung

Das Wachstum der Menschheit führt heute (2015) dazu, dass globale Herausforderungen, wie der Klimawandel, nicht nur durch vom Menschen unabhängige natürliche Vorgänge entstehen – vielmehr folgen solche Prozesse einem Wechselspiel zwischen dem Menschen selbst und geogenen, ökologischen, sozialen, politischen, ökonomischen und mentalen Komponenten. Eine wissenschaftliche geographische Untersuchung dieser Entwicklungen erfordert folglich transdisziplinäre Ansätze, die in der Lage sind, diese unterschiedlichen Parameter zu integrieren und vor allem zu analysieren – und nicht eine strikte Trennung zwischen humangeographischer und physisch-geographischer Forschung.

Die Geographie als wissenschaftliche Disziplin ist dazu prädestiniert, derart komplexe Fragestellungen im Grenzbereich zwischen Natur- und Gesellschaftwissenschaften zu untersuchen. Trotzdem stellt sie nur eingeschränkt, beispielsweise im Rahmen der sich entwickelnden Humanökologie, theoretische und methodische Ansätze bereit, die diese Aufgabe erfüllen. Das Ziel der vorliegenden Arbeit ist daher, die konzeptionelle Entwicklung eines theoretischen Ansatzes sowie einer Methodik, welche Geographen ermöglichen, transdisziplinäre Prozesse im Wechselspiel der Physischen und der Humangeographie zu erforschen.

Um die Notwendigkeit eines solchen ganzheitlichen Ansatzes zu unterstreichen, werden stellvertretend für die beiden Hauptdisziplinen der Geographie Teilprozesse des Klimawandels und Prozesse aus dem Themengebiet der Politischen Geographie gewählt und deren Verbindungen zueinander analysiert. Hierbei stehen vor allem die wechselseitigen Verbindungen zwischen diesen Prozessen im Vordergrund, deren transdiziplinäre Untersuchung durch den entwickelten theoretischen Ansatz ermöglicht wird.

Weiter wird eine geographische Untersuchungsregion gewählt, welche die Notwendigkeit von interdisziplinärer geographischer Forschung verdeutlicht: die Arktis. Bis heute existiert keine einheitliche Abgrenzung dieser Region. Vielmehr wird auf mehrere Möglichkeiten zurückgegriffen, den Hohen Norden hinsichtlich siedlungsgeographischer oder vegetationsgeographischer Gegebenheiten zu begrenzen. Eine eindeutige politische Abgrenzung der Arktis wird zudem dadurch erschwert, dass diese Region große Bereiche ohne staatliche Zuordnung umfasst. Die politische Brisanz arktischer Entwicklungen wächst derzeit außerdem durch eine veränderte Ressourcenverfügbarkeit, die durch den Klimawandel bedingt wird. So führt eine steigende Luft- und Meerestemperatur und das dadurch bedingte schmelzende Meereis beispielsweise dazu, dass die Verfügbarkeit von Rohstoffen, wie Erdöl oder seltene Erden, wächst, während Ressourcen, wie

der Permafrostboden, durch Tauprozesse schwinden. Folglich stellt die Arktis ein geographisches Gebiet dar, in dem sich die gewählten Prozesse direkt bedingen und in gegenseitiger Wechselwirkung zueinander stehen.

Vor diesem Hintergrund wird in der vorliegenden Arbeit ein theoretischer Ansatz entwickelt, der es ermöglicht, Wechselwirkungen zwischen humangeographischen und physisch-geographischen Prozessen zu untersuchen. Dieser stützt sich auf das humanökologische Konzept des Sozialen Metabolismus und auf die soziologische Akteur-Netzwerk-Theorie. Mit Hilfe dieser erfolgt die Identifizierung von vier Sphären, welche maßgeblich zu Verbindungen zwischen den Teilprozessen des „Klimawandels“ und der „politischen Geographie“ beitragen: die globale natürliche Sphäre, die arktische natürliche Sphäre, die arktische soziale Sphäre und die globale soziale Sphäre.
Weiter zeigen Untersuchungen von solchen Verbindungen, dass neben natürlichen und sozialen Komponenten mentale Parameter essentielle Aufgaben hinsichtlich der Aufrechterhaltungen von Wechselwirkungen in arktischen Netzwerken übernehmen. Folglich wird die mentale Sphäre als Wirkungssphäre dem entwickelten theoretischen Ansatz hinzugefügt.

Basierend auf dem entwickelten theoretischen Ansatz, lassen sich arktische Entitäten identifizieren, die die besagten Wechselwirkungen steuern: Ressourcen. Ressourcen werden in der vorliegenden Arbeit als Hybride aus natürlichen, sozialen und mentalen Komponenten verstanden. Um ihr tatsächliches Einflusspotential innerhalb arktischer Netzwerke zu ermitteln, erfolgt eine Anpassung und Erweiterung des Ökosystemdienstleistungs-Ansatzes, welche gleichzeitig das methodische Vorgehen der nachfolgenden Forschung darstellen.

Um die Tauglichkeit der entwickelten Theorie und Methodik der „Actor-network services“, welche maßgeblich auf der Kombination der Akteur-Netzwerk-Theorie mit dem Ansatz der Ökosystemdienstleistungen beruht, hinsichtlich der Ermöglichung transdisziplinärer geographischer Forschung zu untersuchen, werden drei Fallstudien durchgeführt. Jede Fallstudie umfasst die Analyse eines Wirkungsnetzwerkes einer arktischen Ressource - arktische Schiffsrouten, traditionelles Wissen in der Arktis und arktische Landwirtschaft. Die Aufstellung dieser Netzwerke fördert dabei insbesondere ein tiefgreifendes Verständnis von Wirkungszusammenhängen in der Arktis und folglich von Anforderungen an transdisziplinäre geographische Forschung.

Abstract

Today (2015), global challenges, such as climate change, alter multiple parameters of social, political, economic, environmental and mental characteristics. Hence, their scientific exploration requires theories and methods which implement and moreover investigate entities of multiple origin. Geographical research, however, often distinguishes between elements of physical geography and human geography. Hence, such approaches cannot cope with recent multidimensional phenomenons.

The core-idea of this thesis is to develop a conceptual theoretical approach and a suitable methodology that enable geographers to work transdisciplinarily between physical geography and human geography. Hereby, a combination of ideas of both major geographical subdisciplines is achieved, in order to suit the complexity of current transdisciplinary processes.

Firstly, different processes are chosen, which are originally investigated by either physical geography or human geography: processes of climate change and processes of political geography. To strengthen the requirement for a transdisciplinary geographical approach, the tight bonds between these processes are outlined. Hereby, it is demonstrated that connections between processes of climate change and processes of political geography merge these developments inseparably. Hence, an everlasting interconnectivity between processes of climate change and processes of political geography is outlined.

Secondly, a geographical area is chosen to apply the exploratory approach of this thesis: the Arctic. The Arctic illustrates the identified connectivity between processes of "climate change" and processes of "political geography" by definition. Until today (2015), there is no standardised boundary of this region. In contrast, possible delineations of the Arctic are determined by parameters of human geography (Arctic peoples) or physical geography (vegetation, climate, soil). Besides, the High North comprises vast regions without clarified territorial belongings which further complicates (maritime) jurisdiction in the Arctic. Particularly the latter is paired with the recent climate-induced changing of resource availabilities which rises the overall political and economic importance of this region. Consequently, the High North constitutes a perfect case-study for the developed geographical approach.

With this background, a conceptual theoretical approach is developed in this thesis. Hereby, ideas of human ecology and the sociological Actor-Network Theory are used. Both approaches are merged

and moreover adapted to the research question of investigating interdependencies between processes of climate change and processes of political geography in the Arctic. Thus, four spheres are identified which contribute to such connections: the global natural sphere, the Arctic natural sphere, the Arctic social sphere and the global social sphere. Moreover, mental entities reveal as important actors of the network between processes of climate change and processes of political geography. Therefore, a mental sphere gets integrated into further analyses. This essential step allows an understanding and identification of entities whose contributions to the maintaining of network-connections have been unnoticed by the original approaches. Hence, within this thesis a theory is developed that provides a wider understanding of the transdisciplinarity of Arctic networks.

This broad understanding of interdependencies within networks enables an identification of core-elements of Arctic power-relations which are hybrids between the natural, social and mental sphere: resources. They are further analysed with an enlarged ecosystem-services approach. Thus, the conceptual approach of "Actor-network services" is developed in this thesis, which is primarily based on the combination of Actor-Network Theory and the concept of ecosystem-services.
In this course, three Arctic resources are chosen as examples of how to apply the developed theory and methodology: Arctic shipping routes, Arctic traditional knowledge and Arctic agricultural production. The chosen resources cover global, regional and local influences as well as parameters from the natural, social and mental sphere. Hence, the exploration of their networks reveals the suitability of the developed approach to enable geographers to work transdisciplinarily between physical geography and human geography.

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Guide to Acronyms and Abbreviations

ACAP	Arctic Contaminants Action Programme
ACIA	Arctic Climate Impact Assessment
AEPS	Arctic Environmental Protection Strategy
AHDR	Arctic Human Development Report
AMAP	Arctic Monitoring and Assessment Programme
AMSA	Arctic Marine Shipping Assessment
ANT	Actor-Network theory
CAFF	Conservation of Arctic Flora and Fauna
CLCS	Commission on the Limits of the Continental Shelf
EEZ	Exclusive Economic Zone
EFTA	European Free Trade Association
EPPR	Emergency Prevention, Preparedness and Response
EU	European Union
GIS	Geographical information system
GMS	Geostationary meteorological satellite
IAMSR Manual	International Aeronautical and Maritime Search and Rescue Manual
IMO Guidelines	Guidelines for Ships operating in Arctic Ice-Covered Waters
SOLAS Convention	International Convention for Safety of Life at Sea
IPCC	Intergovernmental Panel on Climate Change
IQ	Inuit Qaujimajatuqangit
MEAP	Millennium Ecoystem Assessment Programme
NEP	Northeast Passage
NSR	Northern Sea Route
NWP	Northwest Passage
PAME	Protection of the Arctic Marine Environment
SAR	Search and Rescue
SDWG	Sustainable Development Working Group
SWIPA	Snow, Water, Ice and Permafrost in the Arctic
TEK	Traditional ecological knowledge
TK	Traditional knowledge
TPP	Transpolar Passage
UNCLOS	United Nations Convention on the Law of the Sea
USGS	United States Geological Survey

1 Introduction – climate change and politics in the Arctic

1.1 Prologue

My relationship with geography has been rather like that of a child with its parent:
an underlying love but interspersed with periods of sulking and waywardness.
(Thrift (2002), p.291)

When I decided to study geography in 2006, I was looking forward to achieve a deep insight into the network between the environment and the people living with and from nature. I was keen to explore the processes within this network, in order to understand the uniqueness, similarities and differences of my surroundings. Back then, geography appeared to be the perfect match to satisfy my inquisitiveness. However, during my very first undergraduate university course, my vision of geography as a transdisciplinary research field (as transdisciplinary research is defined by Mittelstraß (2012) as a scientific principle of overcoming disciplinary boundaries) began to crumble, due to the separation of physical geography and human geography. Instead of promoting a holistic view of the earth's systems, the disciplines had grown apart. Both implemented their own theories and methods to analyze questions, not at all aligned with the other sub-discipline. While human geography and physical geography dealt with topics of their own, research in between their fields remained mainly untouched. Being just a beginner at that time, I hoped that the gap between the two sub-disciplines would most probably be closed during the years to come.
Yet, even the lectures and seminars I took during my postgraduate studies still strengthened my impression that physical geography neglects anthropogenic influences frequently, while human geography denies nature's influence far too often. Upon completion of my studies I was left with the feeling that whatever sub-discipline I chose, I would always neglect the importance and complexity of the other.

This thesis develops a theoretical approach, leading to a novel methodological concept to enable geographers to work transdisciplinarily between physical geography and human geography. This thesis aims to link these two sub-disciplines through qualitative analysis, stepping away from a classical division into nature and society. So far, there are few geographic approaches that offer solutions to investigate issues which couple nature and society, most of them being located in the field of human ecology. Yet, even if geographical research addresses nature and society simultaneously, there is still an ongoing controversy about the connection of these two systems. Different suggestions have been made by various authors, such as an overlapping of the two systems or the complete inclusion of one within the other. However, these decisions result mostly in an imbalance of nature's and society's complexity, flexibility towards shifts and power to cause impacts – both on a theoretical and methodological level.

The research in this thesis concentrates on the connections between nature and society. Hereby, the two systems themselves as well as their bonds are described, by analysing their network characteristics. Therefore, representatives of both systems are chosen: processes of climate change and processes of political geography.

In the following, the investigations of processes of political geography in the Arctic involve particularly processes of geopolitics. Hereby, it has to be pointed out that the term geopolitics is not equivalent to the German term "Geopolitik".
Political geography is originally a subdiscipline of human geography, with Aristoteles being referred to one of the subdisciplines first representatives (Knox and Marston, 2008). Political geography deals with the connection between power and geographical places over time (Agnew and Muscarà, 2012). Traditionally two paradigms determined the subdiscipline: Firstly, interdependencies between states and (living) space and secondly, environmental determinism. These paradigms predestined political geographers to theoretically focus on foreign policy which created the field of "Geopolitik" by the end of the 19th century (Knox and Marston, 2008). Consequently, Geopolitik focuses on power relations between states, nations or territories, what resulted in the establishment of traditional antipodes such as "West" and "East" or "Capitalism" and "Communism". In Germany, Geopolitik was mainly influenced by theories and ideas of Friedrich Ratzel (Reuber and Wolkersdorfer, 2004). Yet, the term "Geopolitik" got banned in German speaking areas after the concepts of this research field, mainly the idea of a territorial state, got misused by the Nationalsozialistische Deutsche Arbeiterpartei (NSDAP) during the 3. Reich to justify warfare against other nations (Jahn, 2015; Wolkersdorfer, 2008). Hence, the international term "geopolitics" refers more to the general German term "Politische Geographie" than to the

stigmatised term “Geopolitik”.
Yet, with the end of the Cold War and the vanishing of traditional geopolitical antipodes, geopolitical paradigms shifted on an international level as well (Reuber and Wolkersdorfer, 2004). Geographical places were no longer only interpreted by their natural (physical geographic) characteristics, but also by their social, cultural and economic meaning. Hence, today (2015) political geography investigates how power, power relations and the concentration of power affect anthropogenic actions as well as environmental and natural processes (Agnew and Muscarà, 2012), opening up new research fields besides the traditional ones, including conflicts about territories, boundaries and resources, politics of identity, ecological politics or social movements (Reuber, 2000). Hence, spaces are constantly (re-) defined and always bond to social realities (Glasze and Mattissek, 2014).

To conclude, processes of geopolitics and political geography deal not only with political boundaries, but also with power related to social, economic and ecological geographical characteristics. Therefore, processes of political geography can be seen as predestinated representatives of interdependencies between nature and society in a certain region. Climate change – as the anlogue – affects natural systems on all dimensions, reaching from local to global scales. Consequently, human beings who always depend on their natural environment have to adapt to the induced environmental shifts. Simultaneously, anthropogenic actions lead to environmental changes. Yet, anthropogenic actions are not only driven by ecological parameters, but also by social and economic developments which are again represented by processes of political geography.[1]

1.2 Setting the scene – why the Arctic?

The Arctic illustrates the described gap of disregarding characteristics of either natural or social systems by definition. To this date (2015), the geographical area that belongs to the Arctic or the High North is not explicitly defined. Consequently, different natural and socio-cultural boundaries exist.

The Arctic circle is probably the best known natural border of the High North. Based on solar-climatic circumstances, it resembles the northern most latitude where the sun does not set at summer solstice and does not rise at winter solstice. However, it is also one of the oldest definitions

1 Please note that any masculine or feminine conjugation that is used in this thesis can be substituted with the respective other conjugation, such as referring to a scientist as “he”.

of the High North and not commonly used anymore. Instead, it is often replaced by the tree line as a limit of growth for trees, the 10 °C July isotherm, the permafrost or the sea-ice extent. All of them are referring either to climatic, terrestrial or marine characteristics. Yet, due to recent climatic shifts, natural boarders are moving northwards, what leads to an exclusion of regions that belong to the Arctic historically (ACIA, 2004).

Besides, political and socio-cultural borders also exist in the High North. Politically, five states have direct access to the Arctic Ocean – the Arctic Five (the United States of America, Canada, the Russian Federation, Norway and Denmark through Greenland). Consequently, these states dominate political decision making in the High North (Winkelmann, 2007), although the region is of current global interest. Simultaneously, several indigenous peoples are spread throughout the whole area, marking a region, not congruent with any other mentioned definition.

Hence, whichever border is chosen, either natural or social characteristics of the Arctic are neglected, as Figure 1[2] illustrates (The figure also includes two boundaries, defined by working groups of the Arctic Council – see Chapter 1.4 Political Geography and Geopolitics in the Arctic). Therefore, the following thesis respects natural and social Arctic determinations equally and consequently also the changing borders of the High North.

Although they vary, any possible Arctic definition includes different natural, social and political systems. Therefore, the Arctic resembles the aligned area of conflict between physical geography and human geography – not only by its outer limits, but also by its inner structure.
Hence, the Arctic resembles a puzzle of different ecosystems (marine and terrestrial) and different political systems (for example western influenced and indigenous). In each of them, multiple local, regional and global processes, as well as interdependencies between these processes are identified.
To conclude, there are at least four systems linked to each other: the global social system and its subsystem the Arctic social system, as well as their environments, the global and the Arctic ecosystem. In the following, the global social system is going to be referred to as the social sphere. It contains interactions between humans, political systems and societies. The environment is going to be addressed as the natural sphere. It embraces the geographical spheres of the earth: atmosphere,

2 Please note that due to the chosen polar stereographic projection and the wide area covered by all maps in this thesis, no certain scale is given within the illustrations, because it would only refer to a small part of the respective map, as for example to a particular circle of latitude, due to distortions within the illustrations.

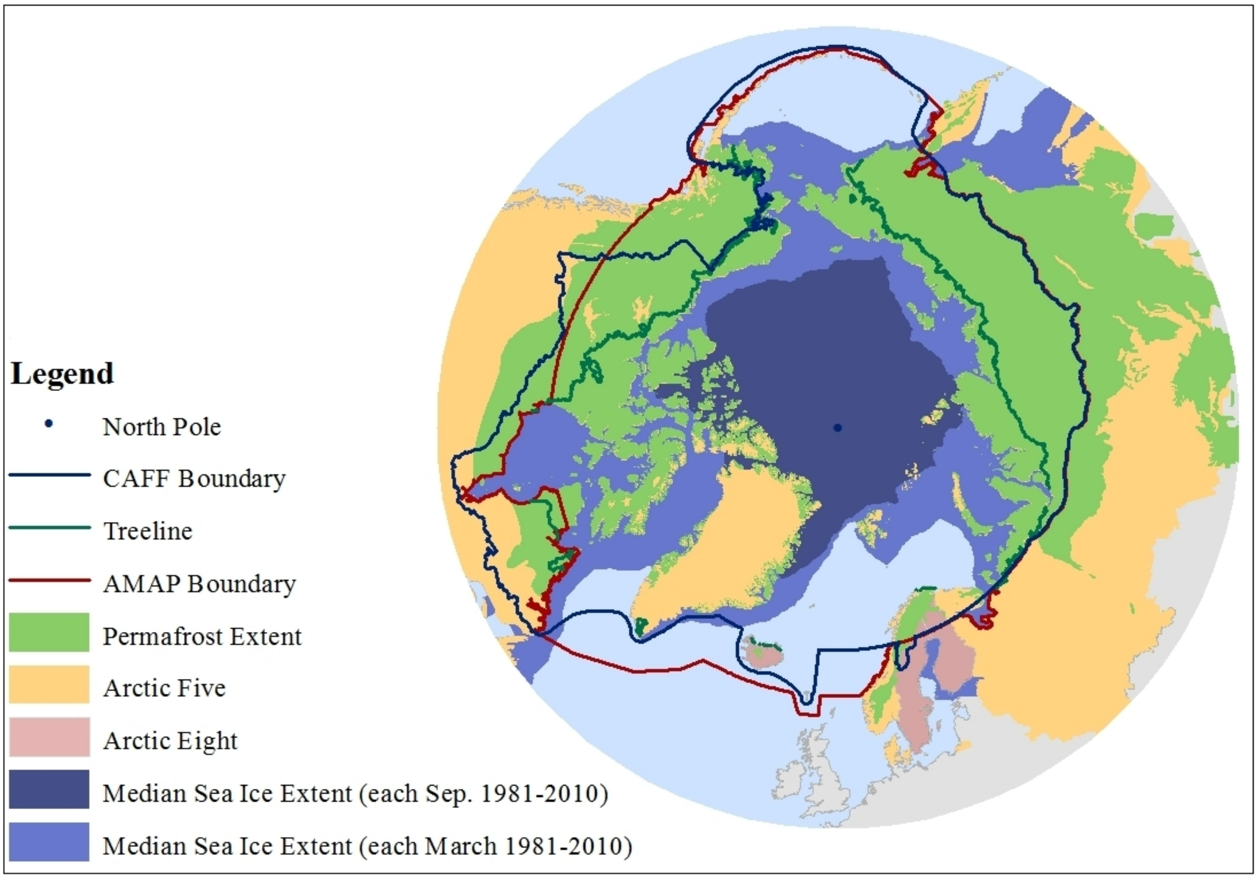


Figure 1: Possible natural and socio-cultural definitions of the Arctic

Please refer to footnote 2 (page 4) for an explanation why no scale is given within the figure.

References:

Background World Map: taken from ArcMap 10

Northpole: Arctic Marine Shipping Assessment 2009 Report, Arctic Council, April 2009

CAFF Boundary: Conservation of Arctic Flora & Fauna, Arctic Council Working Group, October 2009

Treeline: Conservation of Arctic Flora & Fauna, Arctic Council Working Group, October 2009

AMAP Boundary: Arctic Monitoring and Assessment Programme (http://www.amap.no/documents/doc/amap-area-gis/868)

Permafrost Extent: Brown, J., O.J. Ferrians, Jr., J.A. Heginbottom, and E.S. Melnikov. 1998, revised February 2001. Circum-arctic map of permafrost and ground ice conditions. Boulder, CO: National Snow and Ice Data Center. Digital media.

Median Sea Ice Extent (March): Fetterer, F., K. Knowles, W. Meier, and M. Savoie. 2002, updated daily. Sea Ice Index. [median_N_03_1981_2010_polyline.zip]. Boulder, Colorado USA: National Snow and Ice Data Center. http://dx.doi.org/10.7265/N5QJ7F7W

Median Sea Ice Extent (September): Fetterer, F., K. Knowles, W. Meier, and M. Savoie. 2002, updated daily. Sea Ice Index. [median_N_09_1981_2010_polyline.zip]. Boulder, Colorado USA: National Snow and Ice Data Center. http://dx.doi.org/10.7265/N5QJ7F7W.

hydrosphere/cryosphere, lithosphere, pedosphere and the biosphere. This sums up to the following four spheres: social sphere, Arctic social sphere, Arctic natural sphere and natural sphere.

In the following, the unique climatological and political characteristics of the Arctic are outlined, to illustrate the ongoing conflicts and interdependencies between nature and society in the High North. Besides, the content of the next sections is the foundation for the development of the theoretical and methodological concept of this thesis.

1.3 Climate change in the Arctic

Global warming affects the ecosystems of the Arctic, while also leading to far-reaching changes of the High North's social and political systems. Hence, the rising temperature of the Arctic is serving as a key-factor to illustrate the functional chains of these natural shifts. Therefore, selected observed aftermaths of rising temperatures and the various feedback-loops caused through them are described.

The currently recorded values of rising temperatures in vast Arctic areas are already up to three times higher than the global average, due to overall atmospheric heat transportation (Härtling et al., 2011). Particularly average winter temperatures are growing. In Alaska and western Canada this resulted in an increase of 3-4 °C over the past 50 years (ACIA, 2004). The Intergovernmental Panel on Climate Change (IPCC) (2014) even states that the warming of the Arctic will continue to reach higher values than the average global temperature increase by the end of this century (2081-2100). Projections reach values between a minimum of 0.3 °C and a maximum of 4.8 °C, according to the different IPCC scenarios (Intergovernmental Panel on Climate Change (IPCC), 2014).
The growing temperatures cause – amongst other changes – a melting of sea ice and a thawing of permafrost in the Circumpolar North. In contrast to the general temperature rise, which has the highest rates during winter, sea ice is affected mostly by summer temperatures, leading to its biggest decrease during this season. In the period of 1979 to 2012 the IPCC (2014) rates it very likely that the decline ranged between 3.5% and 4.1% per decade. Furthermore, a contribution of anthropogenic developments to this rapid change are rated very likely as well (Intergovernmental Panel on Climate Change (IPCC), 2014a). Therefore, the decline of the Arctic sea ice extent is even faster than the projected decrease of the Fourth Assessment Report of the IPCC from 2007. Some

models even show a nearly sea ice free summer by the end of this century (ACIA, 2004; AMAP, 2012).

Analogue to the vanishing sea ice, permafrost is thawing. The temperature of this specific soil type has increased up to 2 °C, causing an overall northward movement of the permafrost extent. Simultaneously, a deeper active layer is thawing each year. During the recent century, projections show that the permafrost area will move northwards with an overall extent of several 100 kilometres (ACIA, 2004).

Both, the vanishing sea-ice and the thawing of permafrost cause multiple interdependencies that strengthen or weaken future climate-induced changes. To further underline the high connectivity between nature and society in the Arctic selected interdependencies are outlined. Hereby, it is illustrated, how the natural sphere and the social sphere influence each other on different scales. Furthermore, the following examples support the statement that geographical analyses have to involve nature and society as equal components of an interwoven network.

Melting and thawing processes initiate interdependencies and feedback loops. They strengthen or weaken current developments and moreover cause novel shifts within Arctic systems.

Surface melting is, for example, always linked to changing albedo values. Bright ice layers have higher values than dark surfaces which will arise if the ice (or snow) cover melts. The developing rebound effect strengthens the heating processes above and within the surface. It is therefore responsible, for an additional warming of the sea water, amongst others, which causes an even faster melting of sea ice. Besides, an earlier melting leads to a longer period of undiscovered dark surface before the next freezing. The heating-cycle is therefore further intensified. Similar albedo-changing processes are observed on the land surface, for example through dark particles, accumulating on bright, snow-covered surfaces (Ebinger and Zambetakis, 2009; Härtling et al., 2011).

Analogously, feedback-loops are connected with the thawing of permafrost. They are, for example, responsible for the regeneration of thermokarst and karst lakes. In addition, the deeper active layer causes solifluctions and landslides. The IPCC (2014) has particularly high confidence in the harming of infrastructure IPCC (2014) which includes also facilities that store hazardous materials.

It is further possible to link the thawing of permafrost with the global carbon cycle. The usual low Arctic temperatures enable permafrost to function as a carbon sink. It stores organic carbon even in its deep layers, due to cryoturbation processes. With the rising temperatures and resulting aerobe conditions, microorganisms convert organic carbon, that is stored close to the earth's surface, into carbon dioxide. An enlargement of such circumstances, for example through the expanding of Arctic summers, will intensify the activity of microorganisms and therefore also their "carbon dioxide production" (AMAP, 2012; Broll, 2011). Although such emissions do not have the extent to outnumber anthropogenic emissions, they are mostly located in remote areas and spread amongst landscapes. Therefore, established prevention methods are not sufficient to cope with such developments, since they are adapted to punctual emissions mostly (Schuur and Abbott, 2011).
In addition, the anaerobe conditions of Arctic fens cause the creation and release of methane and nitrous oxides, intensifying global warming. However, a simultaneously enlarged growing season will also increase the storing capacities of carbon in the plants biomass (AMAP, 2012; Broll, 2011).

Besides, melting processes cause a shrinking or even vanishing of habitats of endemic Arctic species. At the same time, invasive species are expanding into the area which creates an additional challenge to the existent flora and fauna (Broll, 2011; Ebinger and Zambetakis, 2009; Schickhoff, 2012). Especially ice-obligative species, such as the polar bear (*Ursus maritimus*) and several seal species, are endangered by the sea ice loss. In contrast, migratory species, including different whale types, benefit from it, through gaining bigger habitats (Bhatt et al., 2014).

Such changes affect particularly indigenous peoples of the High North. Their traditional lifestyle depends economically, but moreover ideologically and culturally on their surrounding environment (see Chapter 4.2) (AHDR, 2004). On the other hand, a shrinking of Arctic sea-ice opens up novel possibilities for shipping and resource exploitation in the High North, adding a global perspective to regional shifts (see Chapter 4.1) (Gebhardt and Ingenfeld, 2011; Girg, 2008).

The Arctic Ocean is particularly noteworthy in terms of political geography and geopolitics in the High North, since maritime jurisdiction is not sufficiently clarified yet, what rises the political interest of numerous states, such as Germany or China and of the European Union (Winkelmann, 2008). However, the geopolitical situation of the Arctic is not only challenged by the legal status of the Arctic Ocean, but also by different jurisdictional levels and political systems that apply to the

High North.

1.4 Political geography and geopolitics in the Arctic

Keeping possible definitions of the Arctic in mind results in the co-existence of several jurisdictional levels: international law, European law and national legal systems. Today (2015), the terrestrial Arctic areas are under the sovereignty of several states: the Arctic Five (Winkelmann, 2007), Finland, Iceland and Sweden – hence, the Arctic Eight. These include three federal states (United States of America with Alaska, Canada with Yukon, the Northern Territories, Nunavut and New Foundland and Labrador and the Russian Federation with various entities), three member states of the EU (Denmark – excluding Greenland, Finland and Sweden) and two states which are solely members of the European Free Trade Association (EFTA) (Iceland and Norway – excluding the Svalbard Islands) (Koivurova, 2008a).

The idea of a closer cooperation in the High North already grew in the 1980s, an era affected by rising military and strategic tension as well as an increase of environmental awareness (Pedersen, 2012). Especially the latter led to the adoption of the Arctic Environmental Protection Strategy (AEPS), which was signed by the eight Arctic states in 1991. This date marked the beginning of a cooperation in the Arctic (Koivurova and VanderZwaag, 2007), that still impacts the recent geopolitical situation of the High North.
In order to further promote the political, social, ecological and economic interests of and moreover the cooperation between the circumpolar states, the Arctic Council was established by a ministerial declaration on September 16, 1996 (Kankaanpää and Young, 2012). Today (2015) the Arctic Council represents the leading political instrument of the High North. It is an intergovernmental forum that deals with Arctic issues, addressing for example sustainability and the protection of the Arctic environment (Arctic Council, 2015). Due to its importance for political decision-making in the High North, the structure and functioning of the Arctic Council are briefly outlined.

Under the chairmanship of Canada, the council ended its organisational phase in September 1998 and began to fulfil its new responsibilities, with the passing of the chairmanship to the United States of America (Bloom, 1999). Since then the councils' chairmanship rotates between the member states every two years. Its tasks cover the external representation of the council, but also the coordination

of meetings and projects of the councils' members, permanent participants and working groups. Currently (January 2015), Canada is the chair of the Arctic Council, closing the first rotating circle of the chairmanship between the eight member states (Arctic Council, 2011a; Spence, 2013).
Within the structure of the Arctic Council, six working groups are established: the Arctic Contaminants Action Programme (ACAP), the Arctic Monitoring and Assessment Programme (AMAP), the Protection of the Arctic Marine Environment (PAME), Emergency Prevention, Preparedness and Response (EPPR), the Sustainable Development Working Group (SDWG) and the Conservation of Arctic Flora and Fauna (CAFF). These groups were already initiated during the AEPS cooperation phase (Arctic Council, 1996; Koivurova and VanderZwaag, 2007) and maintain to ensure cooperative working tasks of the Arctic Council until today (2015).

Besides the member states, multiple representatives of indigenous peoples are permanent participants of the Arctic Council. In general, indigenous representatives can apply for a permanent member status if they represent either several indigenous peoples, residing in one member state, or if they represent one indigenous people, residing in several member states. A permanent member status has to be granted by the established Arctic Council members and is not supposed to outnumber the member states at any time (Arctic Council, 1996).

Observers, in contrast, are not as powerful as permanent members. Nevertheless, they have to accept and respect the sovereignty of the Arctic States and their rights as well as the Arctic's jurisdiction. Additionally, observers have to respect the culture, values and interests of all Arctic inhabitants, including indigenous peoples. Observers also have to prove their political and financial cooperativeness in alliance with the work of the Arctic Council (Exner-Pirot, 2012).
Non-Arctic states, intergovernmental and inter-parliamentary organizations on a global and regional level, as well as non-governmental organizations, such as the World Wide Fund for Nature – Global Arctic Programme, have the possibility to become an observer of the Arctic Council (Arctic Council, 1996). Currently, there are 32 observers (Arctic Council, 2011b), including Germany (Winkelmann, 2009a). In addition to six European states (Arctic Council, 2011b), Japan, China, India, Singapore and South Korea have already become observers of the Arctic Council, which is particularly important for the development of Arctic shipping. The European Union continues to maintain its efforts to get granted an observer status (Airoldi, 2008), which implies also a strengthening of its political and economic power in the High North (Graczyk and Koivurova, 2014;

Hong, 2014).

Consequently, the high interest of multiple states, political-economic unions, political representatives and non-governmental organisations of becoming a part of the Arctic Council, represents the rising political meaning of the Arctic on a global scale. Additionally, the wide range of existing observers, permanent participants and members also illustrates the political, social and cultural diversity of the High North what reinforces the involvement of a global and local social sphere into the analyses of this thesis.

However, although the council attracts political interest, its functionality is questioned recently. The council's decisions are based on a consensus of the member states (Arctic Council, 1996), but are not binding on a political level (Winkelmann, 2009a). So far, security-related topics, rights of indigenous peoples and topics regarding economic development are not included in the duties of the council. Hence, its authority is questioned regularly, especially by the United States of America (Humrich, 2011). Consequently a permanent Arctic Council secretariat was established in the Norwegian city Tromsø as an aftermath of the Nuuk Ministerial Meeting in May 2011. The aim of this establishment was to strengthen the council's political acceptance and moreover its work. The permanent secretariat fulfils administrative and organizational tasks and is moreover in charge of a prospering cooperation between the members and the outreach of the council's concerns and interests (Arctic Council, 2014; Sellheim, 2012).

Yet, in the course of climate change and the resulting rising availability of Arctic resources, the circumpolar states are setting up new political frameworks to rise their influence over the High North. In this case, it is therefore widely discussed, if the Arctic Council should retain in its current form (see for example Breum, 2012; Dodds, 2013; Koivurova, 2010; Young, 2009a). Koivurova (2008b) contributes to this controversy, by arguing that the structure of the council is unlikely to change drastically on a medium time frame. The author states that the council seems to be the only currently acceptable cooperational institution for the member states which is mainly based on the fact that the council continued work, initiated by the Arctic Environmental Protection Strategy. Young (2011a) agrees that the Arctic states have, for example, no desire to adopt an Arctic Ocean treaty or a treaty similar to the Antarctic Treaty. Particularly indigenous peoples could interpret such a treaty as harming their interests, while the United States of America will likely not ratify it either.

In addition, negotiational efforts to create such a kind of treaty would probably outnumber its outcomes in terms of impact potential (Young, 2011b).

One major reason that determines the aim to achieve political power over the High North are its resources which are merely located in or under the Arctic Ocean and whose availability is currently changing, due to global warming. Hence, there is a clearly recognizable shift towards a concentration on marine Arctic governance that is further strengthened by growing shipping activities (Koivurova, 2008b). While keeping such changes in mind, Young (2000) names five recommendations according to the future work of the Arctic Council. He recommends particularly that the council must not be recognized as an instrument controlled by policy-makers or other officials, who work for national governments. Furthermore, the author states that the council has to deal with region-wide concerns, while leaving any other issue to be dealt with by appropriative bodies. Young (2000) also argues that the council has to promote future cooperation in the High North. In conclusion, he advises the council to open up to new Arctic players and to further legitimise its function of being a voice of the Arctic (Young, 2000).

The named shift towards a local, regional and global concentration on marine governance of the Arctic, illustrates the geopolitical importance of the Arctic Ocean. Simultaneously, the Arctic Ocean represents a unique ecosystem that contains various endemic species and contributes significantly to global natural flows, such as the global thermal flow (ACIA, 2004). Hence, the Arctic Ocean pictures a natural area of social and political interest. Consequently, analyses of its functions strengthen the requirement for a novel approach that combines natural and social characteristics. Thus, the existing and binding political frameworks, covering the Arctic Ocean, have also to be integrated into such a theoretical concept. The next sections therefore outline the legal basis of maritime areas in general and activities in the Arctic Ocean in particular. The addressed conflicts therefore underline the high connectivity between natural places and political meaning in the Arctic.

Besides the councils influence, increased marine activity in the Arctic constitutes the United Nations Convention on the Law of the Sea (UNCLOS) as legal framework (Koivurova, 2011). UNCLOS regulates the extent of legislation, enforcement control and access authorisations of marine regions (see Figure 2). These dimensions vary according to the distance of an area from straight baselines, low-water lines or closing lines (for bays) of the Arctic coastal states. So far, all Arctic states, except the United States of America, have ratified UNCLOS and proclaimed straight baselines along vast parts of their Arctic coasts. On the landward side of these lines, UNCLOS sets out the internal waters where states hold full sovereignty and receive a maximum of jurisdiction. Attached to the internal waters there is a 12 nautical mile-long zone: the territorial sea, where the coastal state still possesses sovereignty, but has to tolerate innocent passage which comprises continuous and expeditious travels. Further seawards is the contiguous zone, also 12 nautical miles long, followed by a 200 nautical mile zone in which the coastal states are given sovereignty rights over the resources in the ocean bottom and the water column: the exclusive economic zone (EEZ). The EEZ then borders the high sea, where all ships have free passage, apart from rare exceptions (Arctic Council, 2009; Lauster and Mildner, 2009; United Nations, 1994).

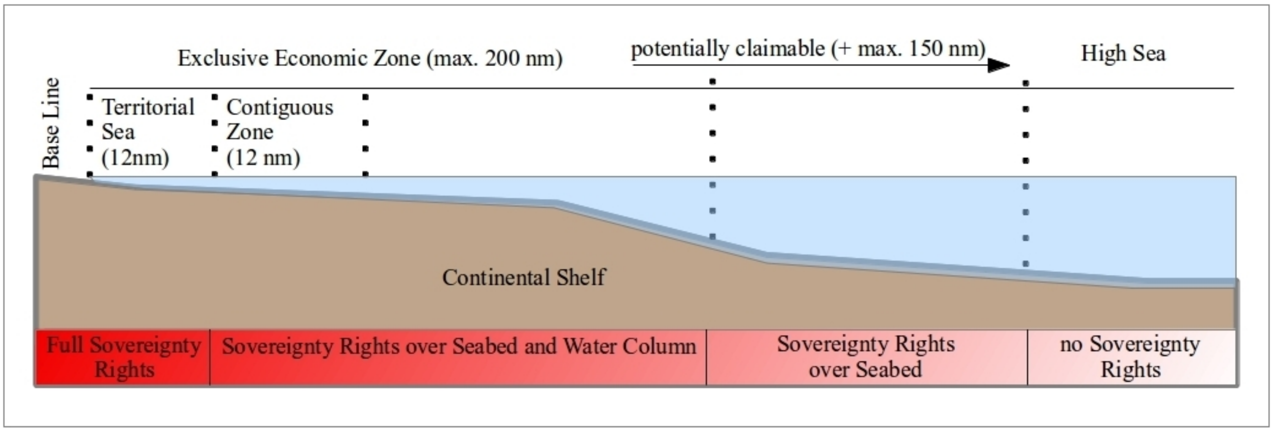


Figure 2: Illustration of UNCLOS

(according to Arctic Council (2009): Arctic Marine Shipping Assessment Report 2009)

Particularly the projected simplified exploitation of marine resources and the aspired controlling rights over the Arctic Ocean result in growing interests in these marine areas (Gerhardt et al., 2010). According to UNCLOS, a coastal state has the possibility to expand its EEZ, when it is able to prove that its underlying continental shelf extends beyond the existing 200 nautical mile border (Arctic Council, 2009; Lauster and Mildner, 2009; United Nations, 1994). In such an extended zone, the coastal state has sovereignty over the living and non-living resources of the seabed while the water column continues to be part of the high sea (Arctic Council, 2009; Lauster and Mildner, 2009; United Nations, 1994).

In order to achieve such an expansion and the allowance to exploit existing resources, three steps are necessary. Firstly, it needs the geological proof that the aspired expansion is a prolongation of the state's continental shelf. Secondly, it requires the submission of a claim to the Commission on the Limits of the Continental Shelf (CLCS), such as the Russian Federation (United Nations Convention on the Law of the Sea and Commission on the Limits of the Continental Shelf, 2013), Norway (Berkman and Young, 2009) and Canada did already (Division for Ocean Affairs and the Law of the Sea, 2014). Thirdly, an examination of the claim by the CLCS is undertaken, which than gives recommendations that the coastal state is expected to put into practice (Commission on the Limits of the Continental Shelf, 2009; Young, 2009b).

60% of the surface's size of the marine Arctic have shown to be continental shelf – an area that equals 11.5 million square kilometres (Larkin, 2009). Therefore and moreover in line with UNCLOS, it is legitimate that several claims overlap or compete against each other (Carlson et al., 2013; Corell, 2009). As an example, Canada, the Russian Federation and Denmark are trying to prove that the Lomonossov Ridge, which divides the Arctic Ocean into an American and a Eurasian Basin, has to be interpreted as a natural prolongation of their continental land masses (Baker, 2010). In the course of this, the Russian Federation, as the first submitting nation (Isted, 2009), claimed an area with the approximate size of 460800 square miles in 2001 (Gunitskiy, 2008). This claim has neither been approved nor rejected by the CLCS in 2002. In contrast, the Russian delegation was asked to gather more evidence to support their claim (Gunitskiy, 2008).
In 2006 Norway handed in their claim, in which they also oppose against the Russian claim and received recommendations from the CLCS in 2009. The mentioned sovereignty rights of Norway over Svalbard and the resulting claim of areas around the island group is particularly crucial, since it evolves conflicts with several countries, amongst them the Russian Federation and Iceland. The latter argues that Norway's sovereignty is based on a treaty (Spitzbergen Treaty) instead of customary law and consequently denies Norway the right to claim areas around Svalbard (Leary, 2008; Pedersen, 2006).

States which ratify UNCLOS only have a ten year period to hand in their claims. In Russia's case, this period was meant to expire in 2007. However, the period got enlarged, mainly due to the delayed establishment of the CLCS in 1999, giving the Russian Federation time until 2009 to hand in its claims, what took place in 2001. The analogue applied to Norway, while Canada's time frame ended in 2013 and Denmark's in 2014. Canada handed in a partial submission in December 2013, stating that its submission concerning its claims in the Arctic Ocean will follow at a later date. Denmark submitted in 2013 and 2014, in addition to an earlier claim from 2009, which dealt with the Faroe Islands. With exception to the latter, no recommendations have been made so far (2015) from the CLCS. In contrast, the period for the United States of America has not even started, since they did not yet ratify UNCLOS (Division for Ocean Affairs and the Law of the Sea, 2014; Matz-Lück, Nele, 2009). Hence, several disputes over maritime and terrestrial areas persist in the Arctic which are discussed in the next sections.

Analogue to the controversy around the outer borders of the Arctic, its internal legal boundaries are not yet clarified. Although there are legal frameworks whose contents cover the full area, territorial and maritime areas under dispute continue to exist.

The uninhabited island Hans constitutes the only territorial dispute in the High North. The island with a size of only 1,3 square kilometres is located between Greenland (Denmark) and the Ellesmere Island (Canada). Both states have defined their common boundary in 1972 with a continuous line, leaving a blank space, where the island is located. Therefore, its ownership remained open. Driven by the potentially existence of resources within the seabed around the island and its strategic position towards growing shipping activities in the Arctic Ocean (see Chapter 4.1), both states maintain their demand of the island until today (2015). In this course, Denmark and Canada cover for example the costs for visits, geological surveys and the installation of a joint weather station (de La Fayette, 2008; Stevenson, 2007).

The efforts both states undertake underline the geopolitical power of the island. Although the island itself does not offer any resources or entities of anthropogenic interest, its position does. Therefore, the Hans Island represents a case where geographical position determines its social and political meaning – hence, connects nature and society in the Arctic.

Besides this territorial dispute, maritime boundaries under dispute concern Canada and the United States of America in the Beaufort Sea, the United States and the Russian Federation in the Bering Strait and the Russian Federation and Norway in the Barents Sea (de La Fayette, 2008). The latter conflict got reconciled in 2010, when both states signed the Treaty Concerning Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean, ending a negotiative phase of over 30 years. In addition to this treaty, the Search and Rescue Agreement (SAR-Agreement) (see Chapter 4) contributed to the strengthening of regional Arctic governance structures (Sørensen, 2013). Yet, disputes over maritime boundaries and overlapping or opposing claims maintain, what underlines the high geopolitical potential of the Arctic Ocean, particularly in the course of climate change.

To conclude, the Arctic assembles an area that illustrates the need for a geographical approach which combines ideas of physical and human geography. Starting with possible boundaries of the High North outlined the geopolitical and climatological importance of this region. Afterwards, various social, political and natural examples have been given that underline the tight connectivity between the natural and the social sphere – not only in the Arctic, but in general. Besides, the given information are the foundation of the following studies.

1.5 Objectives and roadmap of the thesis

Investigations of interdependencies between processes of climate change and processes of political geography and geopolitics in the Arctic include four complex systems: the global and the Arctic natural system and the global and the Arctic social system. Three objectives are addressed in this thesis, to cope the aim of enabling geographers to work transdisciplinarily between physical geography and human geography (see also Figure 3).

Objective 1:
Develop a theoretical approach that covers natural and social / political developments

The theoretical work of the following research is based on Actor-Network theory (see Latour (2010)), enlarged with ideas of human ecology. Hereby, the whole Arctic region, with all arising interdependencies, is taken into account on a theoretical level, to identify the systems' uniquenesses, similarities and differences on several geographical scales.
This novel theoretical approach enables investigations of interdependencies between processes of climate change and processes of political geography and geopolitics. Hence, it leads to a detailed (geographical) understanding of coupled natural-social systems, illustrating transdisciplinary research between physical geography and human geography as a consequence.

Objective 2:
Identify actors and develop a methodological approach to analyse interdependencies between them

Entities that create connections between the four spheres by mediating flows of materials and energy between them are identified. Since there are always multiple interdependencies and moreover loops between the four spheres, any starting point can be chosen for such identifications – either within the natural or social sphere.

The identified mediative actors create and maintain the connections that interweave nature and society. Hence, they are important elements of the described networks. By representing suitable investigation units, these actors are then translated into different value systems, such as money, health, food or power – with the application of an enlarged ecosystem services approach (see Millennium Ecosystem Assessment (Program) (2005)).

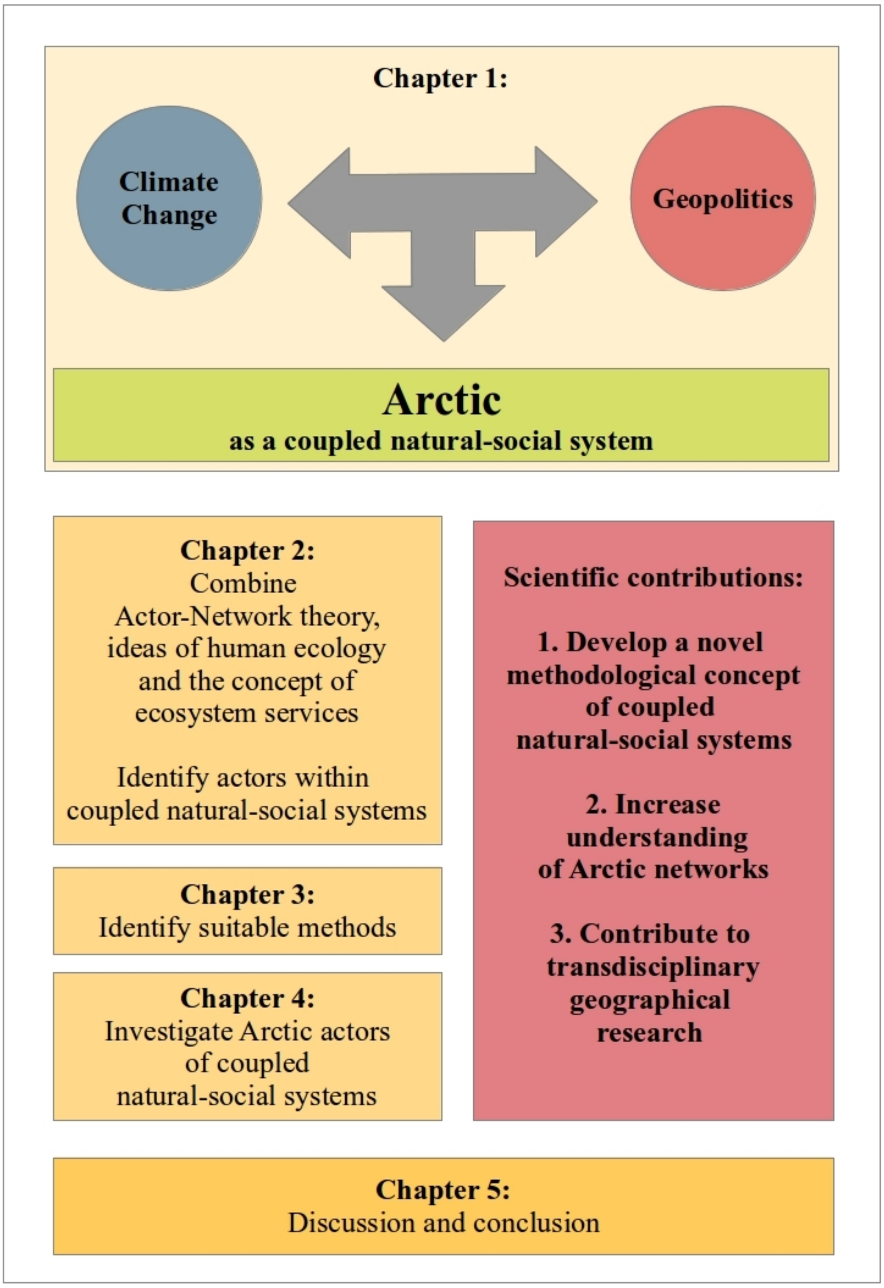


Figure 3: Objectives and roadmap of thesis

The inclusion of the ecosystem services approach leads again to a new interpretation of coupled natural-social systems. Hereby, a method developed to value ecosystems is used to investigate social and political systems. Linked with Actor-Network theory and its adaptation to natural systems, a novel methodological concept is created. It allows geographers to investigate coupled natural-social systems on different scales and from different points of view – without neglecting one or the other system's complexity.

Objective 3:
Test the developed theoretical approach and the methodological concept

Three Arctic actors are chosen, according to their social, political, economic, ecological and cultural characteristics. In addition, their impact potential on different geographical scales is taken into account (Chapter 2). The selected actors are investigated with the developed methodological concept.
Hereby, the analysis of actors is based on literature research, interviews and freely available (GIS-) data. While climate change is regarded as the main natural driving force, the political influence of Germany and the EU resemble important social factors in this thesis. In addition, possible future developments of the actor's usability and exploitability are outlined (Chapter 4).

Overall, the conceptual approach in this thesis improves the understanding of Arctic networks, by identifying their mediative entities and aligned interdependencies. In enabling a merging processes of physical geography and of human geography, it does not only benefit geographers, but also policy makers and stakeholders of the High North (Conclusion and Summary), by enabling a detailed transdisciplinary understanding of Arctic networks.

2 Developing a novel theory to investigate interdependencies between processes of climate change and processes of political geography and geopolitics – exploring networks

Abstract Chapter 2

Objective 1:
Develop a theoretical approach that covers natural and social / political developments

To respect nature's and society's complexity as spheres a human ecology based approach is chosen as a starting point: socio-ecological metabolism. This concept illustrates how nature and society are interwoven and how they exchange flows of materials and energy, but does not credit nature and society equal powers to determine anthropogenic actions. Therefore, the sociological Actor-Network theory (ANT) functions as an enlargement. Focusing on connections and interdependencies between entities, ANT involves core-ideas of the metabolism approach, but treats both spheres equally – in theory. The involvement of a sociological theory into geographical research is not only a novel procedure for physical geographers, but also for ANT, since it is applied to a research problem that is highly connected to fields of natural science and moreover to a specific geographical region: the Arctic.
Yet, ANT does not completely suit the natural and social uniqueness of the Arctic. Hence, a more precise distinction and characterisation of interdependencies between and of involved entities themselves is developed, including particularly mental entities.

Most important outcomes:
1. *(Arctic) nature and (Arctic) society overlap each other, leading to the creation of an overlapping zone: the Hybrid Arctic.*
2. *Interdependencies between nature and society are mediated through entities of the Hybrid Arctic, which merge natural, social and mental characteristics – such entities are referred to as actors.*
3. *Actors can "activate" other entities in connecting them through novel interdependencies what shifts these entities into the Hybrid Arctic.*
4. *The Hybrid-Arctic is constantly changing.*

Objective 2:

Identify actors and develop a methodological approach to analyse interdependencies between them

To suit Objective 2, the concept of ecosystem services is used to analyse the interdependencies of Arctic networks. The adaptation of Actor-Network theory to natural systems, coupled with the adaptation of the ecosystem services approach to social systems creates a novel methodological concept that investigates actors in the Arctic. Hence, it does not only benefit geographers to work transdisciplinarily, but leads to a more detailed understanding of network structures in general.

As an outcome of Objective 1, actors always merge natural, social and mental aspects. Therefore, such actors have to be represented in the natural, social and mental sphere themselves. To investigate actors from different value systems (for example monetary values and intrinsic values), the ecosystem services approach is chosen. However, in order to do so, this approach has to be adapted to the involvement of social and political systems, particularly in terms of supporting ecosystem services.

Most important outcomes:

1. *Actors of the Hybrid Arctic are represented on all geographical scales (local, regional and global).*
2. *Actors of the Hybrid Arctic always represent needs, demands and desires of Arctic network-members and are therefore referred to as ANT-resources.*
3. *ANT-resources merge natural, social and mental characteristics.*

The investigation of interdependencies between processes of climate change and processes of political geography in the Arctic addresses fields of physical geography and human geography. It is moreover linked to related disciplines, belonging to natural, political or social sciences. This generates a need for possibilities to analyse such coupled natural-social systems. Yet, neither traditional approaches of physical geography nor traditional approaches of human geography enable such transdisciplinary research (Kanwischer, 2006; Weichhart, 2003) - although geography, as a scientific discipline, merges aspects from natural sciences and social sciences (Köck, 2008), hence is located somewhere in between. So far, various geographers from both major subdisciplines integrate or get integrated into scientific work from the respective other subdiscipline. However, such developments which bridge between human geography and physical geography tend to arise spontaneously, meaning that there is only a minority of geographers who integrate work from a different subdiscipline while getting integrated into this subdiscipline vice versa (Aufenvenne and Steinbrink, 2014). Hence, although there are certainly research fields that could prosper from the respective other subdiscipline, some authors go as far as stating that both major geographical subdisciplines are drifting apart (Harrison et al., 2004; Thrift, 2002).

In order to further overcome this gap, the implementation of a third column between the two major geographical subdisciplines (physical geography and human geography) is particularly discussed in German-speaking areas – the so-called "Dritte Säule der Geographie". This third column aims to provide methods to investigate research questions neither belonging to the major geographical subdisciplines (Endlicher, 2012; Weichhart, 2008a). Hence, it represents a research area of its own, for which the term "human ecology" is often used as a synonym. The research field of human ecology contributes to the named aim by analysing human beings as a part of nature (Endlicher, 2012; Steiner, 2003; Weichhart, 2009a, 2001). Hereby, the traditional, biological interpretation of "ecology" is applied to humans and their possibilities to create, transform and communicate information. Hence, the source of this research field uses methods from social science to investigate concepts from natural sciences (Weichhart, 1989). Such novel approaches lead to a geographical understanding of society which includes both: constructive-culturalism and material/natural components of societies (Weichhart, 2005) - what is also described as a "material-turn" within geographical research (Kazig and Weichhart, 2009).

Based on these ideas, Figure 4 illustrates the different steps of the development of a transdisciplinary theoretical approach. The figure differentiates between ideas, belonging to the conventional approaches and taken enlargements.

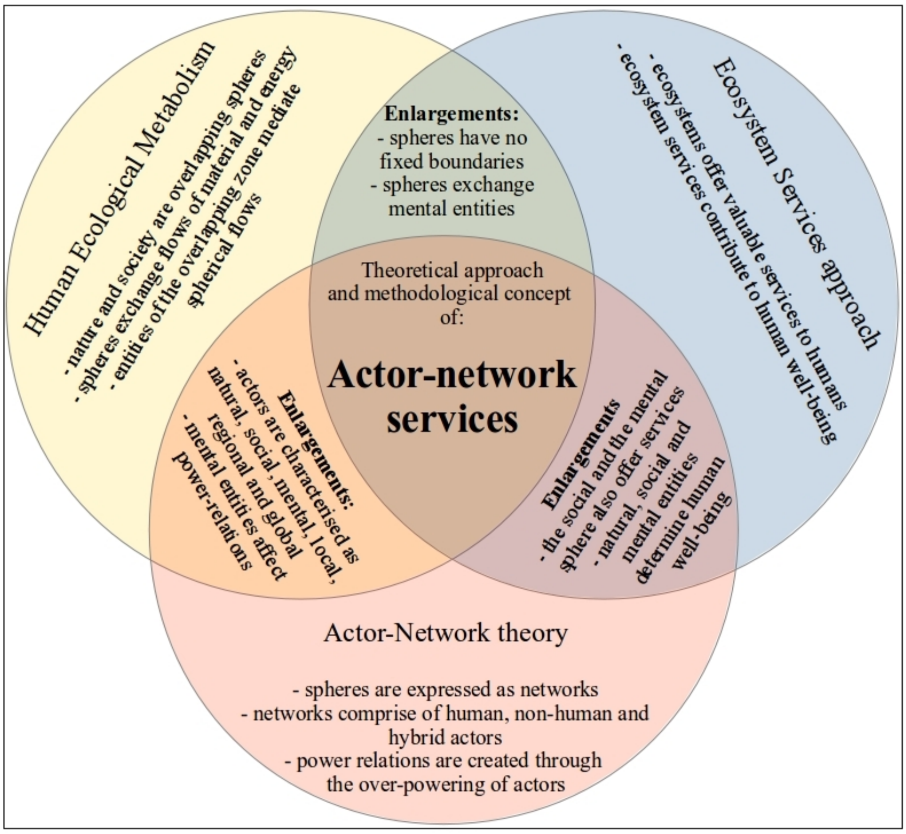


Figure 4: Development of a novel theoretical approach and methodological concept: Actor-network services

Theoretical and methodological approaches with needed enlargements to investigate coupled natural-social systems in the Arctic

2.1 Developing a theoretical approach that covers natural and social / political developments

Particularly one human ecological approach suits the investigations of interdependencies between processes of climate change and processes of political geography: the concept of socio-ecological metabolism (see for example Fischer-Kowalski and Weisz (2005)). This approach focuses on flows of material and energy between the spheres “nature” and “society”. Hereby, flows interweave these two spheres by creating interactions between them. In general, the flows between processes of climate change and processes of political geography are of the same structure then the ones, investigated within metabolism research. Consequently, these studies offer an insight into existing theories and methods of the third column of geography, while also contributing to the defined *Objective 1: Develop a theoretical approach that covers natural and social / political developments.*

2.1.1 Introduction to human ecological metabolism research – a theoretical approach from human ecology

According to Fischer-Kowalski and Weisz (2005), natural science tends to regard natural systems as highly complex. These complex systems are surrounded by human beings who simple cause natural actions. Hence, natural systems consist of various interdependencies, while human beings are reduced to being initiators or driving factors in contrast. Analogue, social scientists analyse components of social or economic systems by merely investigating their internal mechanism. The surrounding nature remains often “silent” and therefore even negligible in order to explain social processes (Fischer-Kowalski and Weisz, 2005).

Within this human ecological approach, a novel interpretation of society is developed. Firstly, socio-ecological systems are defined as systems, created by interactions between society and the surrounding natural environment (Haberl et al., 2004a). Hereby, the term human-environmental system suits as a synonym, since it contains both critical factors, involved into the evolution of such systems (Krausmann et al., 2009). Secondly, the implementation of human-environmental systems leads to a new understanding of society as a hybrid between natural and social parameters. While these novel definitions leave the social part of society untouched, nature now contributes to society through the provision of building materials, the creation of an animal livestock or its influence on the functioning of human bodies (Weisz et al., 2001). Consequently, socio-ecological systems are postulated as systems, formed by an overlapping of the natural sphere and society. Within this overlapping zone, the previously named natural contributions are located and defined as the biophysical structures of society (Haberl et al., 2004a).

A socio-ecological system also includes social factors, such as society's culture or the communication between its members (Fischer-Kowalski and Weisz, 2005). Especially the inclusion of cultural and political parameters, confirms that a socio-ecological system is not a bare synonym for ecosystems – as ecologists understand them. An ecosystem describes a system, involving a certain biotope with all living and non-living entities, man-made entities (analogue to the biophysical structures of society) and the different flows between them (Gebhardt et al., 2011). Hence, conventional ecosystem definitions do not differentiate between human beings and other living creatures. This neglects cultural or political intentions, although they drive human actions far too often to be ignored, when analysing a system's flows.

Yet, there is an ecological research field that includes investigations of the cultural dimension of human behaviour: human ethology. In general, this discipline uses and moreover applies biological methods and biological research questions to study human behaviour. Hence, human ethology research reaches for example from investigations how human behaviour contributes to fitness and survival skills to ethological analyses of cultural patterns amongst a group of people ((Eibl-Eibesfeldt, 2009). However, this field is limited to the creation of human behaviour only (Eibl-Eibesfeldt, 1979), what opens up possibilities to neglect anthropogenic influence on nature in reverse.

Since the investigation of socio-ecological systems involves both, conventional ecosystem research and ideas of human ethology, it requires adapted research methods. Therefore, two dominating concepts are implemented: socio-economic metabolism and the colonisation of natural systems (Fischer-Kowalski and Weisz, 2005).

Socio-economic metabolism analyses flows of material and energy within, into and out of a socio-economic system, what provides a deeper understanding of interactions between nature and society (Fischer-Kowalski and Amann, 2001). These flows permit society to maintain economic processes and to secure its consistency (Haberl, 2008). Hence, certain societies have characteristic metabolic profiles. Such profiles include all material and energy turn overs within one year, divided by the population's size and classified by the analysed material, such as biomass, minerals or water

(Fischer-Kowalski and Weisz, 2005). Therefore, the overall metabolism of a system can be estimated by summing up all metabolisms of each subsystem and all internal exchanges (Fischer-Kowalski and Haberl, 1997). A system's metabolism can be analysed on different scales: global, national, regional or local. Furthermore, functional or temporal studies are feasible (Fischer-Kowalski and Hüttler, 1999).

Within this concept different socio-metabolic regimes are distinguished, according to their environmental impact, as for example hunter and gatherers and agrarian societies. The transition of one society into another is explained by sustainability problems which result from the society's existing metabolism (Krausmann et al., 2008). Such, transitions always lead to new ways of material and energy use – in case of the industrialisation it lead to extensive usage of fossil energy (Haberl et al., 2011; van der Voet, 2011), supplying particularly regions without natural energy sources, such as turf or coal. However, it is even stated that industrialisation itself is just an ongoing transition from the agrarian to a yet unknown system (Sieferle, 2001).

In order to be able to distinguish ordinary changes from transitions, Fischer-Kowalski (2011) names three parameters: Firstly, defined system boundaries to clarify the unit of investigation, secondly, a differentiation between the succeeding states of a transition – although other models exist, an S-shaped curve (Rotmans et al., 2001) illustrates the typical trend for such a development –, and thirdly, an understanding of the phase's order (Fischer-Kowalski, 2011).

As investigations of socio-economic metabolism illustrate: inputs and outputs of a system represent two contrary pieces of the same development, instead of being two independent streams. This interpretation enables a deeper understanding of interactions between nature and society that goes far beyond the environmental impact potential of human-induced toxins and pollutions. However, some observed environmental changes, such as the loss of biodiversity or environmental degradation, cannot be directly connected to metabolic changes. In order to involve such processes into metabolic analyses a complementary concept is needed: the colonisation of nature (Fischer-Kowalski and Weisz, 2005).

The term "colonisation of nature" addresses society's actions to improve nature's use for human beings. It involves all interventions, leading to a maintaining or increase of necessary material and

energy flows. Besides agricultural adjustments, the advancements of labour force, skills, technologies and information also contribute to a higher effectiveness of society's exploitation of nature (Fischer-Kowalski and Weisz, 2008). Hence, a high level of organisation is needed on society's side to colonize nature (Fischer-Kowalski and Weisz, 2005). Although any living creature has to colonize nature to survive, society's colonisation processes go far beyond any other. Particularly the high level of organisation within society constitutes its uniqueness as a process and cannot be found in any other living community, even if there animals, for example different mammal and insect species, which also live in complex communities.
By getting colonised, natural systems are shifting, according to society's demands and needs. As an overall achievement such alterations make natural systems more useful for society (Fischer-Kowalski and Erb, 2006). Yet, colonized systems require constant anthropogenic efforts to persist, why they are more fragile than their original – natural – state, to which they would return without further human intervention (Fischer-Kowalski and Weisz, 2005). However, human-directed interventions create functional and straight interdependencies between social and natural systems (Weichhart, 2009b), separating colonised nature from "plain" human influenced systems (Fischer-Kowalski and Weisz, 2005).

From a geographical point of view, all human influenced systems can be subsumed into the anthroposphere, which also includes the biophysical structures of society (Baccini and Brunner, 2012). However, the anthroposphere does not comprise the previously named social, cultural and political driving factors. Hence, the ideology behind the visible part of human impact is neglected. The idea that a human's thinking drives its actions, even on geological scales, has been implemented into the concept of the noosphere by Vernadsky (1945). The noosphere includes therefore a spectrum, similar to the concept of the colonisation of nature. Yet, the geochemical methods to analyse the noosphere concentrate merely on flows of chemical elements. Hence, they lack particularly the supplementing political and socially driven implementations of the human ecological metabolism approach.

To conclude, human ecological metabolic research offers significant possibilites to investigate interdependencies between processes of climate change and processes of geopolitics. Its theoretical background deals with both, nature and society, leading to the definition of society as a hybrid which involves cultural and natural elements simultaneously. Metabolic research interprets

sustainability as an outcome of material and energy flows that maintain society's economic processes – hence, its status quo. In contrast, not sustainable actions will lead to social transitions that alter society and nature as a consequence. The anthropogenic part of climate change functions as an example here. If regarded as a result of flows between society and nature, it leads to feedback loops and social adaptations. Thus, this particular part of climate change has to be identified as an outcome of not sustainable human actions, such as increased pollution. The resulting natural consequences are then followed by social transitions.
Yet, investigations of interdependencies between processes of climate change and processes of geopolitics not only involve the anthropogenic part of climate change, but also its natural components. The outlined approach, however, does not include the latter parameters, since it concentrates on human induced changes only. Furthermore, the described metabolic research addresses global transitions solely, leading to not applicable methods, regarding the research questions of this thesis. Hence, the approach of socio-economic metabolism does not cover all factors needed to be analysed in this thesis.

2.1.2 Critique – missing factors

Particularly two theoretical postulations and the used methods to analyse socio-ecological systems and their socio-economic metabolism, are not implementable for the investigation of interdependencies between processes of climate change and processes of political geography in the Arctic. The following paragraphs point out these crucial factors and link them to geography, by showing their lack of adaptation to the research objectives of this thesis.

One misleading theoretical postulation addresses the required boundaries of a socio-ecological system. The definition of the system's boundaries is needed, to distinguish between in- and outflows and as a consequence between included and excluded factors (Fischer-Kowalski and Hüttler, 1999). The biophysical structures of society lay in the boundary area between society and nature. Hence, their specification is crucial in terms of defining a system's boundaries, what guides to the second misleading theoretical postulation: the definition of the biophysical structures of society. The anthropogenic actions of hunting, fishing and gathering are included into the flow analyses of socio-economic systems. However, plants which enable these actions, are not. Fischer-Kowalski and Haberl (1997) even state that it is too difficult to distinguish between contributing plants and plants

which do not take part in hunting or gathering, for example (Fischer-Kowalski and Haberl, 1997). An inclusion of plants of anthropogenic use into the biophysical structures of society also shifts system boundaries to a different level. If plants were included, the top of the soil layer which is essential for the growing of plants in general, had to be part of socio-ecological systems, too. Consequently, anthropogenic fertilization, would belong to the internal flows, while erosion pertains to the system's outflows (Fischer-Kowalski and Hüttler, 1999). Yet, the top of the soil layer is determined by the bedrock and the local climate that dictates weathering processes, for example. Hence, it is inexplicit if these flows have to be included into socio-ecological systems as well. If regardless to its essential role, the top of the soil layer was not part of the biophysical structures of society, all flows into this layer had to be regarded as outputs (Moolenaar and Lexmond, 1998).
Therefore, according to a system's boundaries, the differentiation between similar flows into in- and output and the way they are treated methodologically will differ. Furthermore, humans use air, water and other natural resources, which are often regarded as universal entities and therefore not included into metabolic analyses at all.

A a consequence of the two misleading theoretical postulations, any definition of boundaries suppresses a fair part of the system's complexity by either a separation of connected parameters or by the bare neglect of aligned entities. Particularly the mentioned universal entities are crucial to natural systems. Hence, it is worthwhile to rise the question if natural systems also reach metabolic sustainability problems in result of their in- and output flows and if they are therefore subject to transitions.
Apart from the controversy around included or excluded flows, the definition of biophysical structures of society does not pay credit to nature's analogue part: the social structures of nature. Plants and especially animals are connected by the concept of ecosystems and are therefore able to build “social” structures. The absence of a definition of the social structures of nature denies particularly two interdependencies between nature and society. Firstly, a self-colonisation of nature exists that addresses plants and animals living in cities or settlements, without having the certain purpose to optimize society's metabolism and secondly, nature has positive or negative effects on human mental health.

2.1.2.1 Self-colonisation of nature

Apart from the previously described man-made colonisation of nature, there are different species, flora and fauna which “colonise themselves”. Without fulfilling a certain purpose, given to them by society, they are so far not included into the biophysical structures of society, although they are certainly part of it.

At this stage it is necessary to highlight the Arctic's settlement structure in order to link it to the self-colonization of nature. While overall, the Arctic is sparsely populated, these vast nearly uninhabited areas face relatively big cities. A significant amount of Arctic inhabitants live in big settlements, each with a population greater than 5,000 people. As examples, in Alaska 40% of the state's population live in the state's capital Anchorage, in Iceland more than 60% of the total population are residents of Reykjavik and nearly half of the people who live in the Russian Arctic are concentrated in the nine biggest cities of the area (AHDR, 2004). Therefore, species, living in or close to settlements are of importance in the Arctic, why the named influences of self-colonised nature have to be considered, at least on a theoretical level.

Self-colonising species feature urbanophobe or urbanophile characteristics, according to their dependence on human influenced environment (Grant et al., 2011; Wittig et al., 1985). The term synanthropes is also used in this context, often with a distinction between full synanthropes, including exploiters and urbanophile species, casual synantropes, such as adapters or moderate urbanophilic species, and non-synanthropes which obviate living close to human beings, as do avoiders and ubanophobes (Johnston, 2001; McKinney, 2006). Johnston (2001) refers to biological synanthropy as a human-mediated symbiosis between animals / plants and humans. Synanthrophic species cover a wide range from specialists to habitat generalists, the analogue does their dependence on humans (Johnston, 2001). Furthermore, a richness of species, especially alien species, is recorded in cities which is enabled by several outstanding factors, such as landscape heterogeneity, climate benefits or soil diversity (Kuhn et al., 2004). Particularly in the Arctic, climate change and rising anthropogenic activities allow alien species to colonise themselves recently, leading to unpredictable impacts (Lassury and Lewis, 2010) – including an alteration of metabolic flows.

In general, there is no point in denying the influence of such species on society's metabolism.

Really intuitive examples are the black rat (*Rattus rattus*) and the more common brown rat (*Rattus norvegicus*) that replaced the black rat in most cases, which belong to the (extreme) urbanophile species (Schwarz, 2009). Regarding metabolic flows, both species do not comply with a certain human defined purpose. However, they still have a clear impact on society's metabolism, for example by spreading the enterobacteria which causes the disease plague. This example shows, how self-colonised species directly influence material and energy flows. Furthermore, it bridges the factor self-colonisation of nature with nature's effects on human well-being that goes far beyond the spreading of diseases.

2.1.2.2 Nature's effects on human well-being

The second factor that is missing in human ecological metabolism research, is nature's effect on human-well being and as a consequence its impacts on society's metabolism. The World Health Organisation defines health as the complete physical, mental and social well-being (Grad, 2002). It therefore addresses three dimensions which can – hypothetically – be influenced by (colonised) nature: the human body itself, the mental condition and the integration of a human being into a social system.

While the “rat-example” has shown impacts of animals on the human body. The following concentrates, in contrast, mainly on plants and universal entities, since they are not included into society's metabolism so far, what strengthens the previous critique. In addition, the following ideas are again based on the fact that most people, also in the Arctic, live in cities today (2015). What causes them to face numerous issues in terms of increasing iniquitousness in health and well-being (Van Kamp et al., 2003) and therefore in their overall quality of life.

Generally, the term “quality of life” refers to the relationship between humans and their (urban) surrounding, comprising environmental attributes, such as air or water pollution, and anthropogenic characteristics, such as health (Pacione, 2003). Hence, the quality of life also depends on universal entities and particularly on the existing green infrastructure, including all natural, semi natural and man-made (artificial) ecological systems within, around and between urban settlements.

One example, outlining the importance of universal entities to human well-being in the Arctic, is the sunlight. The solar-climate of the High North is highly impacted by periods of complete absence of it. Hence, the people's lifestyle is adapted to Polar night and Polar day. Particularly the darkness can have negative effects on the mental health of the Arctic's and sub-Arctic's population which may result in a delaying of chronotype, sleep difficulties or mental distress and subjective well-being (Friborg et al., 2014; Johnsen et al., 2012; Paul et al., 2015). Hence, people who are mentally stressed, are susceptible to diseases during this period. Consequently, they will need medicine or adapt and cure their overall behaviour. Therefore, the Arctic's metabolism is affected by universal entities, such as the sunlight.

Another example, contributing to human well-being in various ways, apart from having also positive natural effects on biodiversity and corridor building between habitats, is the green infrastructure of settlements (Tzoulas et al., 2007). Green infrastructure supports recreational processes, shapes cultural identities and structures the city (Sandström, 2002). It also encourages people to domiciliate in a certain area which they consider to be pleasant. This will then strengthen the local economy, since employments have to be provided to the resident people (Kambites and Owen, 2006).

Besides, urban greenspace has a significant impact on energy flows of cities, particularly in terms of climate change adaptations (Gill et al., 2007) (Please note that there is also urban greenspace in Arctic cities, such as Tromsø or Anchorage). Some authors even state that green infrastructure will reduce the need for grey infrastructure, such as roads or utility lanes. Furthermore, greenspace prevents human settlements from natural disasters, including floods or fires (Benedict et al., 2002) which also increases human well-being.

These ideas show, that one of the strongest colonisations of nature – planned implementation of plants into urban areas – has essential effects on society's material and energy flows, particularly on mental scales which will then influence economic, social or political decisions. However, these (mental) components of colonisational processes are not included into the original definition of socio-economic systems, although they are required and moreover essential to interdependencies between processes of climate change and processes of political geography and geopolitics.

Such (mental) factors can be implemented on a theoretical level without any hindering, but they cause difficulties according to the originally used methods, when analysing socio-economic systems. Investigating a system's input and output flows is only possible, if the system's boundaries are clearly defined. Adding mental factors to socio-economic systems weakens their boundaries and leads to a fairly open system which is not implementable into the described approach – but needed in order to analyse interdependencies between processes of climate change and processes of political geography and geopolitics.

To conclude, within human ecological metabolism research, nature simply reacts on anthropogenic impacts, so far. Although humans are an important driving factor of natural changes, some environmental shifts cannot be traced back to their social origin. Such natural alterations lead to other shifts or provoke contrary interdependencies within the natural sphere which will then impact society in reverse. Hence, they appear as natural actions. Consequently, nature includes mechanisms, not fully depending on human actions, which ultimately influence society. Since the conceptual approach, developed in this thesis, is meant to treat nature's and society's contribution and complexity equally, these ideas have to be considered on a theoretical and methodological scale.

2.1.2.3 Inapplicable methodology

One of the main purposes to depict global transitions of socio-economic regimes is connected to the decision that the only appropriate research unit is society as a whole. Hence, the collected data is merely on a global or at least countrywide scale (Fischer-Kowalski, 2011; Fischer-Kowalski and Weisz, 2005). Three methods are mainly used to analyse metabolic flows: Firstly, the Material Flow Accounting, secondly, the Energy Flow Accounting and thirdly, the Human Appropriation of Net Primary Production (Haberl et al., 2004b). Especially the latter involves the intensity of the actual land use, since it is defined as the difference between the net primary production of the vegetation before and after the harvest (Haberl et al., 2001). All used data is distinguished by its physical characteristics (Krausmann et al., 2004). Using for example its mass as a unit of flows, enables the establishment of simple measurement techniques which are easily understandable without long explanations. In addition, also the mass flow per unit of time and its quality are crucial to rise the comprehension of the existing pressure on the environment (Bringezu et al., 2003; Fischer-Kowalski et al., 2011).

Consequently, the described human ecological metabolic approach, in alliance with its methods solely works because global society is defined as the appropriate research unit. Hence, several

problems occur, when trying to adapt it to regional socio-economic systems, such as the Arctic. The applied methods, just as Material Flow Accounting, Energy Flow Accounting and Human Appropriation of Net Primary Production, are not precise enough for investigations on regional levels.
As an example, the majority of the food, consumed by Arctic people, is produced in systems, located south of the High North. If solely regarding the socio-economic system "Arctic", such shifts of edibles are registered as material inputs. However, these products are also outputs of a "Not Arctic" system, where they have been manufactured. Hence, the required input flows into the system "Arctic" are not only determined by nature, as it would be on a global scale, but also by the system "Not-Arctic".
To conclude, socio-economic system A produces goods, as a function of its possibilities and the existing demands, and relocates them to socio-economic system B, where the goods are then deconstructed – what describes a typical process in the course of globalization. And while system A creates a regional socio-ecological system with its surrounding nature, it relies also on the supra-national natural system, with which system B forms its socio-ecological system. Consequently, it is not sufficient anymore, to solely separate nature from society on a global level, since there are at least two socio-ecological systems involved into the described shifts of eadables into the Arctic.

Furthermore, the metabolism approach solely deals with data which has a physical representation. Therefore, flow-inducing factors and processes, amongst them political agreements or knowledge gaining, are concealed. Hence, mental entities are not represented so far, although they influence interactions between nature and society – in general, but particularly in the Arctic.
In addition, the strong concentration on the biophysical structures of society, excludes not only the social structure of nature, but also its mental structure, comprising intrinsic values, which are essential, when analysing interdependencies between nature and society on a global, regional or local level – as the ideas of the noosphere and anthroposphere have already pointed out.

The theoretical approach of this thesis has therefore to include an even broader structure, to credit the complexity to nature, society and to the overlapping zone. Hence it reaches further than analysing material and energy flows only. In addition, the so far fixed boundaries of research units do not fit to the objectives of this thesis, as the previous discussion has shown. Firstly, there are no fixed boundaries between nature and society. Secondly, the entities in the overlapping zone are mobile in terms of their belonging to one sphere or the other. Thirdly, the methods used by human ecology, cannot be applied to the Arctic if interdependencies between processes of climate change and processes of political geography and geopolitics are investigated. Hence, there is a strong need for a broader theoretical approach to investigate coupled natural-social systems.

As a consequence, this approach does not distinguish between nature and society. Hence, it still includes the useful overlapping zone, but also complex structures of different origin (natural, social, mental). Therefore, it is highly inspired by Actor-Network theory (ANT) (see for example Latour (2010)) which is adapted in the following to geographical research questions in general and to the uniqueness of the Arctic in particular.

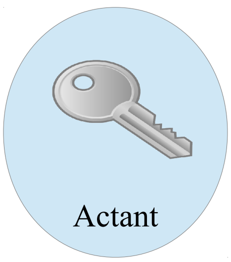
2.1.3 Introduction into Actor-Network Theory (ANT)

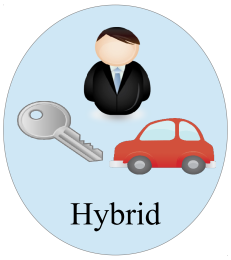
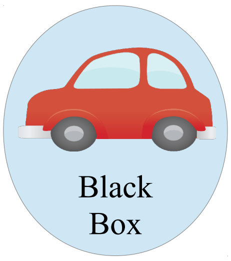
ANT, as it is used in this thesis, has been developed and described by Callon, Latour and Law since the late 1970s and the early 1980s. First of all, Law (2009) states that ANT is not a conventional theory, because it does not aim to explain why something happens, but how it happens, using a descriptive language. Hence, ANT is a tool to analyse situations, being created by actors of various forms and competencies. It also offers a possibility to deal with circumstances, in which human and non-humans are difficult to be separated from one another (Callon, 1999). Therefore, ANT does not seek to work with a-priori restrictions which might limit the analysing possibilities of an actor-network (Latour, 1996a).

Adapting ANT to investigations of interdependencies between processes of climate change and processes of political geography and geopolitics, requires the redefinition of common terms, such as actor or network, using the descriptive language of ANT. Besides, their suitability for *Objective 1: Develop a theoretical approach that covers natural and social / political developments* is discussed and enlarged. Furthermore, ideas of the previously described human ecological approach are involved to point out made improvements. The definitions with made adaptations to the objectives of this thesis and outcomes of the following Chapters 2.1.3.1 to 2.1.3.10 are summarized in Table 1.

Table 1: Summary of definitions

(Symbols based on clip art gallery taken from LibreOffice Draw, Version: 4.3.5.2)

ANT-term	Short Definition
Actor / Mediator / Mediator-entity / ANT-actor (see particularly Chapter 2.1.3.1) 	A human or a non-human entity which has been actively involved in *network*-building processes, by changing a given situation – as for example a key that opens a car or a person that drives a car. Every actor is a mediator / mediator-entity and contributes to the price of maintaining connections over a certain amount of time. Hence, actors possess power over other *network* members, forcing them to fulfil *actions* – as for example a speed bump or a cat on the road which make people reducing the speed of their cars. In comparison to the conventional definition of actors, ANT-actors are the derivation of an *action*, instead of being solely its source – as for example the key which initially allows a person to open the car. Actors are of natural, social or mental origin – as for example a cat, the drivers licence or the pure knowledge how to drive a car. If the holistic idea behind actor has to be underlined, the terms “mediator”, “mediator-entity” or “ANT-actor” are used in this thesis as a synonym to the term “actor”, which is in a traditional understanding bonded to humans only.
Actant (see particularly Chapter 2.1.3.1) 	The term “actant” describes (especially in German speaking areas) non-human *actors*. Actants lead to, enable, limit or deny human *actions* – as for example a car, a speed bump, a cat, the drivers licence ... Furthermore, actants must not have a certain figuration at the starting point of a scientific survey. If analyses determine a precise figuration, the actant turns into an *actor* linguistically. Apart from that, actants have exactly the same characteristics as *actors*. To underline the holistic idea of ANT, the term “actant” is not used in this thesis (after the definitions).

ANT-term	Short Definition
Hybrid (see particularly Chapter 2.1.3.3) 	Several *actors* form a hybrid together. By joining, they achieve possibilities, they do not possess by their own – as for example: neither a car nor a person would be able to fulfil the action "drive" without one another. Consequently, the involved *actors* share the responsibility for *actions* between them, since both are contributing to the fulfilling of the action – the car and the person. Hybrids are created by natural, social and mental *actors* - as for example, to drive a car it does not only need a person and a car, but also the key and the knowledge of how to start, steer and operate the car. Hybrids have the same characteristics as *actors* which makes the distinction between them negligible. Therefore, the term "hybrid" is only used if the hybrid structure of an *actor* is important to the investigation of this thesis.
Key-parameter / Key-element	The terms "key-parameter" and "key-elements" refer to important *actors* that over-power different network-members within the actor-networks, described in this thesis.
Black Box (see particularly Chapter 2.1.3.4) 	A group of *actors* which appear as one single entity to external observers – as an example, a functioning car could be a black box, if it is only of interest that it is driving. If it is of interest why it is driving, the black box "car" has to be opened. Since a black box always involves the cooperation of several *actors*, it can be named and treated as a *hybrid* with unknown components. The opening of black boxes and the investigation of their interior is a core-idea of ANT.
Action (see particularly Chapter 2.1.3.2) 	*Actors*, *actants*, *hybrids* and *black boxes* lead to actions by over-powering other *network* members. The final state of an action cannot be achieved by solely one *actor*, but is always created by the collaboration of different *actors* which build a functional chain or a chain of actions together. Therefore, enabling other *network* members to fulfil actions is inseparably connected with acting – as the previous example of driving a car has shown. The involvement of several *actors* also implies the impossibility to predict an actions' outcomes – as one actor may not fulfil its purpose. For example: The key may break, the engine of the car might not be working.

ANT-term	Short Definition
Translation (see particularly Chapter 2.1.3.6 and Chapter 2.1.3.7)	Due to being connected to network-members and to enabling them *to act*, *actors*, *actants* and *hybrids* translate information, while working as a functional chain. Translations are needed to guarantee the collaboration of *actors* – as an example: a driving person translates knowledge into the mechanical operation of a car.
Social (see particularly Chapter 2.1.3.2)	In comparison to the conventional interpretation, being social is now an attribute of connections. This abolishes the perpetual motion of explaining the social through being social and vice versa. However, actions consists of several natural, social and mental mediators and as a consequence also of connections. Hence, the attribute social can be awarded to actors as well.
Network / Sphere (see particularly Chapter 2.1.3.8) 	A web of activated *actors*, *actants* and *hybrids* - as for example the network of road traffic. A network is described by its amount of connections and by its tightness. A conventional understanding of scale, distance and size does not suit ANT. Instead, the space between the connections remains empty. Traditionally, networks within ANT are described as two-dimensional, due to the idea that connections are flat. In this thesis, attributes are used to categorize *actors*, what adds a third dimension to networks, why they are also referred to as spheres.

2.1.3.1 Redefining actors and adding actants

"Actor" refers, in a conservative way, to humans only. Being an actor involves, to be able to fulfil actions or in simple words: to act. Actors have the possibility to reflect their actions, beforehand and afterwards. This means, that an actor can think about its actions and calculates possible outcomes beforehand. Furthermore, every human action is determined by social, cultural and material parameters, as well as by subjective judging. A broader definition also includes collectives or groups of people or other stakeholders as actors (Heineberg, 2007; Weichhart, 2008b; Werlen, 2010, 2000, 1999, 1997).

In a Latourian perspective, the given interpretation of actor is not broad enough. First of all, a semiotic meaning is included into its definition (Callon and Latour, 1981). Hence, an actor is someone or something which is acting by itself or to which activities are awarded (Latour, 1996a). In order to further stress the involvement of non-living entities, the term “actant” is used.

Secondly, a constraint to humans (in whatever combination) is missing, an actant can be anything – as long as it makes a difference to a certain situation and is regarded as the derivation of actions. Actants cannot force humans to act, but they lead to, limit, deny, ease or enable actions. Within this postulation lies one of the key ideas of ANT: actors and actants change situations, even if they are not identified by the researcher or other participating actors. In order to identify an actant, the arising changes are traced back to its origin and the “discovered” actant turns into an actor, linguistically (Latour, 2010a, 2000a, 1999a). Hence, apart from particularly referring to non-human actors, the term “actant” involves the same characteristics as the term “actor”.

A chair, for example, functions as a representative of non-human actors. Without a chair, a person could not sit in this exact hight, on this exact spot, in this exact position – unless a different non-human actor would replace the chair and its ability to increase the users possibilities. A keyboard is also an intuitive example of a non-human actor. It allows a person to write a digital text, to communicate with other actors. Therefore, it enlarges the acting possibilities of its operator – as long as other non-human actors, such as the connecting cable, the hardware, the software, the printer or the internet connection, are working simultaneously. Another basic example would be a ship which enables sailing on Arctic routes for example. However, when sailing in Arctic waters, also the sea ice and the weather condition are becoming non-human actors, since they determine the actual route, the captain has to take (see also Chapter 4.1).

The ANT-definition of actors does not imply that they have to be successful in terms of achieving their given purpose. Even unsuccessful entities – a text which does not find a reader, a chair, with no one sitting on it, change a situation. For example, the maligned text still stores information, another actor considered important at a time and people who do not want to sit on the chair, still have to walk around or over it to continue their actions. Hence, as long as there is something said or written or done about the entity, it is an actor, because it communicates with its surroundings (Callon, 1990).

Analogue to the human ecological metabolism approach, the term “mediator” is used in an ANT-context. Yet, human ecology limits mediatior-capacities to elements in the overlapping zone, whose definition were already criticised. Within ANT every actor or actant mediates connections between entities. This novel understanding shifts the focus from actors and actants to mediator-capacities – hence, to connections and interdependencies. Consequently, actors are no longer solely the starting point, from where actions ignite, but a force of attraction in contrast. Therefore, actors are defined by the actions, leading to them (Latour, 2010a, 2000a, 1999a). In this case, it does not make any difference, if connections arise between humans or non-humans or even between both. Thus, the term “actant” is subsidised with the expression “actor” in the following, to stress their simultaneous meaning. Moreover, the terms “mediator”, “mediator-entity” and “ANT actor” are used as synonyms to the term “actor” in this thesis, to further underline firstly, the importance of mediator-capacities which any actor adheres by definition and secondly, the disestablished limitation of actors having to be human beings.

Respecting this novel ANT-interpretation of actors, leads to major results for the definition of Arctic actors. Besides the usual stakeholders, such as human beings, states or politicians, literally anything can become an Arctic actor, as long as it changes the Arctic. A ship, a polar bear or even a flag on the ocean's surface are suitable, as long as their existence changes a given situation. Regarding Arctic shipping routes as an actor, for example, identifies various connections with natural entities, such as climate change, the sea ice cover or weather conditions. Their existence and particularly their impact-potential highly affect Arctic shipping. Consequently, they attract (human) actions (see also Figure 5) which turn such natural entities into actors themselves. Hence, through further equalising humans and non-human actors on a theoretical scale, ANT shifts them into the centre of scientific attraction. The analogue goes for connected interdependencies. Therefore, ANT provides a broad, but also deep insight into Arctic networks.

Yet, if an actor is solely defined by the fact that it changes a given situation and that actions are attracted towards it, several questions arise. As for example: How can actions be traced back to their origin, in order to identify actors and how con non-human entities contribute to this process?

2.1.3.2 Redefining action and the attribute social – enabling things to act

As outcomes of the previous sub-chapter, an ANT-actor fulfils four characteristics. Firstly, it changes a given situation. Secondly, an ANT-actor attracts actions and thirdly, maintains cooperation with other actors. Fourthly, ANT-actors are figurative. Hence, ANT actors can be recognized in experiments. If an entity neither changes the setting of an experiment, nor its outcomes, it is invisible to the experiment and consequently to ANT. In this course, connected elements decide if an entity is an actor or not, by directing actions towards it (see also Figure 5). The involved actors have the power, but also the duty to define relevant elements. This is idea is particularly crucial for the design of scientific studies, since it prohibits the conducting researcher of identifying actors, before the start of his studies (Latour, 2010a, 2008a, 2000a, 1999a).
However, in most cases, the failure of an involved actor illustrates its importance for a situation, even if it was unrecognised before. The breaking of a small bolt within a ship, for example, has the potential to endanger a whole trip. In such an event, the meaningfulness of this component becomes visible to other actors, what turns it into an ANT-actor (see Chapter 2.1.3.4 for the definition of black boxes).

Since actors are now characterised by their ability to manipulate, activate, include or exclude other actors, the outcomes of an action cannot be predicted anymore. Hence, an action is no longer a precise activity, performed on a local setting. In contrast, it is a dislocated development. Several actors achieve an action together, by creating, fulfilling and conducting it as a group. It is therefore constructive to regard actions as functional chains between networks (Latour, 2010a, 2008a, 2000a). As the example of a bolt has shown, the activity to sail an ocean is not only accomplished by a human and a ship, but requires the help of bolts, anchor, canvas, ropes and many more.

Latour (1998) states further that non-human and human actors have the same abilities to influence each other, resulting in a symmetry between them (Latour, 1998). Especially this principle, that a human action leads to a non-human action and vice versa (Latour, 1994a), opens room for discussions: First of all, humans, animals and machines seem to have greater possibilities to influence external actors than other "simple" non-human actors, such as a chair or a keyboard. Their ability to think enables particularly humans to guide and attract actions on both, a physical and a mental level. Secondly, while the majority of actants cannot create other actors, humans, animals

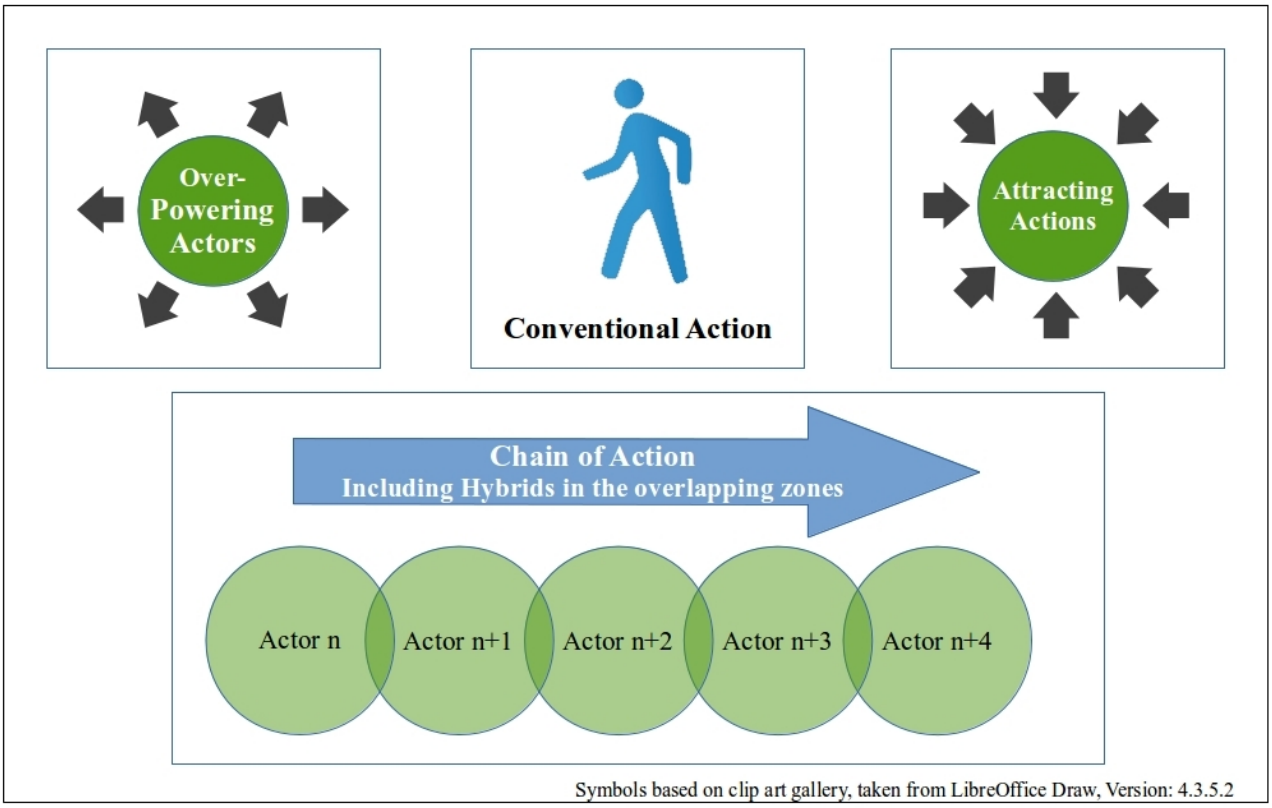


Figure 5: Different types of ANT-actions

In alliance with ANT the term "action" can be interpreted as (left to right): One actor overpowers other network-members (Overpowering Actors), the traditional understanding of the term "action" - an actor fulfils an action (Conventional Action), one actor denies or enables other actors to fulfil actions (Attracting Actions) and the collaboration of different actors to achieve a certain action together (Chain of Actions).

and machines are able and moreover needed to fulfil such creational network-building processes. This also leads to the question, if a simple distinction between human and non-human actors is expedient for investigations in general (Jöns, 2003; Weyer, 2008, 2006).

Hence, ANT has to deal with the ongoing controversy about actors and the search for a suitable characterisation. However, before different groups of actors can be identified and as a consequence defined, it is necessary, to redefine the term "social", since the ability to fulfilling an action is conventionally always bonded to behaving social or unsocial. In reverse, being social is expressed through actions and applies therefore to living creatures only. ANT states in contrast that non-living entities fulfil actions as well. Hence, it has to be clarified, if actants behave social.

According to Latour (2010a) social scientists characterise "being social" through the consisting of social interactions – a perpetual motion, misleadingly used as a premise to explain social processes.

However, in this conventional case the connections between interacting social actors are not regarded as being social themselves. They solely tie social entities together (Latour, 2010a).
While further persisting on the postulation to follow actors in order to detect interdependencies and by creating a comparison to the conventional definition, ANT considers being social as an attribute of connections (Latour, 2009a). Hence, interdependencies, movements and flows between actors are social, while the aligned entities are not. However, these connections are maintained over time and space by actors, who can explain their sustaining efforts to a researcher, for example. Latour (2010a) therefore states that a scientist can learn how "the social" is created, if he simply follows the actors around him. To succeed, the scientist has to be open minded and has to avoid a-priori postulations, in order to allow the actors to express their own ideas and aims. In addition, Latour (2010a) distinguishes between the social force which keeps up connections and the strength that is created through common face-to-face interactions. Thus, a conversation between two people who are physically in the same room always differs from a telephone call, although both conversations might share the same context (Latour, 2010a).
Transforming the attribute social into a connection leads also to the advantage that connections have a temporal and particularly a spatial dimension. These characteristics can be retraced, and so can the shouldered efforts to adhere existing and moreover to create arising interdependencies (Latour, 2010a). Hence, if the social is retraced, it is explained through something that is not simply social as well, but rather a connection with a precise direction and destination – the perpetual motion is destroyed.

In addition, analogue to the ANT-definition of actors, the new ANT-understanding of being social shifts the focus on constantly changing movements, connections and interdependencies (Latour, 2013). By involving non-living entities into social actions, ANT gets one step closer, to treat all entities equal in theory. Simultaneously, ANT supports the principle of symmetry in bereave living creatures of their unique ability to behave social. Yet, ANT has to define how human and non-human actors are able to work together.

2.1.3.3 Creation of hybrids – how actors work together

The novel definitions of actors, actions and the social, enables a full understanding of sentences such as "The ship sails", "The keyboard writes" or "Climate change challenges mankind". Still, living creatures and non-living entities do not share the same spectrum of actions. In most cases, a non-human entity needs the help of a human to accomplish its duty most of the time. However, most of the time and vice versa. By using external entities, a human being enlarges its activity spectrum – and so does the contributing entity. As an example, a ship could not sail without a human actor, but a human being could not sail without a ship either. This example illustrates that non-human entities are not only taking part in actions, but also take over a part of the responsibility to fulfil it. Such a collaboration between two or more actors leads to the creation of a hybrid, an entity which consists of both: a human and a non-human part (Latour, 2010a, 2009b, 2008a, 2000a).

Since they change a given situation and are created during the fulfilling of an action, hybrids are actors themselves. The coalition between a human and non-humans enables the contributing parties to reach and achieve a collective aim. Such a collective aim can differ from the original individual goals of the partners (Latour, 2010a, 2009b, 2008a, 2000a).
However, there is still uncertainty about the explicit definition of a collective or individual aim of a non-human actor (Weyer, 2008). What other aim can a chair or a ship have than the one a person associates it with? Furthermore, the definition of a hybrid is not trivial. Why is the creation between a human and a key a hybrid, but not an actor, although it certainly attracts actions? Is the linkage between the key and the door a hybrid as well (Jöns, 2003)?
Every joining-process of two or more actors describes the creation of a hybrid and the existence of hybrids requires more the merging of characteristics and abilities of several contributing entities. Since a hybrid is always created to fulfil an action and moreover since it fulfils the same tasks within a network than other ANT actors, they are considered as being actors in this thesis. Furthermore, the postulated equal treating of network members abolishes a linguistic differentiation. Hence, the terms "hybrid" and "actor" can be used interchangeable. However, the term "hybrid" is chosen particularly in cases, where the merged characteristics of actors is emphasised.

The concept of hybrids links back to the overlapping zone of the metabolism research that has been chosen as a starting point to develop a theoretical approach to investigate interdependencies between processes of climate change and geopolitics. The overlapping zone has been criticised before as being defined too strictly, leading to the negligence of many entities, including the social structures of nature or self-colonized nature. ANT-hybrids involve all elements of the conventional overlapping zone – including the ones which have been missing before. Hence, Figure 6 illustrates the novel defined overlapping zone, as the Hybrid Arctic. So far, it comprises elements, that merge social and natural characteristics, without further limitations.

Besides natural and social factors which influence hybrid-creating processes, Jöns (2003) work showed that particularly mental entities are essential network members. Hence, they are also crucial to the creation of hybrids (Jöns, 2003). Already Vernadzki (1945) reasoned that human thoughts have deep impacts on nature. The author even interpreted human beings as driving factors on geological scales. His concept of the noosphere (Vernadsky, 1945) is consequently applied today (2015) for example, to investigate interdependencies between scientific knowledge and the purposefully altering of natural systems (Norra, 2014).

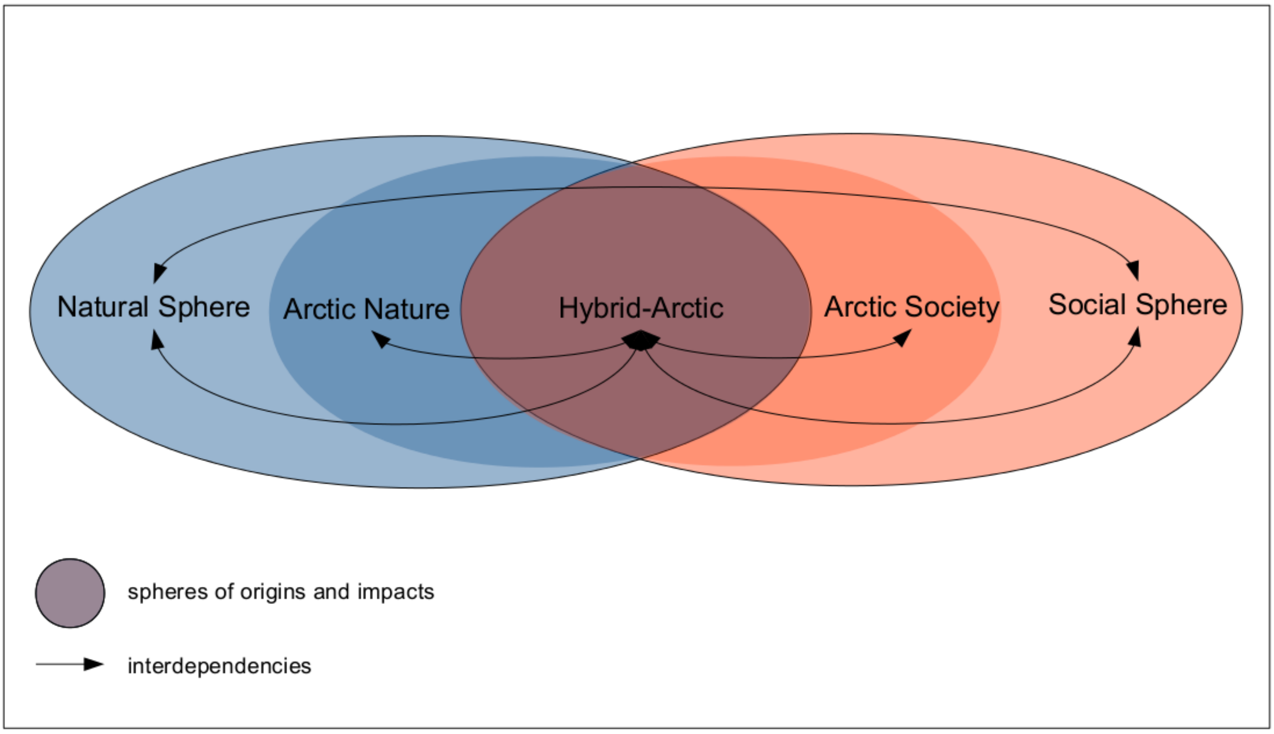


Figure 6: Defining the Hybrid-Arctic

Theoretical scheme of the different spheres involved in interdependencies between processes of climate change and processes of political geography and geopolitics in the Arctic. Hereby, a novel overlapping zone is defined which contains all hybrids between the spheres Arctic Society and Arctic Nature: the Hybrid Arctic.

Apart from the so far neglected role of mental entities, the distinction between human and non-human actors is non-logical. Considering the different abilities of non-human actors, including machines – data storage, processing, “remembering” - or animals – being able to feel, to learn –

leads to the question, if a different distinction would be more suitable (Jöns, 2003; Weyer, 2006) for the research questions of this thesis.

2.1.3.4 Mediation of mental entities and the opening of black boxes

As stated above, some actors have greater possibilities to influence network-building processes than others. Especially the ability to use mental entities, in order to create hybrids and power relations, provides actors with privileged network-positions. Humans in particular have the ability to think, plan and reflect – at least to some extent. Thus, they have to be regarded as hybrids between natural objects, such as their physical body and social parameters and mental entities. In the following it is discussed, how such mental entities are involved into the theoretical approach of this thesis. Therefore, their influence on external living and non-living actors is illustrated.

Firstly, mental entities are bonded to actors who can mediate and moreover alter them. They rely on actors, connecting them to physical objects, other mental entities (Jöns, 2003) or social parameters. Secondly, mental entities are triggering or even manipulating the actors, by whom they are possessed, to fulfil actions. Hence, they are involved in any action or hybrid-building process, as long as a human being contributes to it. However, an actor which is steered by mental entities, is not forced to tell, write or even embody its true incitements. It can pre-modify its motivations and hide them.

In contrast, the existence of a mental entity does not automatically lead to the fulfilling of a pre-defined action. Mental actors can instead guide the actor to other mental entities, creating a mental hybrid and shifting the aspired action into a different one. Yet, the original mental entity is still a part of the chain that leads to the final action. Therefore, it is not always possible to distinguish the actual contribution of mental entities, since the mediative actor can act as a "black box".

The term "black box" is often used, both in social and technical science, to describe a system exclusively by its input and output flows. Inputs are, for example, information or mental entities, while outputs are conducted as actions or the transforming of mental entities (Winner, 1993). Consequently, what happens inside black boxes is not of interest (Bijker and Law, 1994), but the boxes' functions are (Law and Mol, 1995; Winner, 1993).

Analogue, a relatively stabilized network which acts like a single unit – at least for a specific

amount of time – appears as a black box, too. This is mainly caused by the network's ability to translate and transform the materials, it is made of. Hence, a network can be distinguished from its surrounding environment for the period, during which it is relatively stable (Callon and Law, 1997).
In addition, the expression “black box” is used to refer to closure. Closure is an achievement of actors and therefore linked to power-relations within networks (Law and Callon, 1994; Misa, 1994). The concept and abolishment of “closure” is particularly crucial during the process of establishing scientific facts, as demonstrated in Chapter 2.1.3.7.
In general, ANT aims to open black boxes, to explore their interior processes. However, Latour (1988a) and Star (1992) suggest that the emerging consequences have to be faced, after a box was opened. In addition, tools to open these boxes have to exist beforehand (Law et al., 1988).

Hereby, ANT bridges back to the previous critique regarding the treatment of nature and society. The conventional approaches of physical and human geography tend to regard one of the two involved systems as being complex, while the other is treated as a black box. The interior processes of the second system do not matter to the outcomes of the conducted investigations. An intuitive example is again illustrated by broad research about global warming and a ship. As has been pointed out before, it requires various actors and actions to make a ship sail: for example the functioning of bolts inside the ship, a suitable weather condition or the pure knowledge of how to sail a ship. Yet, in respect to global warming and the resulting carbon dioxide emissions during the ship's passage, these actors are not of importance. Hereby, it is often sufficient to treat ships as functioning systems – as black boxes.

However, the acknowledgement of nature's and society's complexity requires the abolishment of former black boxes, amongst them climate change, political geography, geopolitics and the Arctic themselves. Hence, these black boxes have to be opened, through investigations of their interior processes.
Yet, there are limitations regarding the opening of black boxes. When exploring complex black boxes, such as climate change, multiple actors are involved – and it is impossible to integrate all of them in one scientific project. As an example: the rising air temperature, emissions, melting of sea ice, vulnerability and various others belong to the causes and results and therefore to the ANT-actors of global warming in the Arctic. However, these actors are black boxes themselves. Higher temperatures depend not only on emissions, but also on global thermal flows, the surface cover, the

composition of the atmosphere and the existing flora and fauna. Again, these emerging factors are black boxes themselves. The surface cover, for example, is coupled with the surface temperature, the existing soil, the water body and the rainfall. Yet, these components are again black boxes. Consequently, with any involved actor, a new black box, containing various hidden actors, gets integrated into a network and therefore into the scientific research that investigates this network.

Hence, the opening of black boxes does not come to an ending, unless it gets cut off. In this thesis, this is the case, if solely the outcomes of the black box matter for the research objectives or if there are no suitable methods to open it. For example, tracing back mental entities requires to work with expressions of actors which mediate and translate them. Several methods are used in this thesis to identify mental actors (see Chapter 3), but the named uncertainties – is the translating actor telling, writing, expressing the truth about its mental entities? – cannot be denied in all cases. Another reason to cut off the opening is the lack of scientific explanations for a given development. Particularly the various interdependencies, involved in climate change in the Arctic, are not entirely understood today (2015). This refers especially to the postulation of "tipping points" (Gladwell, 2000) which are regularly established in scientific and public debates about global warming (Russill and Nyssa, 2009). Walker (2006) discusses for example possible tipping points of the existence of icebergs, involving the potential of changing winds and anthropogenic factors. His research illustrates the controversy around the existence and trespassing of tipping points (Walker, 2006). According to the ongoing discussions about them, the opening of black boxes gets cut off in this thesis at any point, where scientific models or the available scientific data get to imprecise. Yet, even if it is not possible to open a certain black box in this thesis, its complexity has nevertheless to be recognized.

There are always different actors which create a black boxes together, even if they are unrecognised by external observers. Hence, a black box is always a hybrid and therefore also an actor. The opening of these boxes leads to the configuration of the involved actors. Particularly mental entities will always appear as black boxes, since they are hidden inside an actor. Yet, to know, why actors chose to fulfil certain actions, while rejecting others and therefore to recognize their (true) intentions, is crucial to a deeper understanding of networks – particularly, when investigating interdependencies between processes of climate change and processes of political geography and geopolitics.

It is obvious that humans direct flows of mental entities. However, there are other non-trivial actors with this characteristic: animals and machines. Yet, in order to reach a more detailed level of understanding of network-building processes, it is essential to identify possibilities of machines and animals to create, transform and use mental actors. Particularly similarities to anthropogenic mediator-possibilities have to be identified.

The question, if machines think is not a current one: In 1950 Turing claimed the behaviour of a human being as the only relevant and observable component of intelligence, since any argument against artificial intelligence can be applied to humans as well (Turing, 1950). Thus, he proposes an empirical test to clarify if machines behave intelligently, which is now known as the Turing Test. In order to pass this test, a machine has to convince a human judge to behave human-like, which would be equivalent to being intelligent (Hoffmann, 2010). Discussions about the Turing Test, its legitimacy and if it is possible to build a machine, which passes it, are still continuing today (see for example Epstein et al., 2008).
However, the theory behind intelligent machines has than be different to the theory of human intelligence (Watt, 2008), since the systems, in which they have to function, vary. Artificial intelligence is not designed and meant to replace a human's brain within a human body. Hence, it should not be mistaken for being an exact copy of a human brain (Collins, 1990).

Although they might not pass the Turing Test and do not function identically to a human's brain, machines got deeply integrated into the daily life routines of mankind in the recent past. Apart from creating multiple hybrids with human actors, technological entities are taking over activities which used to be fulfilled by humans (Rammert and Schulz-Schaeffer, 2002a, 2002b). Therefore, the purpose of the research questions, asked in this thesis, does not seek to finally clarify, if machines are as intelligent as humans or not. Instead, it is of importance if machines create, translate and mediate mental entities at all. Therefore, their possibilities to solve problems are discussed and compared to the analogue human abilities.

Problem solving is a process, in which translations and mediations of mental entities are crucial. Machines, including computers, respond to shifting surrounding conditions, by choosing a reaction out of several feasible options. If necessary, they communicate with one another and or with external actors (Rammert and Schulz-Schaeffer, 2002a, 2002b). When facing the task to solve a problem, machines often pre-calculate the outcome of different solutions, before choosing the desired optimum. Therefore, a machine tests multiple possibilities within a short amount of time (Malsch, 1995). Examples for such an optimal solution are the finding of the shortest or fastest way from one point to another, the minimization of existing costs of a production line or the maximization of the actual profits of a company. Whichever, the given problem has to be expressed in a processable language to the machine.

Human problem solving is – in some parts – similar to this. Memories of symbolised, interconnected information get used and combined in processing programs to solve problems (Newell et al., 1958). Such symbolic structures have to be regarded as organised mental representations of certain situations or activities which maintain mentally over a certain period (Langley et al., 2014). Hereby, the problem space is created firstly, by the initial state of a problem, which is translated into symbolic structures, secondly, by possible operators which refer to specific actions, and thirdly, by the transformation of the problem into a different state. Often, heuristics are used to figure out a way through the problem space. Although this procedure does not ensure to find the optimal solution, there is a significant chance that it does (Langley et al., 2014; Newell and Simon, 1976).

In addition, humans often use what is called "means-end analysis" to solve a problem. In this case, they firstly define the current and the desired state of an object. Afterwards they use applicable operators to change the current state of the object. Hereby, each change transforms the object into a state closer to the desired one. Intermediate-operators are also used frequently, to enable the appliance of initially thought-of-operators which further contribute to the solution of the faced problem (Newell et al., 1960). Although this particular theory of human problem solving is not scientifically proven sufficiently, it is strengthened by empirical studies and therefore widely accepted today (Langley et al., 2014).

Humans have to "teach" or program a machine, to enable it to choose from different options. The machine has to be taught, what to do in the case of an emergency or breakdown. Hence, machines are not able to define the desired state of an object or entity by themselves, which is a major difference between them and humans (Grunwald, 2002).

However, it has to be considered that even humans have to experience situations or get taught to accumulate problem solving options (see Figure 7 for the human translation of mental entities). The analogue case: after a machine has been programmed, it calculates the desired solution by itself. In addition, machines are made to take over responsibility for their actions, even on a legal basis (Weiß, 2002).

In ANT-terms, an actor limits, but moreover leads to and enables actions. It is actively involved in networks and mediates information. Hence, machines and technologies function as adequate actors. Additionally, some highly developed ones translate and process mental entities, as long as they are expressed in a machinable formate – namely numbers and codes.
However, the fact that information have to be translated by one actor into a format, comprehensible by connected (external) actors, applies to each and every network member and not exclusively to technological ones (see Figure 7 for the human translation of mental entities). Out of suitable datasets, machines gain new findings and solutions, which they decode again into a human-processable format. Aside from this, machines store and therefore "remember" previously found solutions and compare them with new requirements.
Thus, machines and technologies not only fulfil actions, due to imported mental entities, they also use them to force other network members to act. Furthermore, machines contribute to networks by connecting mental actors with others and including them into chains of actions. Hence, they are indeed translators and mediators of mental entities.

Apart from machines, also animals are able to handle mental entities in the required ways. Analogue to computers, some animals developed skills to solve novel problems. Their possibilities range from the trial-and-error-approach (Beck, 1972), the combining of simple already established learning processes with persistent hardheadedness (Thornton and Samson, 2012), the remembering of positive or negative conditionings (Huang and Chiao, 2013) to the solving of a new problem by watching other individuals from the same species (Tomita and Aoki, 2014). Additionally, animals take decisions and use different tools to achieve their aims (Lorentzen, 2002; Smith and Bentley-Condit, 2010).

Animal tool use is described as the use of a living organism or non-living object to reach an advantage (Hall, 1963). Hence, it involves the usage of an external object, as a functional extension of a body part, such as the arm or the mouth, to achieve an immediate aim (Van Lawick-Goodall, 1970). Hereby, the tool-user has to be responsible for the application of the tool, which is directly manipulated during or before an action. A tool is defined as firstly, an environmental object, being not or being attached to the user, manipulatorily (Beck, 1980) or secondly, a manipulation of an external object in order to change the possibilities of the users physical body or to mediate flows of information between the user and its living and non-living surroundings (Alcock, 1972; St Amant and Horton, 2008). Although it is not included into the "classical" definitions of animal tool use, borderline tool use, covering for example the process of dropping objects to break them, is also observed (Lefebvre et al., 2002).

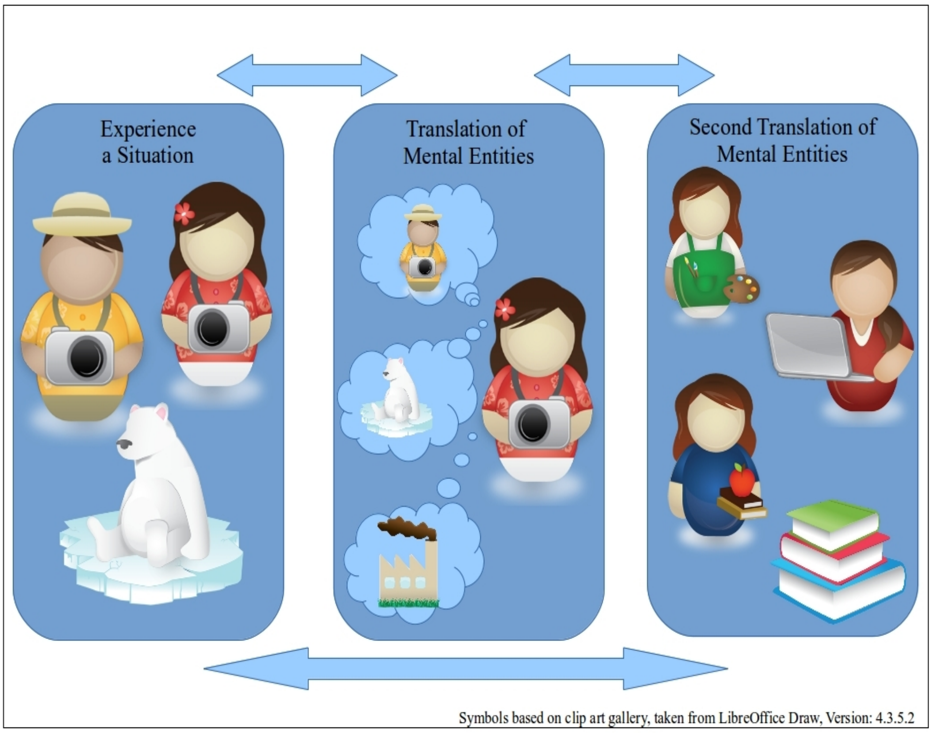


Figure 7: Anthropogenic creation and translation of mental entities

Human beings experience a certain situation and translate their impressions into mental entities which get stored over time. If a human being processes its mental entities, a second translation occurs that transforms the stored information into different mental entities, written texts, oral stories or physical expressions in general – these are also ways to share mental entities with external actors, for example other human beings. Both states of the translation of mental entities influence the way, a human being is experiencing a similar situation and therefore also its ability of problem-solving.

All given definitions have in common that animals use entities to achieve their aims – which is particularly crucial to ANT. In terms of ANT this is equivalent to the creation of hybrids. Together with the used entities, animals can fulfil multiple actions, they could not do without the other entity. Such a procedure requires planning and active manipulation and therefore the ability to mediate mental entities. The animalistic skills of learning and adapting novel behaviours further encourages the previously stressed points. Besides, the given examples prove that animals create networks with non-living objects, even in the absence of human beings.

In addition animals can express emotions such as joy or pain. Analogue to the translation of knowledge into numbers and codes, emotions can be regarded as transformations of observed, felt or in general experienced situations. Some animals are even able to show empathy, which is an emotional reaction, based on the situation of other individuals, instead of the animal's own situation (Edgar et al., 2012). “Targeted helping”, interpreted as the understanding of the desideratum of other individuals in a specific situation (de Waal, 2008), was observed, for example, in a group of Asian elephants (*Elephas maximus*) in southern India (Vidya, 2014). The ability to experience empathy for others, describes the longing for the need of another individual on a cognitive level and therefore creates mental entities which bond the involved individuals together.

Today (2015), humans, machines and animals are involved in every network – directly or indirectly. Thus, they function as essential actors, linking the mental sphere to the natural and social sphere. Yet, in order to fully understand the networks, with which this thesis deals, it is indispensable to regard mental entities as a group of actors and distinguish them from others. However, in some cases the hybrids, created by mental entities, appear as black boxes and the desired distinction is not possible nor constructive to answer the underlying research question of this thesis. Hence, it has to be decided individually and according to evolving cases, if a differentiation between the hybrid-creators is constructive. Still, the question rises, how mental entities influence humans and their mediative qualities in comparison to machines and animals.

2.1.3.5 Influence of mental entities – geography of emotions and intrinsic values

The Arctic-networks analysed in this thesis are strongly linked to regional and local anthropogenic activities within the High North, but also to developments on a global scale. Mental entities are empowered to influence humans on geopolitical (see for example Newman, 1972 or Pagano and Huo, 2007), social (see for example Dorn, 1998), economic (see for example Kneafsey, 2002), ecological (see for example Steiner, 2003) and, of course, mental levels. Furthermore, they determine the attitude of humans towards objects and actors, including the valuation of entities.

Especially for humans, it is nearly impossible to separate their physical body from feelings and emotions (Davidson and Milligan, 2004). Humans, machines and animals mediate mental entities. However, as long as they merge and create hybrids, this argument can be turned vice versa: mental entities mediate flows between humans and other actors, including the researcher himself (Bondi, 2005; Thien, 2005). Hence, emotions have a spatial occurrence, for example through hormones, letters or money (Anderson and Harrison, 2006).
Yet, emotions occur in connection with situations and / or geographical places. Comparably, places are always linked to emotions (Davidson and Milligan, 2004). They are melting pots of social practices and physical structures, while their configuration is continuously changing and transforming (Simonsen, 2007).

From a geographical point of view, these ideas are crucial. By allocating places with emotions, people identify themselves with geographical areas (see also Chapter 2.2.4). Place identification can get as far as considering a place to be a part of oneself and in reverse, empowering it to shape a human being (Droseltis and Vignoles, 2010; Torkington, 2012). The structure and strength of such bonds further opens or denies adaptation-strategies to shifting places, such as the Arctic (Fresque-Baxter and Armitage, 2012).

To briefly outline such connections, the best example is the place a human being calls "home". In this case, home is not only referring to the place, where a human being lives, including a house or an apartment (Lewicka, 2010), but also to the fact that this place determines the human being's lifestyle, its needs and its connection to other important places of human life. Therefore, one's home does not necessarily have to be the place of birth, it can be any chosen place (of residence) (Savage, 2005).
Apart from a dwelling, an individual also attaches the feeling of "home" to a community or a region or even to all of them simultaneously (Cuba and Hummon, 1993). As a supporting or hindering factor, religion – which is highly based on mental entities itself – contributes significantly to place identity, especially, if a person has to move to a new location (Mazumdar and Mazumdar, 2012).

While the feeling of belonging to a certain place settles a person, the experience of homelessness and loneliness leads to an uncomfortable, even frighting and psychologically stressful experience (Ferrari et al., 2015; Parsell, 2011). People who are forced to live in public places, contribute to the

place's identity and also to its reputation in different ways than settled persons do (Parsell, 2011). It is also possible that homeless persons claim public spaces as their home and / or working place (Sheehan, 2010) which proves the seek of human beings to not only call a place home, but to feel at home somewhere.
Furthermore, by identifying oneself with a spatial place – and one's home is a precious characteristic –, human beings create their own geographical patterns, helping them to orientate within their environment (Zierhofer, 1999). The involved process of shifting an entity into a mental representation through the transformation of an external link into an internal bond further implies a valuation of this entity (Steiner, 2003).

Such processes happen in and outside of the Arctic, independently whether an actor has physically been there or not. Particularly the tourism industry benefits from the mental pictures of the Arctic that attract visitors.
Hale (2002) investigated connections between cultural ideas, the appearance of a certain place and their influence on the tourism sector. The fast growing Arctic tourism sector depends on the tourist's eagerness to see and experience the vast lonesome nordic landscapes with their harsh climate. Apart from the environment, also its inhabitants, especially indigenous peoples, serve as major tourist attractions, although the actual living conditions in the High North might not meet tourist expectations (Notzke, 1999a; Wenzel, 2008). The economical, but also social, political and ecological meaning of this mental image of the Arctic is essential – not only for the tourism sector, but for all involved fields.

Apart from "usable values", such as economic profit, place identity also contributes to non-use values (Davidson, 2013), known as the "warm glow", where people receive mental benefits from altruistic actions (Andreoni, 1990; Imas, 2014). These include altruism towards a place and its components – including nature –, as well as the satisfactory feeling human beings create from the pure knowledge about the existence of a place and its components (Davidson, 2013). The latter is also known as existence value (Kontogianni et al., 2012) or intrinsic values.
These non-use values apply not only to places, but to all living and non-living entities. Particularly the effects of the latter on the perception of nature and the concept of ecosystem services is crucial for the network between processes of climate change and processes of political geography and geopolitics. Hence, place identity and its power as a mental Arctic actor is further investigated,

when analysing Objective 3: *Test the developed theoretical approach and the methodological concept*.

Certainly, there are various other ways, in which mental entities affiliate humans with objects or living entities. However, humans constantly interact with their surroundings by creating and maintaining mental images, ideas and values (see Figure 7). Furthermore, the absence of economical use is not a criterion to adhere such connections. Hence, mental entities measure up to non-living actors, by fulfilling analogue duties in networks (Jöns, 2003).

Since the creating of mental entities is an ongoing process – although it underlies shifts and changes – the given examples also prove that networks, which involve humans, machines or animals, always include mental entities. Thus, their key role in network-building processes is credited in this thesis, by adding the attribute "mental" to them. Thereby, the mental sphere contributes to Arctic networks, besides the already identified natural and social spheres. Hence, the mental sphere becomes a system, containing all mental entities, such as knowledge, intrinsic values, thoughts, feelings or instincts. Apart from the additional attribution "mental", mental actors are treated equivalently to all other actors and hybrids.

Although mental entities influence suitable actors in network-building processes, they often occur after their transformation into a written, visual or oral form, including laws, dances or songs. Such a transformation is always fulfilled by an actor (see Figure 7). Furthermore, it always needs an actor to "decode" the original information of the mental entity. Therefore, as a researcher, it is nearly impossible to trace mental entities back to their origin, without paying credit to the actor, with which they appear as a hybrid to the outward "audience".

In regard to the Arctic, mental entities and particularly scientific knowledge are essential for future developments: knowledge about climate change, about indigenous peoples, about shipping in the Arctic, about the existing flora and fauna and so on. Therefore, scientific knowledge functions as an example to outline, how mental entities are created and transformed within networks. ANT provides a clear answer to this problem by explaining the process of scientific controversy.

2.1.3.6 Creation and transformation of mental entities

The search for active connections and entities that make a difference for a certain situation or process is one of the core-ideas of ANT. Scientific knowledge is most active during its implementation. At this particular time, controversial discussions are surrounding the new ideas. Going back to this first steps of the creation of scientific facts opens possibilities for a researcher to recognize their construction-process and therefore their hybrid character. Since any scientific fact had once to be proven to be true, any of them is constructed and discussed by humans (Latour, 2010a, 2010b, 2005, 2000a). Ruddiman (2005) discusses the development of the research field "climate science". Hereby, the author names several examples of scientific facts that have been controversial once, amongst them the theory of the continental drift (Ruddiman, 2005). This applies also to laws of nature. Although they are based on experiments and connected observations, it is not known, if they represent a universal truth. Hence, they are based on circumstances that existed during their discovery and confirmation – reflecting the state of the art of a certain period. However, such circumstances might change after a yet unknown amount of time, leading to a novel adaptation of the law of nature (Weizsäcker, 1951).

After being widely accepted by the scientific community, a fact stops to actively evolve interdependencies within the network and remains inactive and therefore invisible for ANT. Thus, the acceptance of the ongoing controversy about a scientific fact defines it as an ANT-actor that mediates interdependencies within networks (Latour, 2010a, 2008a, 2005). Therefore, instead of calling them matters of fact, ANT calls them matters of concern, in order to highlight their debatable status (Latour, 2008b).

In order to investigate matters of concern, it is not sufficient to solely concentrate on the surrounding conditions that enabled the establishment of a fact, since such a procedure would accept the fact itself without re-questioning it (Latour, 2004). In contrast, going back to the initiation of a fact of concern can help to trace its process of establishment. Gathering data from experiments, publications or scientific discussions are possibilities to reproduce the creating process of a scientific fact and to identify its active state. As an example, today's infrastructure and particularly the internet, are creating ANT-data about scientific facts constantly. Such data have a physical expansiveness and are therefore recognized by tracing scientists (Latour, 2010a, 1986a).

Furthermore, the ongoing dispute about a matter of concern has to be stopped actively. It is not sufficient to just state that a fact is true. Instead, there has to be an institution, such as a scientist, which is responsible for the transformation of a matter of concern into a matter of fact. Hereby, the used methods have to be clearly outlined (Latour, 2010a) and can, again, be retraced by scientists.

The ongoing controversy about matters of concerns also shifts them from being an object into being a network. They comprise different actors and hybrids which create an action chain together, with the aim to transform a matter of concern into a matter of fact. Hence, the connected discussion and controversy maintain matters of concern (Latour, 2008c) on the one hand. On the other, a matter of concern attracts and dictates actions. Consequently, (scientific) facts and knowledge are mental actors – already during their process of creation. Alongside, such processes evolve hybrids constantly.

Focusing on discussions and concerns about facts, implies a concentration on participating objects and issues. By dealing with them beforehand, they are not automatically integrated into already set-up scenarios, what is especially crucial to politics (Latour, 2007). In this context, Latour (2003) states that the manifestation of political matters of fact was initiated and therefore particularly important during the 17th century.
However, exactly these core-ideas of the establishment of political facts are still fundamental today (2015), especially in the Arctic. The High North is affected by various climate-induced shifts and altering political, social, economic or ecological trends. Here, an ANT-interpretation of matters of facts leads to new analysing possibilities and enables actors and scientists to figure out new solutions for current challenges.

Therefore, matters of fact produce indeed active data – particularly in the case of scientific knowledge. Even after a fact has reached a state of common approval, scientific knowledge puts pressure on future actions, ranging from political to ecological intentions. In ANT-terms, influencing others is similar to being active and producing data. Hence, as long as the fact itself affects external entities, it is an actor within a network. Scientific knowledge suits these criteria, especially through its constantly changing characteristics. Moreover, it is evolved by external influences, while guiding external developments simultaneously. Consequently, scientific knowledge and particularly traditional knowledge are treated as mental actors in this thesis.

Knowledge and mental entities in general are often transformed into a different, physical form. By being written down, for example, mental actors can outlast over time. Future generations (of scientists) get access to them easily, what leads to their reactivation, if the described findings or ideas are implemented into current discussions and research. Apart from that, the readout of transformed mental entities accumulates knowledge and combines it in new ways.
Therefore, researchers who work with ANT, have to pay attention to the mediation of their own mental entities which are conducted and created during their research project. Today (2015), the most common way to publish scientific findings is a scientific paper or report. ANT, as a descriptive theory, offers valuable ideas how to write a report, in order to enable the reader to redraw and reactivate the described network.

2.1.3.7 Transforming mental entities – the role of a scientific report

A researcher has to solve three issues, when writing an ANT-report. Firstly, a report has a limited amount of words, pages or in general space. Hence, a researcher who is trying to illustrate a network is often forced with the dilemma of ending space against multiple connections. Secondly, the content of a report starts during an already running development and finishes, while the process is still continuing (Latour, 2010a). Thirdly, following connections is only possible after a certain event happened which made the interdependencies visible and moreover feasible (Callon, 1986).

Hence, it is simply impossible to assemble the entire connections of a network in one written document or in one scientific project. However, the assembled entities have to be active ones. Hence, they have to be actors, which reassemble maintained interdependencies (Latour, 2010a).
One suggested way to achieve this aim lies in the objectivity of the written report. This refers to both, the chosen writing style and the given possibility for reassembled objects to express their own intentions (Latour, 2010a, 1987). In this case, objectivity does not refer to the existence of a universal truth, which a scientist can converge to by the method of falsification as ideas of Karl Popper's Critical Rationalims are implying (Werlen, 2011). In contrast, an ANT-report is objective, if the identification of connections between the named actors is comprehensible. By illustrating involved interdependencies, the price, the actors are paying to maintain connections between them, is also described and documented. Yet, rising the quality of a report is not trivial, since the reassembling of actors bares the risk to confuse them with intermediates (Latour, 2010a, 1991,

1987).

Several methods to ease the researcher's attempt to write high quality ANT-reports are named in the conducted literature. Amongst them is the advice to record every step a researcher takes in the ongoing scientific process in chronological order. Such a record visualises evolutionary developments, but also external reactions towards the chosen methods and formulated findings. Besides, a thematic order is also productive, since it evolves the discovery of previously hidden connections. A third record documents every idea and thought, evolving during the scientific process. Particularly this last method guarantees the possibility to re-enact the development within the final report, what leads to transparency and traceability. In addition, the fourth method illustrates another basic idea of ANT: to record evolving reactions on the final report (Latour, 2010a, 1991, 1987). However, this final step is often part of a second scientific investigation as a follow-up.

The described methods stress the point that beyond the researcher himself, also the written report is an actor of the network it describes (see Figure 8). It is created by network processes and reassembles the traced actors. A report is furthermore read and therefore also translated by ANT-actors and initiates consecutive scientific analysis. By regarding reports as actors, the previously stated argument of mental entities having valuable mediative characteristics, is strengthened indirectly, since a report is always a transformation of mental entities.
Furthermore, a report represents a visible (and also touchable) connection between the researcher and the network. Therefore and also for the connections a researcher is creating between himself and the content of his studies, a researcher is an adequate network member himself. Hence, also researchers are allowed to contribute ideas, opinions and thoughts to the network, they are part of. However, it is not in alliance with ANT to create research solely on a-priori postulations of the conducting researcher.

Although a report is accepted as an ANT-actor, it is always written in the language of humans. Therefore it only affects humans directly, since solely they have the abilities to translate the given information. Hence, it is not possible to describe a network from the point of view of a non-human actor (Weyer, 2008). Coupled with the given statement that a report is the assembly of transformed mental entities, these findings enable another postulation: solely actors, who are able to fully transform mental entities, are able to write a report.

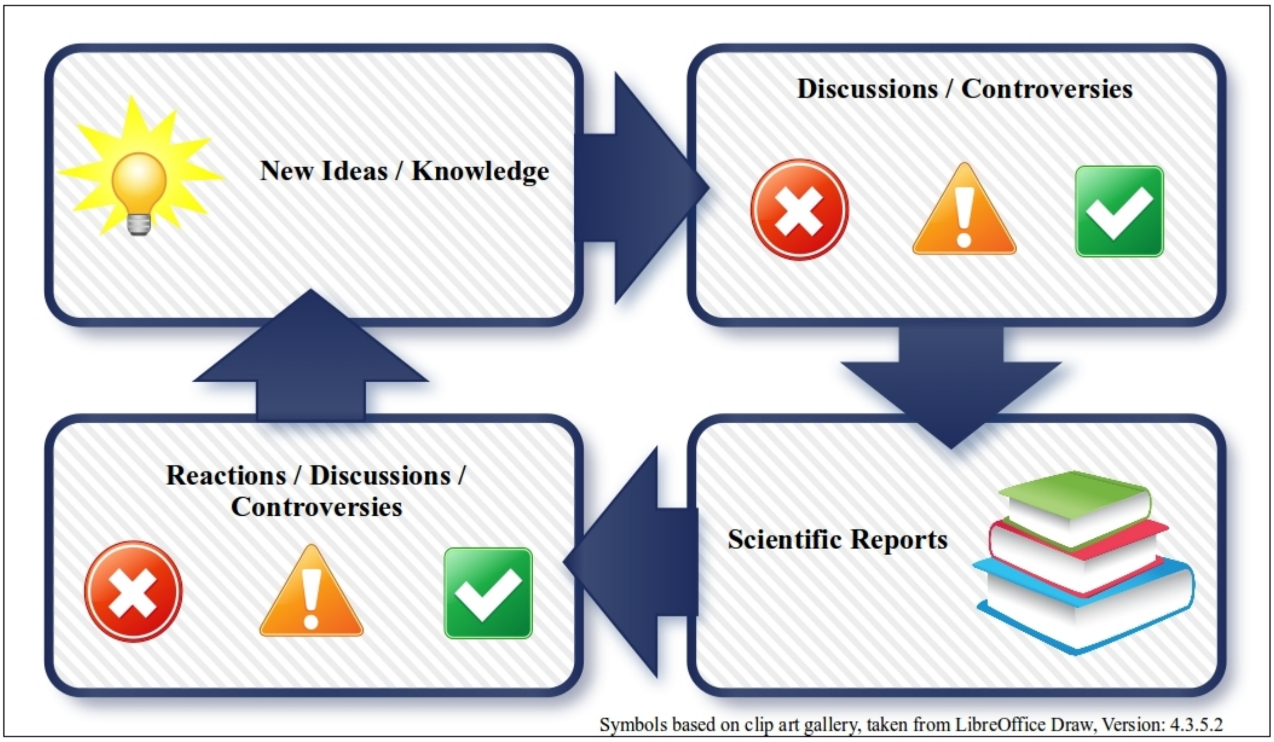


Figure 8: Creation of a scientific report

Scientific reports are involved into a constant circle of creating, discussing and adapting of ideas and knowledge. Hereby, the ideas and knowledge within a report are the results of scientific controversies, while the report itself also initiates and provokes new reactions, discussions and controversies which lead to new ideas and new scientific analysis. Therefore, scientific reports are ANT-actors.

Previously it has been discussed that machines are also mediating mental entities, but again, it needs a human to decode them, in order to completely readout the contained information. Indirectly reports affect non-humans, but the outcomes of a report are always pre-filtered by persons.

If interdependencies between processes of climate change and processes of political geography and geopolitics are expressed in networks, humans are involved in all of them. Therefore, the translation of mental entities takes place in any investigated network of this thesis. Analogue, any network member is influenced by scientific reports and therefore by knowledge.

Combining the definition of (mental) actors as the destination of actions and the definition of actions as functional chains, lead to the conclusion that human beings are hybrids themselves. They consist of a natural body and a human mind, hence, the ability to think, remember and vision. Such a gedankenexperiment shifts mental entities again further away from being a human attribute to being an actor. Besides, this has also major consequences on the characteristics of hybrids and the contributing actors.

Fischer-Kowalski and Steinberger (2011) suggest to focus on hybrid-structures, as Latour (1993) defined them, too. For these authors, hybrids comprise natural and cultural elements, including technologies, infrastructure, the biophysical parts of society, but analogue to ANT also humans (Fischer-Kowalski and Steinberger, 2011; Latour, 1993). Such inclusions change the elements in the previously described human ecological overlapping zone, as well as their ability to influence material and energy flows. Therefore, it has to be discuss how the spheres and networks have to be structured to contain this zone between nature and society.

2.1.3.8 Redefining networks

A network is delineated by its actors. It is described by its interior entities, since they are able to define other actors, as well as the various connections between them. This is particularly crucial in order to retrace the network (Callon, 1990). Network members use the process of translation to identify other actors and moreover put them in relation with one another (Callon et al., 1983). Therefore, the network is fully defined by its actors and vice versa (Latour et al., 2012).

Hence, an actor is able to create connections, while it is made of interdependencies itself (Moser and Law, 1999). The existence of actors – not intermediates – always leads to the emergence of functional chains which are again networks (Latour, 2000b). However, there are several ideas implied in the way the term “network” is used today (2015) that can lead to confusion. Firstly, an actor-network is not a technical network, such as a computer network or road infrastructure. Secondly, an actor-network is not limited to solely social relations between humans. Thirdly, an actor-network is not a pure transport medium of information. Only in its final and stabilized state, an actor-network appears as one of the named networks (Latour, 1996a). Hence, the given examples are still involved into the new understanding of networks, but the term is not limited to such conventional structures.

ANT uses the expression “network” to stress the “flat” linkage between actors, whose dimension is determined by the number of existing connections. Any connections between actors are visible, either in a physical or in other ways. Hence, interdependencies can be retraced, while the space between them remains empty within ANT. Therefore, ANT concentrates on connections only (Latour, 2010a, p. 200, 1999a, 1996a).

However, this thesis uses attributes to categorize actors. By containing supplementary information, the adding of attributes creates a new network dimension – which sum up to three. Consequently, the term “sphere” is an adequate expression of the networks, described in this thesis and therefore used as a synonym to network.

Thinking in terms of such novel networks, changes the way, how distances are interpreted. Two objects can be close to each other geographically, but far away from each other on a mental level and vice versa. It is also possible to think of two entities which are fairly close in space, but cannot reach each other due to natural circumstances. Instead of expressing their distances in geographical patterns, they are now defined by connectivity. Yet, spatial distances can be treated as an additional type of connections (Latour, 1996a) and are still strongly implemented into geographical research. Therefore, the point is not to state that spatial distances do not influence connections at all, but to further shift the focus to other dimensions of interdependencies, such as the mental scale, in order to credit their effect on network building processes.

The new definition characterises networks through their length and their tightness. It therefore abandons conventional ideas of bottom-up and top-down approaches, since the network has no bottom or top and nor do nature or society. Concentrating on connections also suppresses a differentiation between micro- and macro-scale elements. In fact, any network-element is now made of exactly the same substance (Latour, 1996a).

Therefore, it is possible to reassemble elements which switched from being individual to being collective or from being micro to being macro. Furthermore, there are no issues to follow interdependencies between a poorly connected and a strongly connected element (Latour, 1996a).

ANT therefore eases the efforts to follow actors and to put them into relation with one another. However, investigations of interdependencies between processes of climate change and processes of political geography and geopolitics have to distinguish between local, regional and global influences. Hence, these terms are used as additional characteristics of network-members. Yet, such characteristics must not be interpreted as determinations. Therefore, “micro” and “macro” elements are compared directly (Latour, 2010a, 2009c) which is particularly important in Arctic networks, where global developments alter local circumstances and vice versa.

The described networks have no inside or outside. If an entity belongs to the network or not, is determined by its connections. Thus, the size of an element is also defined by the number of interdependencies it obtains. Consequently, size is nothing that is given to the entity naturally, it is evolving and constantly changing, analogue to the connected bonds (Latour, 2010a, 2010c, 1991). Yet, concentrating on the tightness of connections and the numbers of interdependencies still enables to distinguish between important elements and nearly dispensable entities of a network. An actor is important, if it maintains a significant amount of connections or a significant amount of strong bonds. Analogue, a weak actor does not have the power, nor the possibility, to perpetuate a significant number of interdependencies at all. At the far end of the spectrum, a truly non-relevant entity is simply not part of the network, because it is not connected to any other network-member.

This novel understanding of networks shifts the concentration further away from network-boundaries to connections – bridging to the previous statements. In contrast to the definitions of socio-ecological systems, ANT favours open systems which undertake changes and rearrangements flexibly. Hence, instead of being a permanent amount of actors, ANT supports the fact that entities can now move into the network – by getting connected / activated – or leave the network – by getting disconnected.

In this case, ANT suits the Arctic perfectly, where plenty examples of entities, moving into or out of the overlapping zone between nature and society exist. Mineral oil serves as an example for a successful activation process. The entity itself did not change its location nor its amount during the last decades, but its availability did. Due to climate change, exploitation in the Arctic becomes achievable, which is followed by increasing political and economic attention. The rising interest is expressed in various scientific projects, surveys, claims of territories in the Arctic and presence in the media.

These developments show, how an entity gets connected with a network. Without the higher availability, the Arctic's mineral oil would not be of rising interest. Hence, it would be – if all – loosely connected with Arctic networks. However, its economic potential caused the creation of various interdependencies, integrating this entity into a network, making the latter longer and stronger. As ANT dictates, the activation of the entity "mineral oil" is not solely done by the conducted researcher, but by the interest network member's (for example, economics, sales-people, car-drivers, politicians or workers) have in it. Consequently, mineral oil becomes an ANT-actor.

Still, there are some difficulties in clearly distinguishing between actors and networks, especially, when the terms "nature" or "society" are used. Previously, ANT-influenced research shifted its focus from entities themselves, towards connections between actors. In addition, human ecological metabolism has shown that nature and society overlap. However, ANT provides additional advantages to investigate interdependencies between processes of climate change and processes of geopolitics.

2.1.3.9 Adapting the terms "nature" and "society" to ANT

So far, the natural sphere is defined by the geographical spheres of the earth and overlaps with the social sphere, what creates an overlapping zone. ANT does not investigate spheres, but networks. However, the terms "nature" and "society" have been used in a common, yet conservative, way so far.

Hence, nature is often determined as a counterpart to society, while the latter includes culture, cities, the built infrastructure and technology. Nature gets also commonly interpreted as being untouched by humans and their actions (Brunotte et al., 2001a, 2001b; Werlen, 2000).
Society refers to a group of creatures, living in the same geographical area for a certain amount of time. They develop rules and habits, to structure their way of living. Simultaneously, social relations, cultural rites, rules and traditions form a society. In addition, society gets often granted its own evolutionary development. However, there is an ongoing scientific discussion, if individuals are forming the society they live in, through their individual ability to think, reflect and judge, or, if the whole is greater than the pure sum of its parts. Although the term "society" often refers to humans, it is not limited to it and can also include animals or plants (Brunotte et al., 2001a, 2001b; Werlen, 2010).

Characteristics which shape the conventional definitions of nature and society, do not exist within ANT. There are no macro level, microlevel, common size or scales and actors are treated equally. For ANT both society and nature are the result of network-building processes. Consequently, a-priory postulations of scientific analysis would deny the dynamics of these processes (Callon and Latour, 1992). Hence, a distinction between the two expressions is determined as an artificial demarcation, since the term "society" itself is made up or "socially constructed" (Latour, 1994b).

Continuative, the terms “nature” and “society” are not used within ANT or at least appropriated in a different context (Latour, 2009d, 2009e).
In order to overcome the arising gap, ANT uses the term “collective”. A collective is a network, built out of newly connected entities. Although collectives reassemble different entities, objects and actors, they cannot be compared to each other in a similar way to the conservative interpretation of nature and society. In contrast to collectives, society – as an ANT-term – refers to entities which are already connected. Hence, a society is the result of a development and of the actors' efforts to maintain existing linkages (Latour, 2010a, 2008a, 2000a).

Particularly Latour states that nature and society are finalised constructs, and scientists should seek to explain them, instead of using them to explain actions. However, the equalization of nature and society prohibits humans and therefore actors to distinguish between the two of them (Amsterdamska, 1990). As an example, different societies picture their relationship to nature in totally different ways (Bloor, 1999; Jasanoff, 2003). Therefore, the abandonment of a distinction between nature and society limits the actors subjective possibilities to define, question and explain their surrounding environment (Amsterdamska, 1990).
In addition, even Latour uses a distinction between nature and society, for example to define hybrids (Jöns, 2003). In this case it is also worth to mention that a priori postulations are used within ANT, for example through stating that networks between humans and non-humans exist or by defining the principle of symmetry (Schulz-Schaeffer, 2000).

The core idea of implementing ANT into the novel theoretical approach of this thesis, lies in the acceptance of nature's complexity. In alliance, ANT states that a degeneration of nature into being solely the background of scientific explanations is inadmissible (Latour, 1999b).
Analogue to the previous discussion about a priori postulations, actors are allowed to characterise other network members. Hence, if an actor considers an entity to be “natural” or “social”, the conducting scientist has to adapt this point of view. However, as has been outlined before, the involved scientist is also an adequate network-member, implying that he is allowed to distinguish between nature and society as well. Therefore, the terms “natural” and “social” are added as attributes, to stress an actors' affiliation with the natural or the social sphere.

So far, three attributes to characterise actors more closely are defined: natural, social and mental. Acgtors, including the scientist, allocate these attributes to network-members. Combinations of the adjuncts are also possible. As an example, the instincts of an animal can be regarded as being mental and natural at the same time, while the dislike of a human being towards something is a socially impacted mental actor. Entities, comprising social and natural elements have been named earlier, for example the biophysical structure of society. Even the coupling of all three characteristics is possible, if a hybrid-actor consists of all of them. A human being, machines or animals serve as typical examples.

Yet, the combination of attributes can change the appearance of an actor completely. It has also the power to force the scientist or other actors to decide, in which manifestation actors present themselves within the investigated network. In order to further underline the importance of nature's complexity as an actor, even in social networks, the described dilemma is outlined by discussing if nature – as a whole – is solely a natural actor.

2.1.3.10 Changing actors – identification of attributes

The attributes "social", "natural" and "mental" are not only a description of an actor, they also allow statements about the mediative possibilities to influence functional chains. Especially mental entities have restricted, but nonetheless powerful ways to affect actors. Hence, a researcher has to identify particularly, if an entity is represented as a mental actor within the network or not, since this opens up additional chances to create and maintain connections.

Identifying nature as a network and therefore as a complex (eco-) system is logical. Ecosystems comprise different living and non-living entities bonded together through functional loops, affecting, amongst others, nutritions or living space. Each system-component has the power to influence others, by accessing these functional loops. Therefore, ecosystems are open systems, not only containing flows of material and energy, but also exchanging entities with other systems. If the functional internal or external loops are altering, ecosystems can adjust to them, within given possibilities (Nentwig, 1995).
Within this short definition several core-elements of ANT are represented: actors and networks. First of all, an ecosystem is created by non-living and living entities. While the latter involve

amongst others human beings and animals, objects and machines belong to the first category. The possibility to influence other network-members transforms the involved entities into ANT-actors. The creation of functional loops is equivalent to the generation of functional chains. Hence, ecosystems and therefore nature itself, suits the previously defined ideas of ANT-networks.

Yet, there is a different, not trivial way of handling the actor “nature”, by dealing with its mental representation. Humans and nature are inseparably bonded together, due to the fact that humans have to respect natural principles. In order to modify nature in a way that is aspired by anthropogenic needs, humans have to act according to these principles (Groß, 2001).
Although nature is often solely pictured as an endless stock to fulfil peoples' needs and desires on a physical level, it also serves humans on a mental scale. As outlined before, humans are able to create a mental picture of an entity. Furthermore, people delegate typical anthropogenic characteristics to entities, for example by giving them a name to express their uniqueness (Werlen and Weingarten, 2003). While this often refers to a single entity only, humans also gather entities in groups, in order to value them. Hence, humans can esteem a whole network, such as an ecosystem or nature in general. Analogue to valuing a single entity, a person has to identify itself with nature to truly credit the worth of its existence (Graumann and Kruse, 2003). Simultaneously, mental representations of nature enable a human being to define oneself (Steiner, 2003) and such mental identifications remain stable over a certain amount of time. Consequently, they lose their connection with the actual process of creation (Werlen and Weingarten, 2003). Therefore, nature gets transformed into a mental actor – a cared after and protected entity (Hinrichs, 1991).

In addition, the experience of nature changed during the last decades. In earlier days, humans felt extremely close to their near surrounding environment, while the interactions between people and global nature have risen immensely, due to new travelling possibilities and other developments (Mertens, 1998). Such changes enable humans to value nature not only on a local, but also on a regional or even on a global level, resulting in anthropogenic appreciations that maintain, are transformed or vanish after a certain time. Within this lies a constantly rising potential for nature to influence humans (Messerli et al., 2001).
In slightly different ways, also animals can value natural entities. Hence, even without anthropogenic involvement, nature gets transformed into mental entities and gets granted a purpose which leads back to the concept of intrinsic values (Steiner, 2003).

To conclude, it is regular that an actor is represented as a hybrid, a network, a black box and a mental actor at the same time within the same network. Hence, it is essential to investigate these different representations, to grasp an actor's entire potential to influence other network components.

2.1.3.11 Bringing it together – the Actor-network

To conclude, it is now possible to define what actors create together: the actor-network (see Figure 9). The actor-network is a web between actors whose methods to maintain and expand the network are fully described. Hence, everything in ANT is defined by its continuous relations (Law, 2009).

The actors are networks themselves, consisting of various connections and interdependencies whose maintenance represents the "price" to keep up their network. Furthermore, the creation, maintaining and recreation of networks is caused by power, resulting through these developments (McLean and Hassard, 2004). In addition, actor-networks are a descriptive tool of ANT, exposed in reports (Latour, 2010a, 1991, 1987).

Actors create various links between themselves and external entities, underlining moreover their hybrid-structure. New connections are created continuously. Hence, the described actor-network has to be regarded as a complex system. The aim of the conducting scientist is therefore not to illustrate the whole actor-network, but to identify some of the interdependencies, to make them last over time (Latour, 2010a).

However, the development of actor-networks is questioned, since it needs one actor who dominates and therefore activates others actors, in order to create and maintain such networks. While in practice, many networks work exactly like that, there are also contrary examples of webs, in which all actors are of equal strength. Consequently, such equal able actors are forced to communicate and especially to cooperate with other network members, instead of simply overpowering them. Hence, Weyer (2008, 1997a, 1997b) states that ANT does not suit interdependencies between actions of several autonomous actors.

Although this argument seems logical, the fact that actors are networks themselves – even dominating actors, is crucial in this case. By regarding them as a web of connections, their power gets allocated to different actors. Thus, theoretically, their power is shared amongst several actors which create the hybrid "dominating actor" together. Hence, ANT suits the investigation of networks with one or more central-actors.

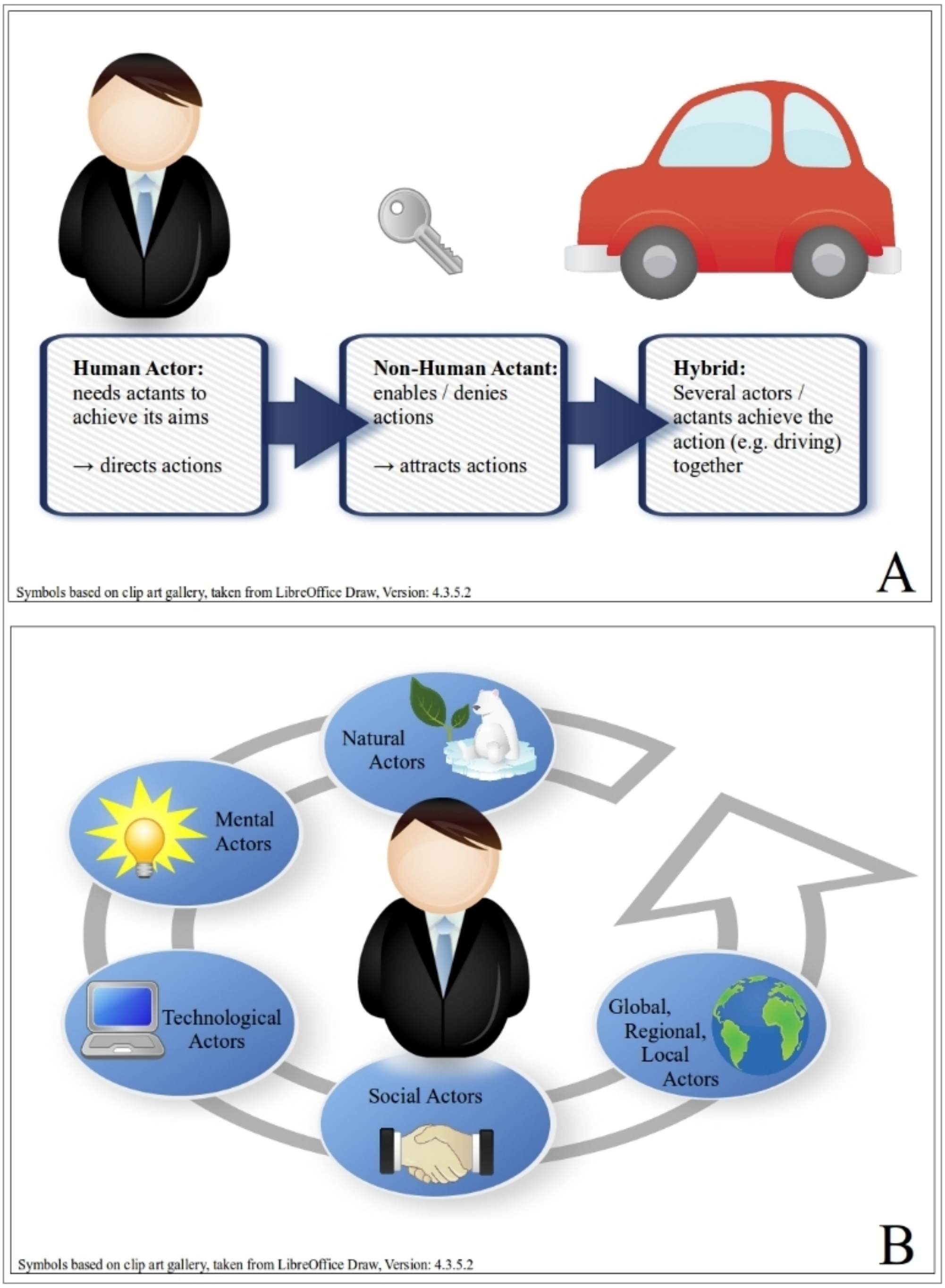


Figure 9: Comparison of a conventional (A) and a novel actor-network (B)

While the conventional actor-network solely distinguishes between human, non-human actors and hybrids, the novel interpretation of an actor-network illustrates different types of actors, as well as their attributes. Hereby, any actor is created through interdependencies between different types of actors and attributes – hence, actors are always hybrids. Therefore a distinction between them is not sufficient anymore.

In an actor-network, any actor results of and initiates connections. However, there is still a lack of knowledge about how actors influence others, in terms of their ability to translate connections (Schulz-Schaeffer, 2000). Normally, the entities which create connections, do not share equal possibilities to maintain them. Intuitive examples are the interdependencies between Arctic shipping and the melting of sea ice. Sea ice melting enables Arctic shipping, while a thick ice layer hinders it. Contrarily, Arctic shipping has limited effects on the thickness and melting processes of sea ice.

In addition, ANT does not explicitly describe of what substance the sought-after connections are made. This arises the question, if different types of connections exist and if one particular type is more powerful than another, what bridges back to the dominant-actor-problem (Amsterdamska, 1990). Moreover, without knowing the tagging of connections, they cannot be identified by scientists (Bloor, 1999; Weyer, 2008).

However, not knowing the “recipe” of connections is an advantage for science as well, since it allows the inclusion and following of various different types of connections. No restrictions in terms of physical, social or mental linkages are made, what opens up multiple possibilities to record connections over space and time.

Yet, if a scientist does not know what he is looking after, recognitions of changing purposes of actors might not be possible, for example (Schulz-Schaeffer, 2000). Furthermore, since a priori postulations have to be avoided, the following of actors is often reduced to taking a snap-shot of the network they are in. Hence, temporal changes within the network might not get realised by the conducting scientist.

A change of purpose that is not realised, is as a consequence not important to the connected actors and therefore neither to ANT. Additionally, if a changing purpose does not provoke any alterations, there is simply no point in recording it. Nevertheless, it can be interpreted as an unimportant mental actor, leading to a weak connection with loosely linked entities.

Although ANT is solely a descriptive theory and its use, as well as its definitions are still controversial, this theory suits *Objective 1: Develop a theoretical approach that covers natural and social / political developments.* Hence, the improvements which are gained by the usage of ANT are summed up in the following.

2.1.4 Improvements towards the developing of a theoretical approach that covers natural and social developments

The outlined human ecological approach has been criticized in three main ways: Firstly, nature and society were not given the same possibilities to influence each other, secondly, mainly flows with physical representations are involved into socio-ecological systems and thirdly, the requirement of existing system-boundaries (see Chapter 2.1.2). Hence, the following outlines which improvements ANT offers in these cases.

To start with the latter, system boundaries are easily translated into an interpretation of nature and society as closed systems. Consequently, the emerging overlapping zone also contains solely an unchangeable amount of entities.
In contrast, ANT deals with open systems by definition. In fact, actor-networks have no outer boundary, but loose connections instead. Entities dock on such loose connections, through the process of activation. Yet, activations even create entirely new interdependencies. If an entity is activated – hence gets connected to an actor-network – it immediately creates a hybrid with the connected actor and moves in the overlapping zone. Therefore, the overlapping zone itself is not a fixed amount of entities, but a flexible area, becoming bigger or smaller, according to the amount of connected entities and emerging interdependencies. Due to the hybrid structure of humans, for example, the overlapping zone always exists – it cannot vanish. Hence, nature and society cannot be separated entirely. Consequently, ANT further strengthens this initial idea of the socio-ecological metabolism approach.

Human ecological metabolism deals mainly with global processes and its methods are inapplicable to the unique situation of the Arctic. ANT, on the contrary, does not seek to distinguish between a macro or micro level. Hence, global, regional and local developments become comparable and therefore the natural and the social sphere can be divided into a global and an Arctic part without further adjustments.
However, global influences still affect a higher amount of people than local shifts, although the latter often result in deep impacts. Consequently, they possess different power relations. ANT deals with these power relations, analogue to any other, through the focussing on connections. In addition, two new attributes are defined in this thesis, to underline influences from different

geographical dimensions on the research topics of this thesis: Arctic and global. Although they cannot supplement each other, a combination with the remaining attributes (natural, social, mental) does not involve any conflicts. However, due to a bias between Arctic networks and global networks, an isolation of the new attributes is also not possible. Hence, Arctic developments are always included into global shifts, which further underlines the ANT-statement that they belong to the same actor-network.

Particularly flows, created by mental entities, lack a physical representation. Although they depend on chemical and physical processes which have indeed a spatial dimension, their interior investigation goes far beyond the scope of this thesis. Hence, unless they are expressed and transformed into a transferable format by the possessing actor, they appear as black boxes. Therefore, they are excluded from the socio-ecological metabolism approach and even not represented satisfactorily within ANT.

To overcome this gap, the mental sphere is defined as an equal part of the metabolism, crediting mental actors, their enormous account in network-building processes. Regarding mental entities as actors is a crucial step towards the opening of such black boxes. The novel involvement of mental actors, including feelings, thoughts or opinions, also underlines the fact that a ANT-connection itself cannot be good or bad per se. In contrast, the connected actors decide if an interdependency leads to advantages or / and disadvantages, depending on their individual point of view. Hence, differentiations between “good” and “bad” are always bonded to actors. Consequently, the same link can have positive and negative consequences simultaneously. Since ANT follows actors and records their opinions, these categorisations are retraced in this thesis as well.

Referring to the first point of the mentioned critique: ANT already credits nature significantly more power to influence society than the metabolism concept. Both spheres are now defined as networks, comprising analogue structures between their entities. Therefore, the first critique is solved, by the adaptation of ANT.

However, the full inclusion of nature and society, confronts the conducting scientist with the handling of complex networks. If everything is connected, such as ANT claims, it is crucial which exclusions a scientist chooses in his studies. It is impossible to involve any connected actor and even ANT states that networks have to be cut-off somewhere – as will be done in this thesis. Hence, the presented networks are only small details within bigger webs, consisting of nature and society.

Besides the decision, where to end scientific investigations, a scientist has also to define, where to start it – thematically and geographically. Yet, there is no specific starting point, that has significant favours according to any other. If everything is connected, any starting point is as good as any other.

1. If a thematically starting-point is chosen, the conducting scientist will be guided automatically towards powerful actors, since they possess multiple connections. Even if the starting-point is not yet linked to the network, this exact connection can be created during the analysis, leading to the object of scientific interest.
2. If a geographical starting point is chosen, it has to be considered that most of the actors are not created in the location, where they are at the time of the scientific analysis. Instead, they have been formed somewhere else, by a creating actor such as a human being or a machine, and moved to their current location. If a scientist retraces an actor's route, the actual place of existence links to the new locations and also to other actors, for example to the creating actor. By identifying the creating actor, the scientist also investigates possible purposes of entities, given to them by other actors. Hence, the scientist connects a current chain of action with the origins of involved actors (Latour, 2010a, 1998). Therefore, he automatically interweaves connected places and actors.
3. If a person as a starting-point, it has to be pointed out again that any actor is also an actor-network. The identity and character of a person are highly influenced by external drivers and so are their abilities and skills. Hence, a human person is defined by its connections and interdependencies (Callon, 1999, 1990; Latour, 2010a, 1991). Therefore, following one person, will guide the scientist to connected actors, places and times.

Hence, even if the starting-point of a scientific study is represented by one entity (theme, place, living object, non-living object), it contains a whole network. Consequently, it will direct the scientist to its connections, illustrating its power relations within the network.

In general, power relations are differentiated into "power over" and "power to" another actor. Consequently, methods of power and power as a storage medium are treated equally, since both evolve out of connections (Law, 1990). Hence, strength and weakness are combined into plain processes (Latour, 1988b).

As another outcome, focusing on interdependencies adds a generative, yet productive facet to the conventional concept of power (Fox, 2000). If an actor has power over other actors, not only in theory, but also in practice, other network members will fulfil the actions the powerful actors orders.

If an actor has power over others in theory, but they do not act due to its commands, the actors is basically powerless. Therefore, power is not something an actor can own or accumulate, but an attribute which is expressed in practice, by making other actors act due to the powerful actor's intention (Latour, 1986b).

To conclude, the enlarged ANT lead to significant improvements, in comparison to the human ecological metabolism approach. Yet, so far needed contents of a theoretical approach that covers natural and social / political developments (Objective 1) have only been described. Hence, the following discusses *Objective 2: Identify actors and develop a methodological approach to analyse interdependencies between them.*

2.2 Identifying actors and develop a methodological approach to analyse interdependencies between them

The theoretical approach developed in this thesis suits the unique situation of the Arctic and investigations of interdependencies between processes of climate change and processes of political geography and geopolitics. However, the theory is still lacking applicable methods. As a starting point, the following outlines, how ANT is conventionally applied, in order to identify similarities. Hence, the focus is solely on the used methods to investigate networks within the outlined studies.

2.2.1 Working with ANT

An interaction between people, technological objects, machines and digital entities creates a classical actor-network, by abolishing a differentiation between social and technical actors. Hence, there is no need to decide about the adaptation of technology or if technology has the power to act external to society in advance to the conducted investigations (Tatnall and Lepa, 2003) (Please note, that digital entities, such as web pages, are described – in terms of the attributes, suggested in this thesis – as being a hybrid of natural, social and mental actors). Based on the simplified identification of the importance of hidden actors through their failure, ANT is suitable for analyses of failures, cases in which technology's adaptation does not succeed or in which an adapted technology collapses, due to innovation processes, in general (Tatnall and Lepa, 2003).
Especially Latour himself has written various pieces about the definition and role of technology (see

for example Latour and Venn (2002)). His best known one is the explanation of the failure of Aramis, a former, and once described as being revolutionary, public transportation system (Latour, 1996b).
A recent study of this field was done by Sarker, Sarker and Siderova (2006). They investigated the process that caused a business process change failure of a telecommunication company in the United States, by using ANT principles (Sarker et al., 2006). Business process change is defined as the improvement of business processes – hence, being more competitive through efficient and profit-orientated strategical initiatives (Harmon, 2007; Pateli and Philippidou, 2011). The authors collected their data through interviews with employees. The contents of the interviews depended on the individual involvement of the employee within the sequence of failure. Face-to-face interviews were used to identify involved emotions and to draw connections between entities. Such interviews lasted around one to two hours. To clarify inconsistencies, telephone interviews were conducted (Sarker et al., 2006).

ANT is also applied to several currently pressing issues. Possibilities of elderly people to adopt the internet into their daily lifestyle and the reasons leading to such adaptations are investigated, for example. Hereby, interviews were used, to distinguish the subjective ideas and aims, illustrating the relationship between people and e-commerce (Tatnall and Lepa, 2003).
Another pressing issue is analysed by Dery et al. (2013). The authors investigated, how Human resource information systems get implemented into business structures. For that purpose, an interpretative case study was set up. The resulting data collection was again fulfilled by semi-structured interviews. The interviews were conducted by two interviewers. The resulting data was complemented with observations of the system in use, documentations, generated by the company itself and information which are open to the public (Dery et al., 2013).

These examples share a common practice of collecting data: interviews. Consequently, the illustrated network reflects the points of view of the involved humans, although various non-human actors are involved. Hereby, the former critique that it is not possible to retrace networks from the perspective of non-humans beings. However, it is not possible to solve this dilemma. In contrast, semi-structured interviews suit ANT in significant ways. They avoid a priori postulations, while supporting the aim to include involved emotions and feelings – strengthening the former suggestion to involve mental entities as adequate actors. Additionally, semi-structured interviews also support the previous statement that technology is interpreted as a hybrid between natural, social and mental entities.

The inclusion of mental entities bridges to another field, in which ANT is applied: the analyses of interdependencies between science, technology and narratives (see for example Latour et al., 1992). To analyse the narratives of urban fragmentation in Mumbay, Wissink (2013) adapted ANT, by substituting the terms and the meaning of “science and technology” with “urban space”, in order to investigate the “narrative of loss”. To understand the process behind controversy and acceptance, the author believes that ANT requires a high descriptive outlay. With a case study and conducted interviews, the author tried to include any involved party and used also newspaper articles to follow the controversial discussion around the investigated topic (Wissink, 2013).
The analysis of narratives strengthens again the comments, which have been made about mental actors and their power relations in this thesis. However, even in this example with its strong focus on mental actors, transformed manifestations of mental actors (interviews and written documents) were used to trace them back. Yet, in the case of interdependencies between processes of climate change and processes of political geography and geopolitics in the Arctic, the note of aiming to include the intention of any involved party is not practicable – simply, because they are endless and time constraints apply. In respect to the cited research of Wissink (2013), the point has to be stressed that it is not possible for a researcher to interview every actors of a network. Speaking to actors, if understood in a traditional way, is restricted to humans only and excludes as a consequence multiple entities from the investigations. If interpreted in ANT-terms, any actor can “speak” or at least communicate with the scientist. However, it is not known, if the scientist has the ability to translate these various ways of speaking.

The involvement of processes of political geography and geopolitics into the research question of this thesis, requires the analysis of international relations. However, Barry (2013) states that particularly these relations cannot be integrated directly, when using ANT. The author claims that in a political environment, context and history possess more important roles than in scientific processes. Furthermore, an expert, working on international relations or politics, has to be fully aware of the various possibilities of how his work affects the addressed field. In contrary to ANT, space and especially boarders are crucial to international relations (Barry, 2013) and in addition to contributing mental or social components, boarders – at least on international levels – always have a spatial expansion.

Besides geopolitical developments, my thesis involves nature in a way, unknown to ANT-adaptations, yet. However, Law and Singleton (2013) apply ANT to the ethnography of Norwegian salmon farming. As an outcome, the authors state that ANT does not pre-exist. Contrarily, it has to be created and adapted throughout each and every attempt to work with it. Furthermore, Law and Singleton (2013) stress the point that ANT gains theoretical knowledge through case studies and that it has therefore to be grounded. In order to investigate Norwegian salmon farming, the authors interview experts of the field. Yet, the authors distinguish between different wild and farmed species of fish (Law and Singleton, 2013). Hence, they describe a system which separates between nature and society. Therefore, the authors' procedure cannot be adopted in alliance with Objective 1.

The survey of Burgess, Clark and Harisson (2000) integrates nature on a deeper level. The authors analyse, how nature conservation schemes for wet grazing lands are understood by farmers and conservationists due to their different interpretation of nature and the amount of knowledge they possess. The authors claim that ANT allows a simultaneous and moreover equal existence of two interpretations of conservation – one of the farmers, one of the conservatives. In addition, the authors investigate, how “nature” gets translated by the used methods of scientists and farmers. Hence, they deal merely with numbers, tables and categories on the scientific side and with local knowledge from the farmers. The authors even recorded differences in the cognition of important components of the existent ecosystems (Burgess et al., 2000).

Although the (mental) translation of nature into networks is respected by Burgess, Clark and Harisson (2000), even this example does not succeed in fulfilling the final step to credit nature its full power to influence network-members. Nature is still represented as a single-edged environment which people can transform to their will.

For this thesis, such an interpretation of nature is not sufficient. Climate change challenges people in the Arctic on multiple levels. Therefore, nature has to be treated as an equal network to society – with equivalent possibilities of over-powering other actors. Hence, all previously outlined methodologies are limited in respect of the analysis of such power relations. Some even miss methods to investigate natural entities in general. Therefore, none of them fit entirely to the objectives of this thesis, without further adaptation. However, with the developed theoretical approach, the definition and outlining of characteristics of Arctic actors – of the elements of the

Hybrid-Arctic – become accessible. Hence, by identifying such actors, suitable methods to analyse them can be selected.

2.2.2 Identifying important actors of Arctic actor-networks

According to the developed theoretical approach and in respect to the core-principles of ANT (see Chapter 2.1), the sought-after Arctic actors have to fulfil four different requirements:

1. Actors have to be able to mediate flows between processes of political geography and geopolitics and processes of climate change. Therefore, such entities have to manifest hybrid-structures between these two systems, whereas a natural component is represented by climate change and a social component is represented through processes of political geography and geopolitics.
2. Required entities must attract mental entities, to cover the demands of people, their knowledge about the entity, intrinsic values granted to it and political initiatives. Particularly the latter evolve in the mental sphere.
3. Actors have to fulfil an active role in networks, including the ability to over-power other actors. In addition, mediative actors can be traced back to their process of creation, including particularly their activation.
4. Combinations of different time and spatial scales are needed. The defined actors influence not only global or local developments, but persist as controversies over a certain time period.

By combining these four requirements, one group of entities that gets predestinated to comply with the function as actors between processes of climate change and processes of geopolitics in the Arctic is identified: resources. Yet, they have to be interpreted in a novel way – an ANT-way.

Conventionally, resources are defined as entities, which secure economic activities of humans. Hence, they are crucial to production and aid. Resources are described as accumulations of entities of worth or as the (economic) potential of an ecosystem or a landscape (Leser et al., 1998). Broader definitions involve existing reservoirs and assure the existence of biotic and abiotic life-friendly systems (Brunotte et al., 2001b).

The ANT-definition of a resource is actor-based: An actor has to define the resource itself, by regarding it as being crucial to its own survival on a biotic, abiotic, social or mental level. Hence, if interpreted in an ANT-way, resources comprise natural, social and mental characteristics. In general, this involves also postulations, made by machines, animals or any other actor. However, due to the lack of methods, postulations of animal, technological or objective-based resources cannot always be identified by humans.

Consequently, any Arctic entity that is affected by climate change and sought-after by other actors, particularly on a political dimension, is therefore an ANT-resource (see Figure 10). Hence, such entities merge processes of climate change and processes of political geography and geopolitics in the Arctic, by maintaining metabolic flows between the natural, social and mental sphere – not only on an Arctic scale, but also on global levels (Kürner et al., 2015).

Due to the recently changing availability of Arctic resources, their impact potential on social, natural and mental systems is shifting. These alterations are mainly caused by natural changes which result in both, an increasing or a vanishing of the desired entity within its actor-network. Due to society's demands, resources force human beings to react on their changing availabilities that affect living conditions in general. Such anthropogenic reactions involve, for example, an increasing interest in an entity, an increasing knowledge and communication about it and also the altering of intrinsic values. Society's reactions then affect nature in reverse, further influencing the resource's availability and so on.

Hence, former uninterested entities become resources, due to an eased access in the near future, or a resource gets inactivated, due to its complete disappearance, for example. Consequently, entities move in and out of the overlapping zone, leading to the Hybrid-Arctic constantly changing. In addition, the various reactions of the natural, social and mental spheres that are enforced by resources during their activation, their activated time and their inactivation, represent an over-powering of other network members.

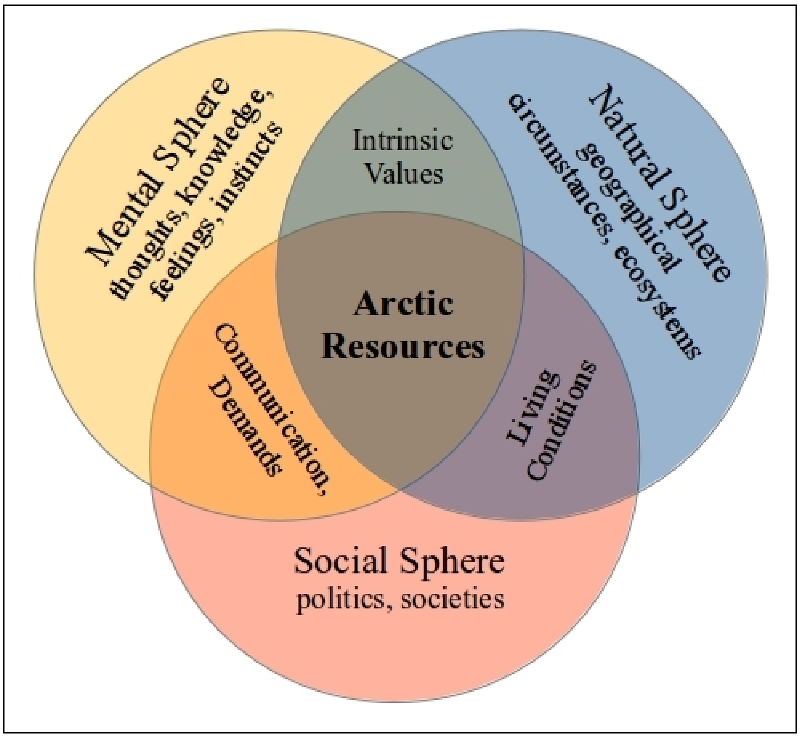


Figure 10: Hybrid-resources

Interpretation of resources as mediative actors between processes of climate change and processes of political geography and geopolitics in the Arctic, by combining natural, social and mental characteristics.

2.2.3 Identifying Arctic resources

By following the ANT-definition, developed in this thesis, resources are described as being part of the Hybrid-Arctic. Hence, they are powerful actors of local, regional and global importance, representing the various interdependencies between processes of political geography and geopolitics and processes of climate change in the High North.
During this initiative stage of identifying Arctic resources, each step taken is illustrated. In doing so, a scientific report will be elaborated according to ANT-principles (see Chapter 2.1.3.7).

In order to identify Arctic resources that suit the ANT-definition, a qualitative literature review was conducted. To obey to the idea of abolishing as much a priori postulations as possible, the review started with the analysis of multiple reports, published by Arctic research working groups, such as the Arctic Climate Impact Assessment (ACIA, 2004), the Arctic Human Development Report (AHDR, 2004), the Arctic Marine Shipping Assessment Report (AMAP et al., 2013), the Arctic

Biodiversity Assessment (CAFF, 2013) and the Arctic Climate Issues 2011: Changes in Arctic Snow, Water, Ice and Permafrost (AMAP, 2012).

Based on these findings, a quantitative literature review was done with ISI Web of Science to re-prove the found resources. Again, the used keywords were kept as broad as possible:

Artic or "high* north*" or "circumpol*north*"*

AND resource or "raw material source*"*

AND international or global* or "cross national*" or national* or nationalwide* or local* or regional**

AND importan or concern* or interest* or meaningful* or significan**

In March 2014, the search request listed 362 hits. After reading the titles and, if necessary for clarification, also the abstracts, the Arctic resources, listed in Table 2, were identified.

The large temporal gap between the initial identification of resources, using qualitative literature research, and the quantitative literature research with ISI Web of Science, was chosen to avoid a too strong representation of current scientific focuses or media-influenced opinions. As an example: during the second literature research, grasslands or agricultural land were only represented as minor Arctic resources, while the resource "security" had an overwhelming response. Focusing only on the quantitative literature review would therefore have led to a possible neglection of grasslands and agricultural land. In comparison, the quantitative literature review enabled the identification of currently requested Arctic resources – in no specific order – such as shipping routes, mineral oil and gas, fish, territorial space, health (including mental health) and security (including food security). Hence, the temporal gap allowed the involvement of recently evolved Arctic resources.

However, the lists in Table 2 and Table 3 are far from being complete. Yet, it covers a wide range from social, natural and mental resources, as the new ANT-definition requires.

Analogue to the attributes of actors defined earlier, resources are labelled as being of mainly global, regional or local importance. "Local" refers to being important for only a relatively small group of people or just for one country at a time. In contrast, the term "regional" is chosen, if two or more Arctic states are involved in currently changing availabilities of a resource and "global" addresses significant impacts on more than two Arctic states or on systems, outside of the Arctic. Hence, being globally or regionally meaningful always implies an importance on a local level, although the interpretation of involved entities and their prominence within the process might differ on these scales.

Furthermore, the geographical location of Arctic resources is distinguished between being on land surface, in the water column or in the sea floor. This differentiation particularly suits the geopolitical situation of the Arctic, including the unresolved territorial belongings of vast (marine) Arctic areas. Shifting the access towards resources that are located in the water column or in the sea floor therefore holds significant geopolitical potential. In addition, there are resources, based on coupled conditions on land and in the ocean, such as shipping routes. Apart from requirements concerning the ice layer of the ocean, they also depend on harbours and on-land infrastructure to be developed. Other resources, especially mental resources, are bond to an actor. Hence, if this actor is able to switch its location between land and ocean, the resource is as well.

Particularly the latter argument leads to the third attribute: being immobile or mobile. Any resource that is bonded to a mobile actor, is in consequent characterised as being mobile, such as knowledge or human capital. In addition, woodland is regarded as a mobile resource, due to recently changing Arctic habitats. Although a single tree cannot move by itself, the area covered with trees changes its circumference. Analogue, actual shipping routes also differ according to the predominant sea-ice condition on a year to year or even on a day to day basis. In contrast, the location of mineral oil and gas is fixed (on human time frames), but the access towards this resource is currently changing, due to global warming.

In order to further credit the changing availabilities of resources and their possibilities to adapt to climate change, they are sorted as “Regenerative resources” and “Not renewable resources”. Analogue to the previous attribute, “not renewable” refers to human time frames and to the overall existence of the resource, not to their alterability in general.

Table 2: Identification of not renewable Arctic resources

Arctic Resource	Level of Influence	Location	Alterability
Mineral Oil / Gas	global	sea floor	access adapting
Rare Earths	global	sea floor	immobile, access adapting

Arctic Resource	Level of Influence	Location	Alterability
Minerals / Diamonds	regional and global	sea floor	immobile, access adapting
Unclarified Territorial Space	global	mainly located in the Arctic ocean	access adaptive
Strategic Places	global	terrestrial / marine conditions	immobile
Endemic Species	local, regional and global	terrestrial / marine conditions	partly adaptive
Permafrost	local	terrestrial	not adaptive

Table 3: Identification of regenerative Arctic resources
Selected resources that function as case studies in this thesis are marked in grey colour.

Arctic Resource	Level of Influence	Location	Alterability
Shipping Routes	global	terrestrial / marine conditions	access adapting
Fish	global	water column	mobile
Animal Stock	regional	terrestrial	mobile
Woodland	regional	terrestrial	mobile
Agricultural Production	regional	terrestrial	mobile
Grassland	regional	on land surface	mobile
Infrastructure	local, regional and global	terrestrial / marine conditions	adaptive
Security in the Arctic	regional and global	mainly affected by access to the Arctic ocean	adaptive
Food Security	local and regional	terrestrial / marine conditions	adaptive
(Mental) Health	local and regional	terrestrial / marine conditions	adaptive
Human Capital	regional	terrestrial / marine conditions	mobile
Traditional Knowledge	local	terrestrial / marine conditions	adaptive
(Mental) Pictures of the Arctic	local, regional and global	terrestrial / marine conditions	adaptive
Tourism	local and regional	terrestrial / marine conditions	adaptive

Three of the identified resources (which are marked in grey colour in Table 3) are selected to apply the developed theoretical approach and moreover to generate a suitable methodology. These resources are: Firstly, shipping routes – a resource with global impact potential which is highly affected by the current social, cultural and political structure of the High North, secondly, traditional knowledge – a mental resource of the Arctic which is bond to its knowledge-holders and their future development and thirdly, agricultural production – a so far minor Arctic resource whose impact potential depends directly on recent changes. Since all selected resources are regenerative, the connections and power-relations within their actor-networks are currently shifting. Hence, they are predestinated to test the developed theoretical approach of this thesis.

Starting with the latter: Agricultural production consists – in a conservative way – of agricultural land, woodland, grassland, animal stock. A detailed definition, which suits the Arctic's situation, is given in Chapter 5.
Agricultural production is chosen, because it determines anthropogenic survival in general. Moreover, it represents the anthropogenic desire to change and adapt nature, as it has been involved into the socio-ecological metabolism approach. Apart from that, agricultural production is an essential resource around the world, except for the Arctic. Analysing the possibilities to develop agricultural production in the Arctic in the context of global warming is therefore a predestinated geographical case study to apply the developed theoretical approach.

Traditional agricultural activities, including hunting and gathering, bond the resource "agricultural production" to the second choice: traditional knowledge. Traditional knowledge is tied to the indigenous peoples of the Arctic and therefore as unique as the High North's environment and societies. It is locally important and determines the life and culture of Arctic peoples. Yet, traditional knowledge is adaptive and underlies deep reaching changes, caused by shifts in the natural, social and mental sphere (Abele, 1997).
Traditional knowledge is chosen as an example of Arctic mental actors. The investigation of traditional knowledge credits an understanding of a human-nature relationship that differs completely from the western one. Hence, it leads to new ideas of interdependencies, but also to a deeper understanding of connections between social, political, economic and environmental developments on local, regional and global scales.

Multiple components of traditional knowledge refer to the current (sea) ice condition, since they enable hunting or fishing activities (Pearce et al., 2015). Hence, traditional knowledge also contributes – in some ways – to the investigation of the third chosen resource: Arctic shipping routes.

Shipping routes represent an emerging Arctic resource of global importance. Although research about Arctic shipping routes is often limited to economic and technical aspects, such lanes have a deep impact on the social and natural sphere in general. Hence, shipping is regarded as a rising economic option in the High North, but also a threat towards the region's ecology (Ware et al., 2014).

One of the main purposes of Arctic shipping is re-supply shipping (Jensen, 2010) – hence the transportation of cargo. Therefore, goods produced in the Arctic are also transported by ships, which links the resources "Arctic shipping routes" and "Arctic agricultural production".

As briefly touched above, the three chosen resources are connected with each other – just as everything is, when working with ANT. Hence, although they are analysed separately, there are indeed bonds and superimpositions between them.

In order to analyse the actor-networks of the three chosen ANT-resources in the Arctic, a methodological concept is developed in the next chapter. This step also fulfils *Objective 2: Identify actors and develop a methodological approach to analyse interdependencies between them*.

2.2.4 Developing a methodological approach to analyse interdependencies between Arctic resources

So far, ANT does not offer a methodology that suits *Objective 2: Identify actors and develop a methodological approach to analyse interdependencies between them*, as has been outlined before. Hence, an ecological approach which is also applied within geographical research is chosen and adapted to the research objectives of this thesis: the ecosystem services approach.

The conventional ecosystem services approach offers possibilities to recognize, distinguish and value the different ways, in which an ecosystem serves human beings. Besides classical economic merits, also non-profit values get integrated into this approach. Since, ANT-resources are understood as hybrids which always involve natural characteristics, the conventional ecosystem services approach can be used to analyse – at least – natural interdependencies in networks.

The initiative idea of the ecosystem services approach, as outlined in the Millennium Ecosystem Assessment Report 2005, is to link services, provided by ecosystems, to their benefits on components of human well-being. Ecosystems are regarded as functional webs between living organisms and non-living constituents. Hereby, the complete range from undisturbed nature to intensively used ecosystems is covered. The provided services benefit humans in different ways, but mainly result in a contribution to their overall state of well-being. The latter is created through the supply of humans with basic materials for a good life, the enabling of stable social relations, the protecting of an individual's security and the influencing of the overall health of a person. Furthermore, these four components concur and therefore influence a person's freedom of choice and action and vice versa. The factor freedom of choice and action is therefore an outcome of the four other parameters of human well-being. It refers particularly to the selfdetermination of an individual in respect to its aims and goals, but also to its determination by others. According to the concept of ecosystem services, human well-being is facilitated by environmental factors, comprising supporting, provisioning, regulating and cultural ecosystem services. Hereby, supporting ecosystem services are the foundation of the three other services, provided by ecosystems. They contain mostly services, which are supplied by universal goods (see Chapter 2.1.2), such as the nutrient cycle or the primary production. Provisioning services refer to anything, an ecosystem is providing for mankind, including fresh water or food. Regulating services include all ecosystem services that fulfil regulating purposes, such as climate regulation or water purification. The previous services are completed by the cultural services of an ecosystem which imply for example spiritual or recreational functions of an ecosystem (Millennium Ecosystem Assessment Program, 2005).
In general, the idea behind ecosystem services is based on the assumption that humans depend on nature. Hence, ecosystem services research requires a high level of multidisciplinarity, in order to identify the different possibilities in which nature increases peoples' benefits. Analogue to ideas of the socio-ecological metabolism, input and particularly output flows of ecosystems are essential, when pinpointing anthropogenic benefits (Bagstad et al., 2013). In addition, analysing ecosystem services implies the drawing of direct connections between science and society, contributing amongst others, to nature conservation, resource management or policy (Jax et al., 2013).

The conventional ecosystem services approach has been applied to various research fields and scales. Investigations cover a wide range from one precise component of an ecosystem (see for example a survey on eelgrass (*Zostera marina*) by Plummer et al., 2013), over one ecosystem in particular (see a survey of the provided ecosystem services of coral reefs by Hicks et al., 2013 and Micheli et al., 2014), to the sum of all ecosystems of a whole country (such as the study of Kubiszewski et al., 2013 in Bhutan). In addition, the analyses of profitable practices, including land-use (see amongst others Bateman et al., 2013), the investigation of urban environments and the meaning of green infrastructure (such as Andersson et al., 2014), as well as the identifying of connections between culture and ecosystem services (see for example von Heland and Folke, 2014) are also possible with this concept.

The high multidisciplinarity of the ecosystem services approach suits the developed theoretical framework. Besides, it covers cultural services, which comprise mainly non-profitable values which particularly contribute to human's well-being. Such cultural services consist amongst others recreational or religious parameters – hence, cultural services involve mental actors.

Furthermore, identifying possible benefits of ecosystems and their interdependencies with human well-being resemble the ANT-activity of following connections between the natural, the social and the mental sphere. In addition, it also strengthens the previous statement that resources are valuable actors which mediate flows between these spheres.

Although the term "benefit" is used in this case, it does not limit ecosystem services to have solely positive consequences on human beings. Contrariwise, analysing an ecosystem's benefits, enables the identification of misused or overused parameters. Furthermore, when combined with natural, social, economic or ecological developments, ecosystem services research allows projections about the rising or decreasing potential of the current resource-use. Besides, any entity, defined as a resource by a (human) actor, can be integrated into and analysed with this approach, independent from spacial or temporal dimensions.

However, the conventional ecosystem services approach solely focuses on the benefits of natural parameters – excluding human-beings as a source of benefits – so far. Besides, it leaves other crucial parameters of the developed theoretical approach behind, for example technological ones, although they influence ecosystem services significantly today (2015). This is, amongst others, illustrated by the role of artificial fertilizers in land-use systems or the function of biochemicals (Fitter, 2013).

Apart from such missing factors, the translation of services into different value systems is mainly limited to anthropogenic values and therefore to the unit "money". This is mainly caused by a recent implementation of ecosystem services into political decision-making (Purushothaman et al., 2013). Payments for ecosystem services were, for example, established in forest conservation, as a market-based approach (Locatelli et al., 2014). They were meant to incite persons or groups in charge to prioritize environmental-friendly management and decision making, which suits the users of ecosystem services (Kaczan et al., 2013). However, monetizations of ecosystem services get – in theory – often interpreted as an adjustment to disadvantaged holders. In addition, the idea of payments for ecosystem services pretend to be a "win-win" situation to policy makers and conservationists, particularly in developing countries. Yet, possible payments for ecosystem services are no political panaceas, instead they should rather be regarded as one possible solution, embedded into a whole set of potential actions (Muradian et al., 2013).

Moreover, the fixation on money as an appropriate unit leads to additional difficulties: While, for example, the economic value of a school of fish in the Arctic can be relatively easy expressed in the unit "money", the price of an intact landscape cannot (see for example (Tengberg et al., 2012) for the analysis of the cultural value of a landscape). Although cultural services contribute significantly to the well-being of humans, they are usually not fully considered in the calculation of the value of ecosystem services, due to methodological challenges (Plieninger et al., 2013). Hence, analyses of the monetary and non-monetary values of particularly cultural ecosystem services are currently undertaken (Grönmeier et al., 2013; Tengberg et al., 2012; van Berkel and Verburg, 2014). Furthermore, blueprints of how to conduct surveys about ecosystem services are developed (see for example Crossman et al., 2013).

To conclude, the aim of rising an ecosystem's value, through summarizing the worth of the ecosystems' services, is challenged by the issue of calculating indirect effects which are caused by the systems components themselves. So far, the value of an ecosystem is mainly limited to an economic level, disobeying its mental and social importance. A polar bear (*Ursus maritimus*) functions, for example, as a tourist attraction, as financial income for indigenous peoples – in the case of trophy hunting or sports hunting – and as an icon of climate change. If its population changes, every named service will in- or decrease. Hence, one entity is connected to several ecosystem services. Consequently, the entire services of an ecosystem's member have to be integrated methodologically.

Apart from that, ecosystems and their constituents fulfil different services for various users simultaneously, as the example of the polar bear (*Ursus maritimus*) has demonstrated. Hence, only accepting monetary units creates the following problem: the animal is very important to indigenous peoples, but also to the tourism sector. However, the latter has a higher economic value than the First Nations. Does this lead to the conclusion that changes, affecting the tourism sector, are more important than shifts challenging indigenous peoples of the Arctic?
When working with the developed theoretical approach, this simple conclusion cannot be drawn. Being closely connected represents strong power relations. Therefore, even slight shifts force bonded actors to fulfil adaptational processes, while weak connections can compensate such changes easily. In addition, the unit "money" represents an ANT-actor itself that shifts flows between connected actors. By regarding money as an actor, the monetary value of ecosystem services is being translated into a connection and is therefore equivalent to any other type of link within the network.

After translating values into connections, the conventional ecosystem services approach is further adapted through the addition of supporting social system services and supporting mental system services. Hereby, it becomes possible to credit the impact potential of the social and mental sphere on Arctic networks. Hence, this adaptation results in the definition of the Actor-Network services approach that is illustrated in Figure 11.

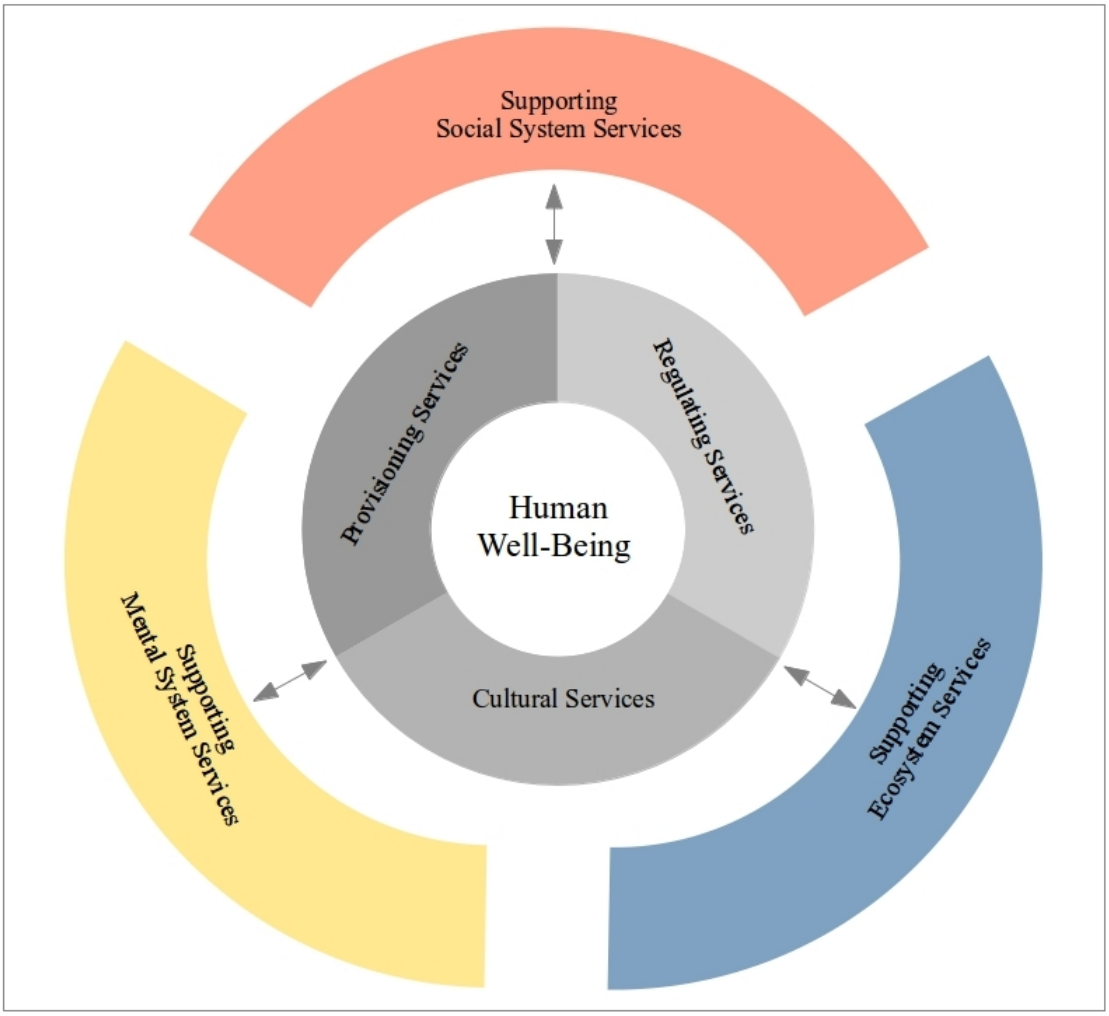


Figure 11: Actor-network services approach

Coupling the social and mental sphere with the conventional ecosystem services approach under the framework of ANT. Supporting services are now provided by the social sphere, the mental sphere and the natural sphere. Hence, all three spheres shape human well-being together.

2.3 Summary

The aim to analyse connections between processes of climate change and processes of political geography and geopolitics in the Arctic leads to the need for a novel theoretical and methodological approach that combines three complex spheres: the natural, the social and the mental sphere. Hence, two theoretical approaches, one from human ecology, one sociological approach are merged and the methodological concept of ecosystem-services is enlarged in order to suit the research objectives of this thesis.

Inspired by the human ecological metabolism research, nature and society are interpreted as two overlapping spheres. Consequently, they exchange flows of entities, constantly. With this postulation, the research focus of the studies in this thesis shifts towards connections between natural, social and mental elements. By using ANT to explore the entities of the overlapping zone between these elements, the following characteristics are found. Firstly, elements of the overlapping zone mediate flows between nature, society and the mental sphere. Secondly, these elements consist of natural, social and mental parameters and thirdly, they interweave local, regional and global processes.

Particularly, knowledge, thoughts, opinions and feelings contribute to these three characteristics. Hence, the mental sphere enlarges the complexity of the characterised elements of the overlapping zone. Consequently, Arctic-resources are identified as actors between natural, social and mental characteristics (see Figure 10).

The exploration of the natural components of Arctic resources, leads towards the ecosystem services approach. Complemented with suitable adaptations the social and mental characteristics of resources, a novel Actor-network services approach is defined to investigate Arctic resources and their mediative roles within networks.

To conclude, the developed approach has three steps that are represented by the research objectives of this thesis: *1. Develop a theoretical approach that covers natural and social / political developments*, 2. *Identify actors and develop a methodological approach to analyse interdependencies between them and 3. Test the developed theoretical approach and the methodological concept.*

Three Arctic resources have already been chosen in this chapter: shipping routes, traditional knowledge and agricultural production. Their actor-networks are explored in Chapter 4 through applying the developed theory and methodological concept. Hereby, a detailed understanding of Arctic networks is provided which represents transdisciplinary research between physical geography and human geography. However, Chapter 3 outlines the used methods beforehand.

3 Methods to analyse the actor-networks of Arctic resources

Several methods are used in this thesis to analyse the actor-networks of Arctic resources by applying the Actor-Network services approach. These methods are:

1. Qualitative literature review
   To gain a first insight into the actor-networks of Arctic resources, a qualitative approach is chosen. Hereby, important thematic literature, for example reports, such as the Arctic Marine Shipping Assessment 2009 Report (Arctic Council, 2009), are scanned to identify actors. This method has several advantages: a) It allows to start the identification of actors without a-priori postulations about network-members (Reuber and Gebhardt, 2011), which is in alliance with ANT and b) the retracing of identified actors is determined by the actors themselves and not by the conducting researcher, since a priori postulations are missing. Yet, this method hardly discovers power-relations within the actor-networks of Arctic resources, why the following complementing methods are selected.
2. Systematic quantitative literature review
   To put results from the qualitative literature review into perspective, a quantitative literature review is undertaken. Hereby, the used keywords are kept as broad as possible to be able to identify as many actors of the resource's network as possible. If a quantitative literature review is done, the used set of keywords is named within the text of this thesis. To identify power-relations, suitable literature is selected by a consideration of title and abstract. It is then counted due to the literatures' topics (see Pickering and Byrne (2014) for detailed information about systematic quantitative literature review). Please note that only the mentioned steps of this method have been applied in this thesis since it serves mainly supplementing purposes and has therefore been combined with other methods. However, to still guarantee an ANT-conform identification of involved actors, a prior qualitative method has to be applied in order to identify suitable keywords.
3. Semi-structured interviews
   Besides quantitative literature reviews, also semi-structured interviews are conducted to identify power-relations within actor-networks of the chosen resources. Analogue to the quantitative literature review, semi-structured interviews use broad questions which allow the interviewed person to express their own ideas, feelings, opinions and experiences

(Pfaffenbach, 2011). Hence, the researcher is again able to follow the actors within a resource's network in a way that suits ANT.

4. Informal talks with experts (only as supportive method to gain initiatives)

   In order to gather more qualitative data which resemble power-relations within the actor-networks of Arctic resources, various informal talks with (research) experts have been undertaken during international conferences and workshops in Germany, Norway and Belgium. These were supplemented by face-to-face talks during research stays abroad in Norway, Canada and Australia between 2012 and 2014. Particularly the informal style of these talks which is partly analogue to the style of semi-structured interviews, suits ANT, since it creates possibilities to follow Arctic actors. However, the outcomes of such talks were solely used as initiatives for the previously named methods.

5. Illustrations with Geographical Information Systems (GIS)

   GIS-data is used to illustrate and moreover combine findings from the previous methods. Although a graphical analysis of data suits ANT, since it uncovers previously hidden actors, this method only fulfilled supplementing tasks in this thesis. Particularly a lack of freely available GIS-data is responsible for the minor significance of this method.

When applying the developed theoretical approach and the methodological concept of Actor-network services, a combination of several of the described methods is used to gain a broad and at the same time deep insight into the actor-networks of Arctic resources. Hereby, the uniqueness of each resource is particularly respected.

4 Testing the developed theoretical approach and the concept of Actor-Network services

In the following, the actor-networks of Arctic resources are analysed and power-relations within them are investigated. Although a combination of different methods is meant to identify as many actors as possible, there is no feasible option nor a method nor the needed time to follow a complete actor-network (see Chapter 2). Therefore, the illustrated networks enable a deep understanding of Arctic networks, but they do not claim to be complete.

4.1 Case study 1: Shipping routes in the Arctic – an Arctic resource with global impact potential

Abstract Case study 1

Objective 3:
Test the developed theoretical approach and the methodological concept

To suit Objective 3, "Arctic shipping routes" is selected as the first Arctic resource to test the developed methodological concept. Hereby, Arctic shipping is understood as an ANT-action that is enabled through the mediative cooperation of different actors. These actors belong to the natural, social and mental sphere. (Powerful) Actors as well as the connections and interdependencies between them are identified by qualitative literature review, scientific talks, conference presentations and illustrated with freely available GIS-data – amongst them: the legal situation, knowledge about shipping and natural premisses.
Most important outcomes:

1. *The concept of Actor-network services creates new possibilities to understand Arctic shipping, particularly through involving natural, social and mental actors.*
2. *The importance of mental actors within the network is essential, but needs further scientific investigations.*

The recent development of shipping routes in the Arctic is of global meaning. Shipping merges prospering economic options, but causes also natural threats. Hence, (scientific) knowledge about

Arctic shipping is crucial, in terms of its future usability and particularly its security. Therefore, shipping routes comprise natural, social and mental components. According to the previous findings, these components enable the action “Shipping in the Arctic” together. Consequently, the actors of the network around Arctic shipping routes function as a case study to test the concept of Actor-Network services.

This test involves five concrete steps:

1. Identifying connected actors of Arctic shipping routes and exploring initial network connections
2. Investigating the remaining interdependencies within the network
3. Applying the concept of Actor-Network services
4. Connecting possible future scenarios with current power-relations
5. Outlining the suitability of the developed methodological concept

The actor-network of Arctic shipping lanes is investigated within the next sections. Hereby, connected actors and evolving interdependencies are identified on local, regional and global scales. Consequently, entities that have to be involved in transdisciplinary geographical research about shipping in the High North are outlined.

Four ANT-suitable methods are applied to investigate the actor-network of Arctic shipping lanes:

1. Initiatives are gained from first qualitative sightings of the Arctic Marine Shipping Assessment 2009 Report (AMSA 2009 Report), published by the Arctic Council in 2009 (Arctic Council, 2009), and the Status on Implementation of the AMSA 2011 Report, released in 2011 by the Arctic Council (Arctic Council and Protection of the Arctic Marine Environment (PAME), 2011). Hereby, mainly three topics function as initiatives: marine safety in the High North, environmental conservation and protection of indigenous peoples as well as the marine infrastructure in the Arctic Ocean (Brigham, 2013).
2. Based on these sightings, a second qualitative literature review is conducted.
3. Scientific talks, presentations and discussions, given during national and international conferences in Germany and Norway during 2012-2014 and a research stay in Norway emerge new initiatives, supporting / refuting previously gained impressions from the literature review.
4. Freely available (GIS) data is used to illustrate connected actors with the help of special subject maps, generated with ArcMap (ESRI). This method mainly fulfils supporting tasks.

Consequently, (powerful) actors of the actor-network of Arctic shipping routes are identified. Hereby, the development of shipping lanes in the High North and the current (2015) advantages and disadvantages of their usage are outlined. Connected actors are inserted upon their first appearance in brackets, in capital letters and in italic type within the text. In addition, initial connections that evolve within the actor-network of Arctic shipping routes are characterised. Whenever a connection is mentioned within the text, the contributing actors are named in brackets and in italic type. The actor which dominate the process of maintaining the connection is typed in bolt style. As an example, the actor "Climate" overpowers the actor "Natural Premisses" within the actor-network of the Arctic shipping routes. The current climate change affects various natural parameters, such as the water temperature, the sea ice conditions and others. If both actors are contributing to the connection equally, both are highlighted in bolt style. All identified actors and determined connections of Chapter 4.1 are illustrated in Figure 13.

4.1.1 Identifying connected actors of Arctic shipping routes and exploring initial network connections

European explorers investigated Arctic waters and their suitability for shipping, already since 325 B.C.. By sailing northwards, Iceland was reached and colonized by the Vikings from Scandinavia in 850 A.D. who then continued to colonize Greenland. Simultaneously, explorations of the northern coastline of America were undertaken (see Table 4 for a comparison of Arctic shipping routes). The initial search for the Northwest Passage (NWP) began in the 1490s, under the aim of establishing lucrative trading routes with Asian countries, particularly with India and China (actor: *ECONOMIES*). Roald Amundsen successfully completed the passage with his vessel *Goja* from 1903 to 1906. However, not before the summer of 2007, the NWP was ice free for the first time (actor: *NATURAL PREMISSES*). Hence, efforts to maintain and moreover improve shipping in polar waters are still continuing today (Arctic Council, 2009; Winkelmann, 2009b) (connection: *Economies* – ***Natural Premisses***).

Analogue strains were taken to find a shorter shipping route to – again – China and India via the Russian part of the Arctic (actor: *KNOWLEDGE*). After first attempts by Russian settlers and traders in the 11th century, the first transit of a considerable part of the Northeast Passage (NEP) was achieved by Fridjof Nansen's *Fram* between 1893 and 1896. 12 years later, Amundsen completed the passage and became the first human being, who circumnavigated the Arctic Ocean. Since then, travel increased constantly. In 2012 46 vessels travelled through the Northern Sea Route (NSR), an essential part of the NEP that reaches from Kara Gate to the Bering Straight. In 2013 this number even increased to 71 vessels, but decreased again in 2014 to 22 vessels (Arctic Council, 2009; Northern Sea Route Information Office, 2015; Pettersen, 2012).

The Transpolar Passage (TPP) represents the shortest connection between the Atlantic Oceans and the Pacific. It stretches right across the North Pole which has been reached by the surface vessel *Arktika* in 1977 for the first time. However, the advantages of the TPP that is mainly the reduced travel distance, are solely of favour, when the ocean is ice free (Arctic Council, 2009; Østreng et al., 2013). Thus, the passage cannot be successfully used today. As a consequence, the is neglected TPP in the following.

Table 4: Comparison of Arctic shipping routes

(Data taken from Arctic Council, 2009; Arctic Council and Protection of the Arctic Marine Environment (PAME), 2015; Humpert and Raspotnik, 2012a; Stephenson et al., 2011)

	Northeast Passage, including the **Northern Sea Route**	Northwest Passage	Transpolar Passage
Course of the Route	Northwest Europe → North Cape → **Kara Gate** → **Bering Strai**t → Pacific	Atlantic → North America → Canadian Arctic Archipelago → North Alaska → Bering Strait → Pacific	Atlantic → East Greenland → North Pole → Bering Strait → Pacific
Length	5,169 km (Northern Sea Route)	9,324 km	6,960 km
Commercial Transits in 2013 / 2014	71 / 31 (Northern Sea Route)	1 / 1	0 (2012) no data for 2013 / 2014
Current Accessibility July – September Type A vessels (2000 - 2014)	86% (Northern Sea Route)	63%	64%

	Northeast Passage, including the **Northern Sea Route**	Northwest Passage	Transpolar Passage
Projected Accessibility July – September Type A vessels (2045 - 2059)	100% (Northern Sea Route)	82%	100%

Recent Arctic shipping mainly fulfils five purposes: commercial shipping, tourism and recreation, scientific research, shipping for off-shore exploration and ice-breaking and re-supply shipping (Jensen, 2010). Particularly the latter is of regional importance, for example in Canada. Besides, commercial Arctic shipping attracted the media's interest on a global level (actor: *MEDIA*) (Østreng, 2012). As an example, the Barents Observer reported in September 2009 that German vessels were the first ships of the year to transport commercial cargo through the NEP (Nilsen, 2009) (connection: *Media* – ***Knowledge***). Commercial shipping is the main German economic interest in the Arctic, particularly since Germany obtains a world leading container fleet (Pelaudeix and Rodon, 2014). In addition, shipping is essential to maintain other economic activities, including resource exploitation, such as fisheries.

After a lack of knowledge and technological constraints (actor: *EQUIPMENT*) have limited Arctic shipping since its beginning, climate change (actor: *CLIMATE*) recently offers vast benefits for marine development in the High North. The commercial potential of Arctic shipping lanes, paired with undissolved territorial questions (actor: *LEGAL SITUATION*) (Girg, 2008; Winkelmann, 2009a, 2007), exemplifies the current importance of shipping routes as an actor within Arctic networks.

In the course of evolving connections between the social / political, the mental and the natural sphere, advantages of the two (three) Arctic shipping routes, illustrated in Figure 11 are emphasized widely. Projections show that transit along the NSR increases with a factor of approximately 20% per year (Miller and Ruiz, 2014) (connection: *Economies* – ***Climate***). Primarily the media supports a spreading of economic benefits amongst the public, as an article of the Tagesschau from September 2014 demonstrates. Herein, the NWP is characterised as a potentially cheap alternative to the Panama Canal and the Suez Canal. It is further stated that Arctic routes result in a saving of

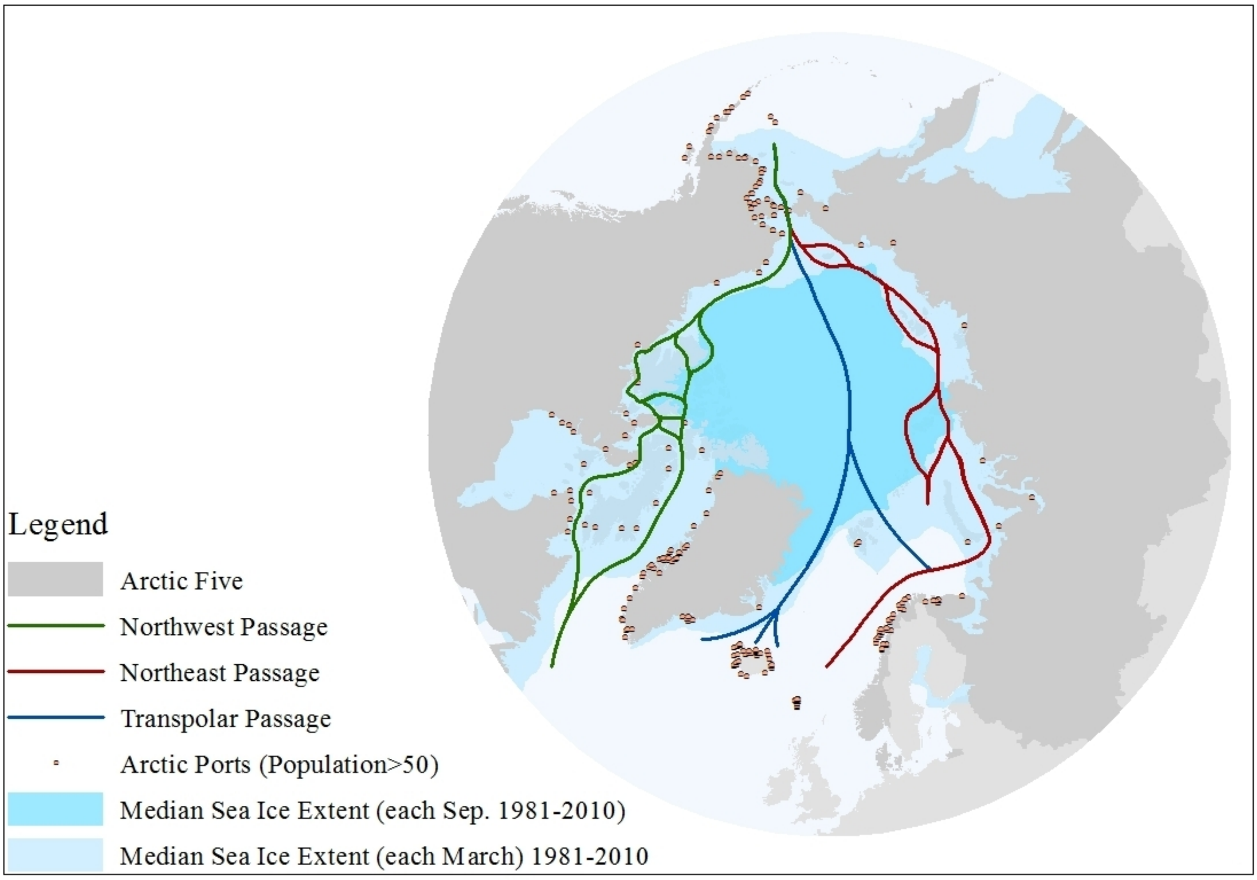


Figure 12: Arctic shipping routes

Theoretical course of the NWP, NEP and TPP, their dependence on existing sea ice and Arctic ports along the routes.

Please refer to footnote 2 (page 4) for an explanation why no scale is given within the figure.

References:

Background World Map: taken from ArcMap 10

Northwest Passage, Northeast Passage: Arctic Marine Shipping Assessment 2009 Report, Arctic Council, April 2009

Transpolar Passage: inserted manually, based on: Humpert and Raspotnik, 2012b

Arctic Ports: Arctic Marine Shipping Assessment 2009 Report, Arctic Council, April 2009

Median Sea Ice Extent (September):Fetterer, F., K. Knowles, W. Meier, and M. Savoie. 2002, updated daily. Sea Ice Index. [median_N_09_1981_2010_polyline.zip]. Boulder, Colorado USA: National Snow and Ice Data Center. http://dx.doi.org/10.7265/N5QJ7F7W.

Median Sea Ice Extent (March): Fetterer, F., K. Knowles, W. Meier, and M. Savoie. 2002, updated daily. Sea Ice Index. [median_N_03_1981_2010_polyline.zip]. Boulder, Colorado USA: National Snow and Ice Data Center. http://dx.doi.org/10.7265/N5QJ7F7W.

7,000 km, compared to the voyage from Europe to Asia via the Suez Canal (Staeger, 2014; Tagesschau, 2014). Lassere (2014) also calculates a route from Rotterdam to Yokohama that sums up to a length of 13,400 km via the NSR and 21200 via the Suez Canal (Lasserre, 2014a). In addition, the economic centre of Europe is moving to the northeast, particularly due to the constant development of Eastern-European countries. Simultaneously, the economic centre of Asia is moving northwards, due to the (economic) growth of China. Hence, the benefits gained from the shorter travel distance via Arctic routes, in comparison to traditional lanes, will even increase (Verny and Grigentin, 2009).

Other advantages apply, when travelling through the Arctic. Firstly, Arctic routes reduce the existing travel costs (Ebinger and Zambetakis, 2009) through a maximum of a 40% shortening of existing passages from Europe to north-east Asia. Secondly, a higher energy efficiency can be achieved. Super-slow sailing further decreases the caused pollution during the travel (Humpert and Raspotnik, 2012b) (actor: *NATURAL THREATS*). Schøyen and Bråthen (2011) compare two emission-scenarios, when shipping mineral fertilizer from Southern Norway to Southern China. With the same amount of draft laden and identical carrying capacities, the bulk carrier that travels via the Suez Canal emits 2,928 mt CO_2. In comparison, the bulk carrier which takes the NSR emits only 1,495 mt CO_2, leading to a saving of 1,433 mt CO_2. Hence, approximately half of the emissions are saved in this example. Hereby, the speed via the Suez Canal is 14.4 knots and via the NSR is 11.5 knots (Schøyen and Bråthen, 2011) (connection: *Natural Threats* – ***Climate***).
However, if a company chooses not to sail with slow speed, its ships can accomplish to make the voyage several times within the shippable season, since the days at sea are significantly reduced. As an example, if a ship travels again with a speed of 15 knots, the route via the Suez Canal takes 32 days, while the NSR solely takes 18 days (Schøyen and Bråthen, 2011). Moreover, the vessels will not have to sail in politically unstable areas, affected by piracy (Borgerson, 2008), such as the sea around Somalia. The Somali maritime piracy alone is responsible for a yearly loss of US$18 billion to the world economy. Although only 149 ships had to be ransomed, since the very first known Somali hijack in 2005, numerous have been attacked (International Bank for Reconstruction and Development / The World Bank, 2013). Consequently, travelling through Arctic routes is – in this perceptive – safer and therefore more cost-efficient.

However, there are indeed (security-related) uncertainties, when travelling in polar waters. Such risks are mainly based on natural premisses and the climate of the polar regions. Their aftermaths result in numerous developments that decrease the economic potential of Arctic shipping lanes: Firstly, security-related uncertainties lead to high insurance fees which reduce the economic profit of northern shipping lanes (Verny and Grigentin, 2009). Lasserre (2014) calculates insurance costs of US$1,200,000 / US$800,000 for a 6 month period of travelling from Rotterdam to Yokohama via the NSR / Suez Canal. Consequently, the insurance costs estimate 6.61% of the total travel costs via the NSR and 5.34% of the total travel costs via the Suez Canal. However, the models the author is using, show a great variety, reaching from US$100,000 per trip to US$3,344 per day (Lasserre, 2014b).

Secondly, there is a lack of modern deepwater ports, coupled with areas of shallow water along Arctic shipping routes. This constellation causes a limitation of the size of shippable vessels and moreover higher construction costs (connection: ***Economies*** – *Equipment*). The latter is also based on the fact that ships which operate in polar waters have to suit higher (facility) standards (connection: *Equipment* – ***Climate***). Consequently, technological improvements are needed to increase the economic efficiency of Arctic shipping routes (Buixadé Farré et al., 2014) (connection: *Equipment* – ***Knowledge***).

Thirdly, such requirements are also bonded to an improvement of on-land infrastructure, as the lack of ports, Search and Rescue (SAR) centres and settlements in the Arctic demonstrate (actor: *INFRASTRUCTURE*). Hence, in order to secure travels in Arctic waters, considerable actions have to be taken. Amongst them is an improved mapping and monitoring of the area, particularly in terms of timeliness (connection: ***Natural Premisses*** – *Equipment*). In general, the coastal states' navigational possibilities have to be enhanced (Det Norske Veritas, 2010). Moreover, within the named request lies the need to develop an extensive SAR-infrastructure in the Arctic (connection: *Infrastructure* – ***Knowledge***). Such an improved infrastructure increases not only economic benefits of Arctic shipping routes, but moreover contributes to the overall safety, while being at sea (Steinicke and Albrecht, 2012) (actor: *EMOTIONAL FACTORS* and connection: ***Infrastructure*** – ***Emotional Factors***)

Security of Arctic shipping is strongly related to natural circumstances, such as sea ice. Yet, to reliably monitor such natural characteristics, the scientific knowledge about them has to be enlarged also (actor: *SCIENCE*). In this case, scientific knowledge includes knowledge about the sea ice development itself (connection: *Science* – ***Natural Premisses***), methods and technologiey to reliable record, map and picture it (connection: ***Science*** – *Equipment*). As one possible result, suitable SAR-locations can be calculated and installed (connection: ***Science*** – *Emotional Factors*). Hence, the sought-after economic profits are particularly linked to entities of the mental sphere.

To conclude, the previous sections outline connections between the natural sphere and the Arctic social sphere, as well as linkages between the Arctic social sphere and the mental sphere. In the following, it is demonstrated how the Arctic natural sphere is affected by the improvement of Arctic shipping lanes. Hence, with this next step, all four spheres of Arctic actor-networks get involved equally into the investigations of this thesis.

Particularly the highly specialised and fragile Arctic ecosystems are affected by rising shipping activities. Especially the oil spill, in the aftermath of the accident of the vessel *Exxon Valdez* in 1989 at the Prince William Sound, and the resulting environmental issues (Peterson et al., 2003) underline this statement (connection: ***Equipment*** – ***Natural Threats***). This accident caused an oil spill of approximately 42 million litres of oil that affected a minimum of 1990 km of shoreline. Hereby, the overall inaccessibility of the region hindered the clean up significantly (McNutt, 2014) (connection: ***Natural Premisses*** – *Natural Threats*). In the aftermath of this oil spill, around 250,000 birds, as well as thousands of whales, seals and other marine mammals were killed. In addition, billion of fish eggs got destroyed (Bodkin et al., 2012; Malakoff, 2014). The long-term effects of this accident and the oil that remained within the ecosystem are still scientifically analysed today (2015).
Besides the rising risk of accidents, other environmental challenges are connected to higher shipping activities in the Arctic. A growing amount of vessels, including cruise ships and research vessels, generates an exceeding and moreover a simplification of immigration paths of invasive marine and terrestrial species into the High North (Arctic Council, 2009; CAFF, 2013). One alien species that spread along Arctic waters is the red king crab (*Paralithodes camschaticus*). This animal got introduced into the Barents Sea during the 1960s and 1970s by Russian Scientists. The overall goal was to establish a novel fishery sector in Russia and Norway. Since then, the crab spread from 36° E to 26°E within the Barents Sea. Norwegian catches were worth over 150 million NOK in 2011. Yet, there are great differences in the yearly values of these catches, due to changing market prices. In contrast, the total catch of the red king crab in Alaskan waters has been fluctuating

between 3000 – 10000 tonnes during recent years (Sundet, 2014).

Yet, the crab entangles in gill nets and removes baits from long lines. Hence, it causes problems for the local Norwegian fisheries. Besides, the crab harms the existing ecosystem, due to its diet. Consequently, a management plan was established that should limit the spreading of the crab into additional areas (Sundet, 2014).

The snow crab (*Chionoecetes opilio)* represents another species that has significant values for commercial fisheries. The average catch within their natural habitat accounts 25,000 tonnes between the years 2008 and 2010. The natural habitat of the snow crab includes the Bering Sea, the coastlines of eastern Canada and western Greenland. However, the snow crab got introduced into the Barents Sea unintentionally – in contrast to the red king crab (connection: *Natural Threats* – ***Knowledge***). In 1996, five individuals were caught by Russian vessels for the first time in Arctic waters. Since then, the crab has spread along the coastlines of Russia and Norway, opening up commercial benefits for the fisheries of these countries. Both species resemble significant economic potentials, particularly since they are no competitors. Consequently, a management plan for these novel crab fishery regions is needed, to secure and moreover enlarge the economic value of these animals. Yet, the fast spreading of the crabs, paired with a missing management also demonstrates their impact on existing ecosystems (Agnalt et al., 2011; Pettersen, 2014; Somerton et al., 2013; Sundet, 2014) (connection: ***Legal Situation*** – *Natural Threats*).

The examples of the king crab and the snow crab illustrate, how deliberate or unintended natural changes affect the economic meaning of a certain geographical area. Simultaneously, these developments underline the deep impact of global alterations on the Arctic's natural sphere. Hence, these examples demonstrate the involvement of entities from the four spheres: global natural sphere (climate change), Arctic natural sphere (alien species), Arctic social sphere (local fisheries) and global social sphere (global market value).

Yet, with the involvement of these four spheres, comes also the need to modify the meaning of Arctic shipping routes. So far, they have been credited a high local importance and a significant potential to gain also global influence. However, when compared to one of the major global shipping routes, the Suez Canal, the capability of Arctic routes is easily overstated. In 2013, 16,596 vessels travelled through the Suez Canal (Suez Canal Authority, 2014), while there were only 71 voyages registered along the NSR. Out of the latter, merely 19 were trans-Arctic voyages which completed the entire passage from the Atlantic to the Pacific Oceans (Buixadé Farré et al., 2014). Hence, the NSR, which is the most prospering Arctic shipping lane, can – if at all – be regarded as a complement to the Suez Canal on a seasonal basis (Reuters, 2013).

Table 5 summarizes the characteristics of the main Arctic passages and the Suez Canal. Advantages / Disadvantages in comparison to the respectively other route are marked with "+" / "-". Significant divergences are marked with "++" or "--". The numbers of usage in 2013 refer to the NSR which is the most accessible part of Arctic shipping lanes.

Table 5: Comparison of Arctic passages and the Suez-Canal

(Data from (Buixadé Farré et al., 2014; Humpert and Raspotnik, 2012b; Suez Canal Authority, 2014)

Parameter	Arctic passages	Suez-Canal
Usage in 2013	71 vessels along the NSR	16,596 vessels
Length	++	--
Current usability	– (30 ice-free days in 2010)	++
Projected usability	- (120 ice-free days by the middle of the century)	+
Fuel consumption	+	-
CO_2-emission	+	-
Insurance	-	+
Legal situation	-	+
Piracy	+	-
Overall security for life at sea and the environment	--	++

To conclude, eleven[3] actors of the actor-network of Arctic shipping routes have been identified in Chapter 4.1 and are illustrated in Figure 13. The chosen colours demonstrate their belonging to the social (red), natural (blue) or mental (yellow) sphere. Important hybrid-structures are marked with the merging of two colours. Besides, Figure 13 illustrates all perceived interdependencies of

3 Please note that in the case studies of this thesis, the number eleven represents an arbitrary choice of representative actors of the selected actor-networks.

Chapter 4.1 with thin black lines. Yet, Figure 13 does not claim to be exhaustive nor complete (see Chapter 2 for detailed explanations). As has been argued in Chapter 2, powerful actors possess more or tighter connections than other actors, while simultaneously overpowering other actors. Consequently, Figure 13 allows the determination of powerful actors of the network of "Arctic shipping routes" firstly, by identifying the connections an actor is contributing to and secondly, by

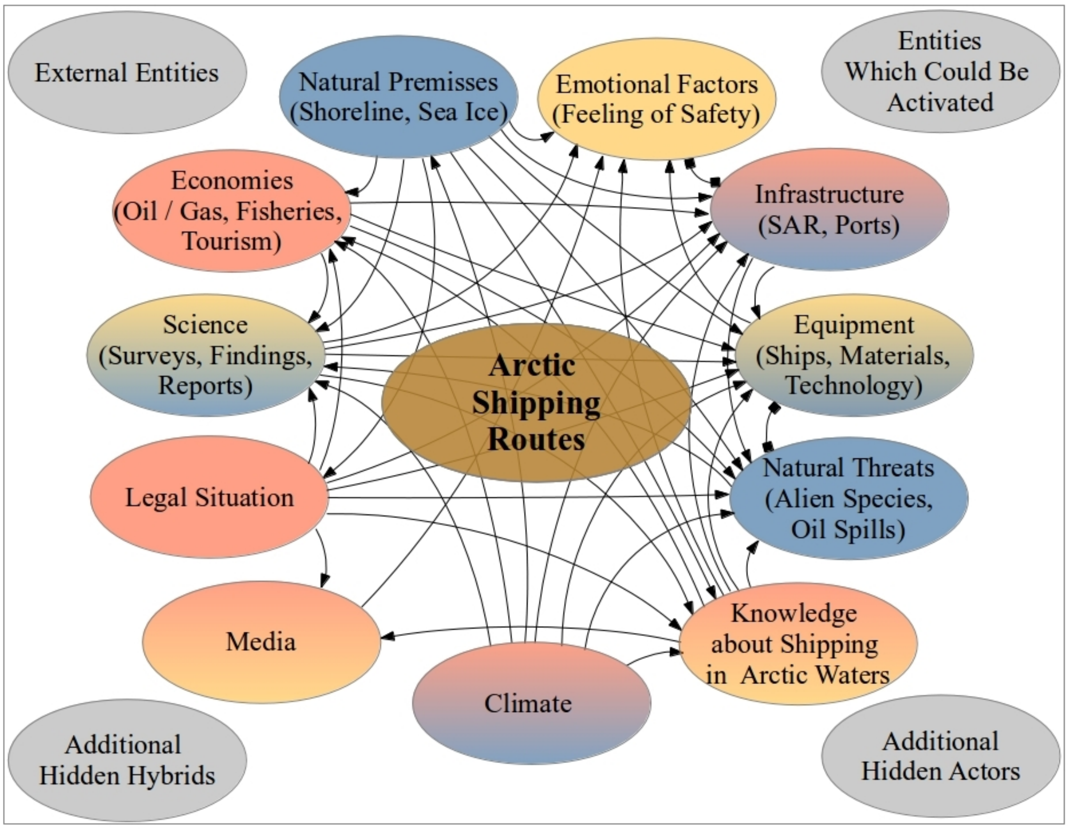


Figure 13: Identified actors and connections of the actor-network of Arctic shipping routes

The identified actors are marked in colours, representing the main sphere of their origin (blue = natural sphere, red = social sphere, yellow = mental sphere). Connections between the actors are shown by thin black lines. The arrow indicates the direction of the connection, leading from the most powerful actor to the actor, it is overpowering. If both actors contribute equally to a connection, the interdependency between them is marked with two squares. However, all connections have to be regarded as interdependencies. Therefore, Figure 13 highlights powerful actors in two ways: Firstly, the simple number of connection, an actor is contributing to and secondly, the number of connections an actor is dominating.

The additional light grey items indicate actors which have not been identified in this chapter or entities which have not been activated and connected to the actor-network by the identified actors, yet. Hence, Figure 13 does not illustrate the complete actor-network of Arctic shipping routes (see Chapter 2).

identifying the connections, that lead from a certain actor to other actors within the network.

According to the first criterion, powerful actors contribute to more connection than over-powered actors. Hence, the following ranking occurs: “Knowledge” (highest number of connections), “Equipment” / “Science” / “Infrastructure” / “Natural Premisses”, “Economies” / “Legal Situation” / “Natural Threats”, “Climate”, “Emotional Factors” and “Media” (lowest number of connection). According to the second criterion, connections lead from powerful actors to over-powered actors. Thus the following ranking results: “Climate” (with all connections leading from this actor to other actors), “Natural Premisses”, “Legal Situation” and “Knowledge” (with a majority of connections leading from these actors to other actors), “Economies” (with half of the connection leading from or to this actor), “Science” “Media”, “Infrastructure”, “Natural Threats”, “Equipment” and “Emotional Factors” (with a majority of connections leading to these actors from other actors).

By combining both used criteria, the identified power-relations of the network of Arctic shipping routes are illustrated in the following ranking, starting with the most powerful actor: Natural premisses, knowledge / climate, legal situation, science / economies, infrastructure, equipment / natural threats, media and emotional factors. This final ranking outlines the importance of processes of climate change and geopolitics for the development of Arctic shipping lanes, while also highlighting mental resources. Hence, this result strengthens the postulated requirement of a transdisciplinary geographical research approach.

4.1.2 Investigating the remaining interdependencies within the network

Besides the previously named connections, there are various other interdependencies, illustrated in Figure 13. In the following, the actors “Legal Situation”, “Infrastructure” and “Economies” are functioning as initiatives for the genesis of the remaining connections. By outlining their interdependencies, the illustrated actor-network of Arctic shipping routes is further explored.

In 2007, the Russian Federation positioned a titanium flag in the sea floor, above the location of the North Pole. Herein, Russia initiated and moreover provoked global discussions about the sovereignty of the Arctic Ocean (Dodds, 2010). By being aired on world-wide television (connection: *Media* – ***Legal Situation*** and connection: ***Media*** – *Emotional Factors*), this act forced other coastal states to react on Russia’s initiative (Ó Tuathail, 1996). At first, the global consensus existed that the Arctic Ocean had to be treated as a terra nullius which does not belong to anyone. However, the so-called Ilulissat Declaration established the attitude of the five coastal states in 2008 – in contrast to the idea of a terra nullius. With defining the states' sovereignty over the Arctic Ocean, the Ilulissat Declaration determined the beginning of a new territorialisation of the High North (K. Dodds, 2013). As an aftermath, the Arctic Five submitted competing land claims which opened up political potential for cooperation, but also possibilities for territorial conflicts in the High North (Carlson et al., 2013). The submitted claims underline particularly the exclusive role of the Arctic Ocean (Kao et al., 2012).

The positioning of the flag and the following geopolitical and medial discussions and actions demonstrate the involvement of different spatial scales. Hereby, a local action that is based on the navigability of the Arctic Ocean, evolves global responses. Moreover, the "flag-action" is still present in current discussions, what demonstrates the merging of different temporal scales within the actor-network of shipping routes.

As has been demonstrated before, Arctic shipping lanes involve a strong geopolitical component. However, solely the TPP runs through vast areas without clarified territorial belongings, as Figure 14 illustrates, as at July 2013. Therefore, the recent claims have no direct impact on the actual course of the routes, because the NWP and the NEP are located in areas within the Territorial Seas or the Exclusive Economic Zones (connection: ***Legal Situation*** – *Economies*). Yet, the claims can indeed affect their current right of usage. Therefore, the following further merges Arctic spheres with global dimensions on a political level, by describing connections between Arctic shipping lanes and the legal situation.

While, for example, the EU, the United States of America and China argue that the NWP and NEP have to be treated as international straits, Russia and Canada hold against this position. In their point of view, both passages travel through internal waters (Blunden, 2012). The NWP, for example, crosses the Canadian Arctic Archipelago which Canada regards as a part of their internal water. However, if the NWP actually runs through internal waters, Canada is credited full sovereignty over the passage. Such rights include the power to deny access to domestic and foreign ships. In contrast, Canada would have significantly less power over the actual usage of the shipping lane, if this status is deprived (Huebert, 2008) (connection: ***Natural Premisses*** – *Legal Situation*).

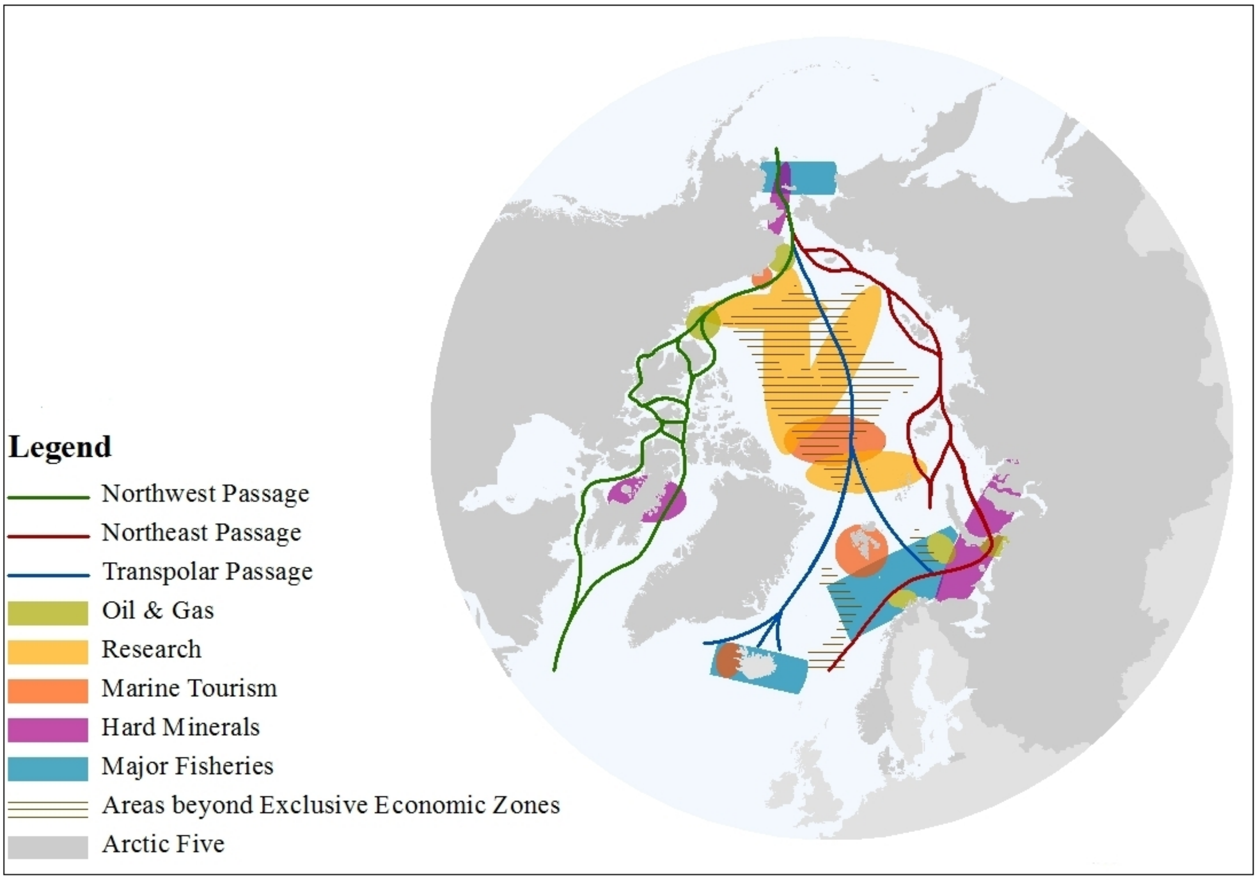


Figure 14: Coupling of Arctic transit shipping routes, unresolved territorial belongings (based on UNCLOS) and selected usage conflicts in the Arctic Ocean (as at July 2013)

Please refer to footnote 2 (page 4) for an explanation why no scale is given within the figure.

References:

Background Wolrd Map: taken from ArcMap 10

Northwest Passage, Northeast Passage: Arctic Marine Shipping Assessment 2009 Report, Arctic Council, April 2009

Transpolar Passage: inserted manually, based on: Humpert and Raspotnik, 2012a

Oil & Gas, Research, Marine Tourism, Hard Minerals, Major Fisheries: inserted manually, based on: CAFF 2010 Arctic Biodiversity Trends: Selected indicators of change http://www.abds.is/explore-stressors/dms-shipping/view_document/22-current-marine-shipping-uses-in-the-arctic

Areas beyond Exclusive Economic Zones: inserted manually, based on: IBRU: The Centre for Borders Research at Durham University

The decision over the passages' usage is discussed widely. According to Canada, its right to treat the NWP as part of its internal waters, is not affected by current or future melting of the sea ice shelf in the region. However, the United Kingdom, acting as a representative of the European Community, protested against this view diplomatically in 1985. Hereby, a definition of internal waters that is based on the usage of straight base lines was promoted. Additionally, the United States of America inherit an active part in arguing against Canada's understanding of internal waters (Huebert, 2008).

An example of Canada's understanding of internal waters, was given in 2010. Herein, Canada exercised their rights to control the NWP, by hindering the German research vessel *Polarstern* from entering the triangular area between the Baffin Bay, Ellesmer Island and Greenland for scientific purposes (connection: ***Legal Situation*** – *Science* and connection: ***Legal Situation*** – ***Knowledge***). This hindering was particularly initiated by a group who acts in place of the Inuits of the region. Their concerns address mainly two points. Firstly, there was no adequate consultation of the local indigenous peoples and secondly, the research activities might affect the migration routes of marine mammals in the Lancaster Sound, a traditional hunting ground (Hoag, 2010) (connection: *Science* – ***Natural Threats***).

This example clearly outlines the political influence of indigenous peoples in Canada (see also Chapter 4). Besides, one of the major German interests in the Arctic is also represented: research (connection: ***Science*** – ***Knowledge***). Germany has been running expeditions to the High North since 1868 (Pelaudeix and Rodon, 2014). Today, two permanent stations are maintained by the Alfred-Wegener-Institute (AWI) for Polar and Marine Research in the Arctic, one on Svalbard, Norway, and one in Siberia, Russia (Alfred-Wegener-Institut, 2014) (connection: ***Science*** – *Infrastructure*). Aircraft and research vessels, including the *Polarstern*, complement the infrastructure of the institute. Hereby, German research activities in the Arctic address both, investigations of climate change (connection: *Science* – ***Climate***) and the search for conventional resources, such as oil and gas (Pelaudeix and Rodon, 2014) (connection: *Science* – ***Economies***).

The oil and gas industry with their off-shore exploitation represent an intuitive example to link various network-members that are connected with shipping in the Arctic (see also Figure 13). The exploring, exploitation, transportation and distribution of mineral resources in the Arctic requires shipping activities. Moreover, the oil and gas industry needs platforms to exploit the existing deposits. Consequently, Ships have to circumnavigate these platforms, since they are forced to guarantee a secure distance (connection: ***Economies*** – *Infrastructure*). However, the constantly changing sea ice conditions determine effective circumnavigations (connection: ***Natural Premisses***

– *Knowledge*). Hence, the installation of a functional and reliable navigation system is required, to guarantee safe shipping in Arctic waters.

In addition, growing economic activities also rise the risk of accidents. Simultaneously, ships disburden alien species to inhabit the High North. Furthermore, intensified shipping leads to a rising of local emissions and pollutions (connection: ***Economies*** – *Natural Threats*). Particularly the latter links back to previously outlined calculations of emissions, caused by shipping in the High North. Such calculations often neglect the fact that ships, travelling through Arctic waters, are often accompanied by ice-breakers. Hence, there is not one ship making the voyage, but two or even three. As an example, a Russian research vessel was accompanied by a nuclear ice-breaker in 2004 (Ashik, 2012). Moreover, ships might need ice-breakers to free them from sea ice in which they got stuck. Consequently, the evolved transit time, pollutions and emissions rise. However, due to climate change, the period in which vessels do not need the assistance of ice-breakers is estimated to extend between three to six months for the NSR by the end of this century (Franckx and Boone, 2012).

In terms of oil, gas and rare earths, the Arctic Ocean comprises vast natural mineral deposits (see Table 6). According to the United States Geological Survey, 13% of the world's undiscovered oil and more than two times as much of the world's undiscovered gas (30%) may be located north of the Arctic Circle, concentrated mainly in Russian areas (Gautier et al., 2009). This equalises to 44 billion barrels of natural gas liquids, plus 1,669 trillion cubic feet of natural gas and 90 million barrels of oil (USGS Cicrum-Arctic Resource Appraisal Assessment Team, 2008). In 2009, there were 61 discovered gas and oil fields within the Arctic region, with the majority being located in Russia (Budzik, 2009). Hence, Russia is strongly depending on its energy sector. Consequently, Arctic resources turn into an alternative supply to fulfil demands within Russia, Europe and Asia. Yet, ongoing political rivalry, evolved by politics and economics, weakens Russia’s position as a prospering global exporter of Arctic oil and gas (Filimonova, 2013), as the recent (2015) crisis in the Ukraine has demonstrated.

Table 6: Five most important provinces for oil and gas exploration and exploitation in the Arctic

In total, 25 provinces within the Arctic Circle were analysed. Hereby, the oil and gas resources of these provinces were estimated.

(Data taken from (USGS Cicrum-Arctic Resource Appraisal Assessment Team, 2008)

Ranking	Oil (Million barrels)	Gas (total) (Billion cubic feet)
1. Province	Arctic Alaska (29,960.94)	West Siberian Basin (651,498.56)
2. Province	Amerasian Basin (9,723.58)	East Barents Basin (317,557.97)
3. Province	East Greenland Rift Basins (8,902.13)	Arctic Alaska (221,397.60)
4. Province	East Barents Basin (7,406.49)	Yenisey-Khatanga Basin (99,964.26)
5. Province	West Greenland – East Canada (7,274.40)	East Greenland Rift Basins (86,180.06)
Sum	63,267.54	1,376,598.45
% of total estimated Arctic amount	70.31	82.50

The discovered resource fields are mainly positioned on-shore. However, 84% of the undiscovered deposits are said to be off-shore (Blaauw, 2013), analogue to the Shtokman field in the Barents Basin. This area is located 650 km northeast from Murmansk and possesses a distance of 540 km off-shore. The Shtokman field is supposed to be one of the largest off-shore gas fields world-wide (Moe, 2010).

So far, the high costs have often hindered commercial production. Nevertheless, the continuing demands for oil and gas increase the cost-effectiveness of resource exploitation in the Arctic. Even a higher storm frequency and intensified ice-movements that rise in the course of climate change, are not prohibiting the growing economic potential of Arctic mineral resources. In case of the Shtokman field, the start of the gas production is planned for 2016/2017 and exports shall be established to America and Europe, via the North Stream Pipeline (Harsem et al., 2011).

Germany depends heavily on Russian and Norwegian oil and gas and so does the European Union, why they steadily observe the development of Arctic resource fields. Besides the reliance on the Arctic's energy sector, Germany imports more than 20% of the consumed fish from countries of the High North. Yet, fisheries represent another economic sector that is enabled by Arctic shipping.

The gross domestic products of the majority of the five Arctic states rely on fishing. Greenland, for example, is the world's second largest exporter of shrimps (AHDR, 2004). After the fall of Greenland's cod industry in the 1960s, shrimps exceeded their economic value and became the major export product (Hamilton et al., 2003) (see also Table 9).
Fishing also represents the most important industry of the Faroe Islands. In Iceland, where merging cold and warm currents create rich fishing grounds, the primary sector is mainly based on fisheries, too, in similarity to Greenland. In Norway, Canada and Russia, coastal fisheries obtain at least significant economic potential (AHDR, 2004). In nowadays (2015), climate change causes an extended open water period in summer which can lead to an increasing biomass of fish stock (connection: ***Climate*** – *Natural Premisses*). Particularly the resulting rising of the primary and secondary production are therefore of significant commercial meaning (McBride et al., 2014). However, increasing fisheries also alter the local fish fauna in the Arctic, leading to unpredictable bycatch which further challenges the existing ecosystems (Christiansen et al., 2014).

Yet, there is another economic branch, for which safe and functional shipping lanes are crucial: Marine tourism. Marine tourism is a steadily growing business in the Arctic, particularly the cruise sector. Svalbard, for example, is a popular destination for luxury cruises (Gyimóthy and Mykletun, 2004). Besides, the number of ships, visiting the Canadian Arctic is constantly increasing since 1984, when the first cruise ship *Explorer*, completed the NWP. This number even doubled from 11 vessels in 2005 to 22 in 2006 (Buhasz, 2006; Stewart and Draper, 2008). Between 2006 and 2010, planned cruises continued to increase with a factor of 70% (Stewart et al., 2010).
These ships may travel through the Arctic archipelago and use therefore parts of the NWP. Hence, the (sea-ice) condition of the latter is crucial to commercial maritime tourism in Canada (Stewart et al., 2007) and so is the legal status of the passage, linking again the actors "Legal Situation" and "Economies".
So far, Canadian communities along the NWP which have turned into tourist destinations lately have taken opportunities to share the culture of Arctic natives with tourists and to introduce them to the surrounding Arctic environment (connection: *Economies* – ***Knowledge***). On the other side, tourists have shown support for sustainable actions within the tourism sector, due to the inimitability of the Arctic region (Chen, 2014). Consequently, sustainable developments exist within the sector of cruise tourism.

Still, concerns about the impacts of cruise tourism on marine mammals and the overall environment exist (Stewart et al., 2013). Consequently, cruise tourism has to be established in a way that respects the High North and particularly its fragility, its vulnerability and its inhabitants (Hall, 2001; Marsh and Staple, 1995). Tourism requires, for example, the logistics to deal with the waste products of cruise liners, while constantly supplying it with provisions. In fact, the litter, tourists leave behind, has the potential to cause serious damage in the Arctic (Johnson, 2002; Mason et al., 2000a) (connection: ***Infrastructure*** – *Natural Threats*). Furthermore, cruise tourism needs the installation of tourist destinations, berthing facilities and passenger terminals (connection: ***Infrastructure*** – *Equipment*). Yet, such infrastructural developments imply the destruction of natural habitats and natural heritage (Johnson, 2002).

Besides the missing infrastructure for cruise tourism, there is a general lack of on-land infrastructure along Arctic shipping lanes (connection: ***Natural Premisses*** – *Infrastructure*). In terms of the NSR, for example, only 16 ports are located along the route, including the port of Murmansk, the biggest Russian port in the Arctic (Buixadé Farré et al., 2014; Humpert and Raspotnik, 2012b). Moreover, a functioning rail connection, which only 4 out of the 18 Russian Arctic ports have so far (Buixadé Farré et al., 2014), has to be improved. Such on-land infrastructure guarantees for example functional (re-) loading of cargo and refuelling of ships along the routes (Prowse et al., 2009).

Additionally, particularly the Arctic's SAR-infrastructure is essential, as the aftermath of a glacier rapture and the caused injuries of tourists have demonstrated in 2007 (Moreno and Amelung, 2009). Another example, underlining the urgency for safe travels in Arctic waters, is the incident of the vessel *Maxim Gorgy*, in 1989, when nearly 600 tourists were trapped on an ice floe, after the ship stranded. Hereby, the natural circumstances hindered the rescue, although the weather conditions were not extreme at the time (Rottem, 2014) (connection: *Infrastructure* – ***Climate,*** connection: ***Natural Premisses*** – *Emotional Factors*, connection: *Emotional Factors* – ***Knowledge*** and connection: *Emotional Factors* – ***Equipment***).
Today, eight parties are responsible for SAR-operations in the Arctic: Canada, the United States of America, the Russian Federation, Norway, Denmark, Iceland and, with a supporting role, Sweden and Finland (connection: ***Legal Situation*** – *Infrastructure*). Their cooperation is regulated by the "Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic", which

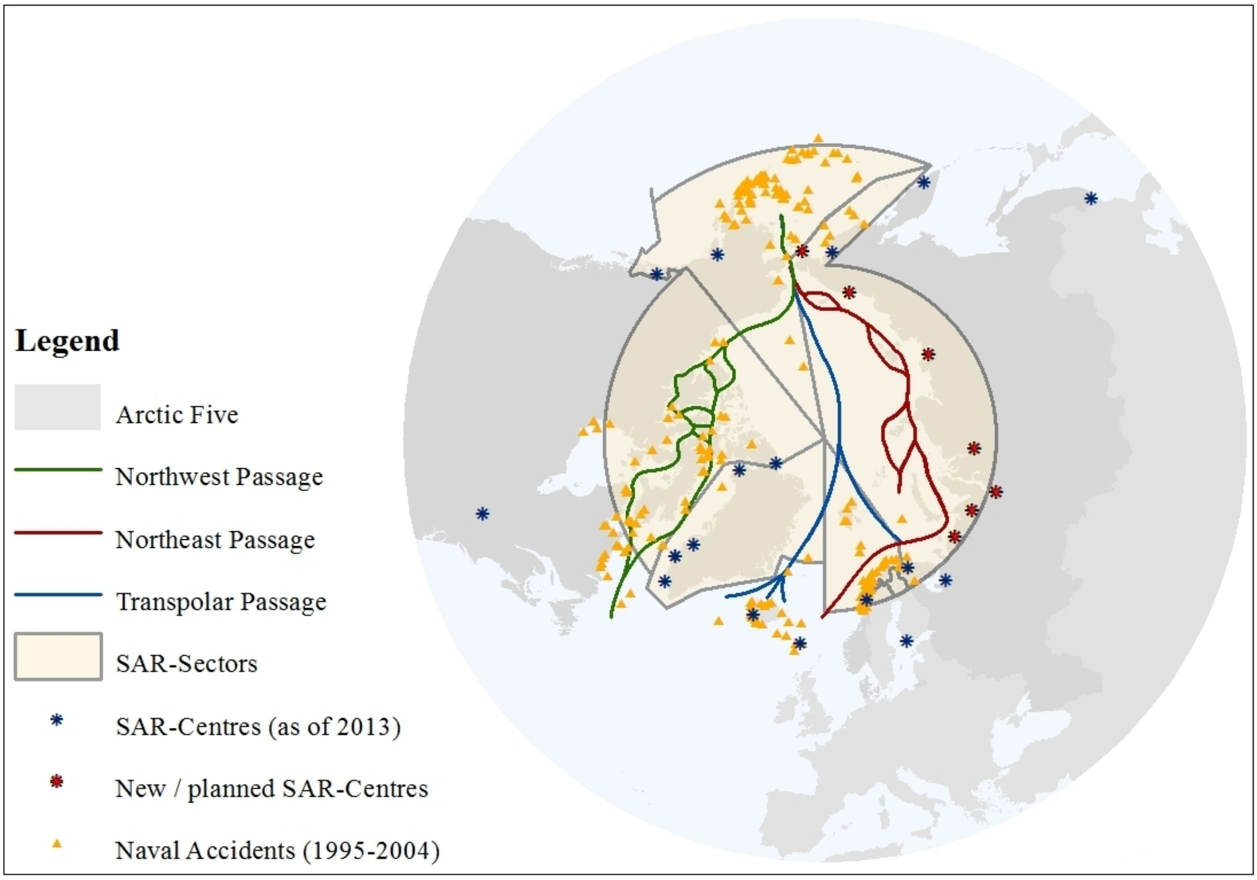


Figure 15: SAR-sectors, SAR-centres and naval accidents (within 1995-2004) in the Arctic

A combination of these factors demonstrates the vast parts of all routes, without functional and fast operating SAR-infrastructure, but also Russias attempt to develop the NEP

Please refer to footnote 2 (page 4) for an explanation why no scale is given within the figure.

References:

Background World Map: taken from ArcMap 10

Northwest Passage, Northeast Passage: Arctic Marine Shipping Assessment 2009 Report, Arctic Council, April 2009

Transpolar Passage: inserted manually, based on: Humpert and Raspotnik, 2012a

SAR-Sectors: inserted manually, based on: Arctic Council, 2011c

SAR-Centres: inserted manually, based on: Steinicke and Albrecht, 2012

New / planned SAR-Centres: inserted manually, based on: Pettersen, 2011 and Vokuev, 2013

Naval Accidents: Protection of the Arctic Marine Environment (PAME - www.pame.is) working group of the Arctic Council, Arctic Marine Shipping Assessment 2009 Report, Arctic Council, April 2009 http://www.abds.is/explore-stressors/dms-shipping/view_document/250-locations-of-sub-arctic-and-arctic-shipping-accidents-and-incident-causes-1995-2004 the Arctic Council passed in 2011. Not only is it respecting UNCLOS, it also defines different search and rescue areas and names responsible SAR-centres (see Figure 14). The agreement further clarifies that each party has to cover the costs, which evolve during SAR-operations within their sector, unless other agreements have been made. In addition, it postulates that joint exercises and training has to be organised by the eight parties (Arctic Council, 2011c) (connection: ***Legal Situation*** – *Equipment*). Moreover, this agreement, represents the first legally binding instrument which has been arranged under the patronage of the Arctic Council (Takei, 2013).

In general, there are several agreements concerning SAR on a legal basis – apart from the previously outlined UNCLOS – which apply to the Arctic: the International Convention on Maritime Search and Rescue (SAR), the Convention on International Civil Aviation (Chicago Convention), the International Aeronautical and Maritime Search and Rescue Manual (IAMSAR Manual), the Guidelines for Ships operating in Arctic Ice-Covered Waters (IMO Guidelines) as well as the more common International Convention for Safety of Life at Sea (SOLAS Convention). Moreover, the operational framework comprises systems to track ships, warning systems that are based on meteorological and navigational parameters (connection: *Knowledge* – ***Climate***), information distributing systems and SAR distress alert detection for SAR in the Arctic (Steinicke and Albrecht, 2012).

However, as Figure 14 illustrates, most of the SAR-centres are located outside of the Arctic Ocean and often fail to have access to providing infrastructure, such as roads or medical facilities. Even if there is additional assistance from the Coast Guard, there are serious limitations, for example, in areas where none of their vessels is stationed near to the Arctic Ocean. This applies for example in Canada which covers the largest SAR-sector. In addition, bigger rescue vessels are solely stationed near Halifax. Hence, in case of an emergency, a serious amount of time will be consumed by the transportation of ships into Arctic waters. This results in a complication of target-oriented SAR-missions, both on temporal and spatial dimensions. Therefore, a closer cooperation between the coastal states and also between the public and the private sector are essential to improve secure shipping in the High North. However, such improvements are costly (Steinicke and Albrecht, 2012). Consequently, the installed SAR-infrastructure has to match prospering economic values as well as (ecological) risks of Arctic shipping lanes.

Particularly security-related issues of the actor “Infrastructure” demonstrate the involvement of human beings (Arctic Council, 2009). Thus, their human capital links infrastructure and the actor “knowledge”.

As demonstrated, economies, infrastructure and the legal situation are closely bonded to one another. In fact, it is impossible to separate them entirely. The evolving interdependencies demonstrate, how the network around Arctic shipping routes mediate flows between the natural, the social and the mental sphere over different spacial and temporal scales. Hence, the connections lead from local to global dimensions and from short to long time frames. Consequently, shipping routes are indeed ANT-resources and can be further analysed with the developed concept of Actor-network services.

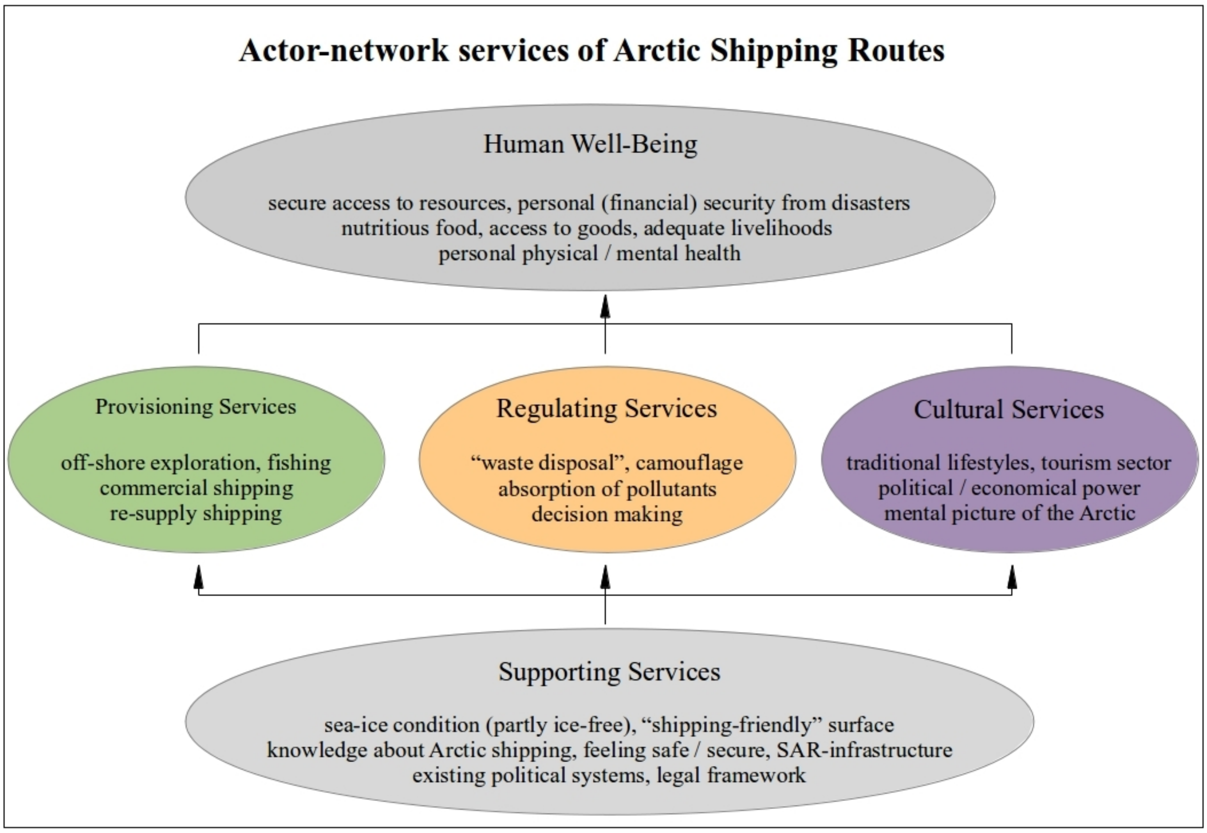


Figure 16: Actor-network services of Arctic shipping routes

By enlarging the traditional ecosystem-services approach with benefits, provided by the social and mental system, the methodological concept of Actor-network services is created.

4.1.3 Applying the concept of Actor-network services

This final step completes the first case study to test the developed methodological concept of this thesis that enables and emphasizes transdiciplinary geographical research. Figure 16 therefore not only summarizes previously gained insights into the services that are provided by Arctic shipping routes, but also links them to aspects of human-well being. Moreover, the interpretation of Arctic shipping routes as a hybrid-system reveals regulating services and cultural services of this actor-network which have been hidden so far.

The regulating services of Arctic shipping routes comprise waste disposal, camouflage travelling, absorption of pollutants and decision making in the High North. In order to reconstruct these services, it is important to recapitulate that shipping routes consist of natural (the ocean, its sea ice layer and the condition of the shoreline), mental (knowledge about and feelings connected with Arctic shipping) and social components (existing political systems and legal frameworks). Together with evolving hybrids (available ships, SAR- and on-land infrastructure), these natural, social and mental characteristics create the supporting services of shipping routes in the High North. Any other service that is offered by Arctic shipping routes is based on supporting services. To demonstrate their importance, they are linked with regulating services of Arctic shipping lanes.

The supporting natural components of Arctic shipping routes, namely the terrestrial and marine ecosystems, are currently challenged by the waste and litter, tourists leave behind, when using shipping lanes in the High North. Particularly plastics challenge the Arctic's flora and fauna recently. However, the states of the High North are aware of these challenges. Canada for example, prohibits the discharge of garbage in its entire Arctic waters (AMAP, 2013; “Discharges to Water,” 2010; Millennium Ecosystem Assessment Program, 2005; Poland et al., 2003). Besides the system's function as an enlarged “waste disposal”, these natural components serve also as modulators of pollutants, contaminations and climate-active gases which are partly generated by shipping activities themselves (AMAP, 2013; Millennium Ecosystem Assessment Program, 2005; Poland et al., 2003).

Furthermore, the natural component “partly existing ice cover” provides camouflaged travelling activities of submarines underneath its surface. As an example, Russia uses special-operation subs to investigate the sea floor of the Arctic Ocean. During one of its operations in October 2014, Russia took advantage of the ability to sink underneath the ice cover, before the sub got identified

by Norwegian researchers (Staalesen, 2014). This example further demonstrates the tight bonds between the systems “climate change” which causes a melting of the sea-ice, and “geopolitics” which is responsible for enlarged marine operations.
The named regulative services are linked to components of human well-being. Firstly, they have a strong connection to the security of humans on a personal level, as the need for an infrastructure demonstrated. Secondly, regulative services afford safe access to resources and security from disasters, since they cover political operations and attenuate natural challenges. Thirdly, they affect people's health and their provision with basic material for good life, since they allow maritime trading and re-supplying in the High North.

Significant cultural services are particularly bonded to the growing cruise shipping sector. Hereby attractive destinations are connected to vast abandoned Arctic settings. This constellation results in emotions, such as being surrounded by unaffected nature which many tourists are longing for. Additionally, Arctic travels get mentally associated with explorations and unique (cultural) experiences (Fay and Karlsdóttir, 2011; Hall and Saarinen, 2010; Mason et al., 2000b). Therefore, the mental picture of the Arctic which is also generated by the Actor-network services of shipping routes, contributes to the cultural services of the High North.
Furthermore, the achieving of political and economic power over these shipping lanes are crucial cultural services as well, since such empowerments are always resulting of social and political constellations. The ownership of geographical areas and places is delicate in the Arctic, although such strategic places solely offer very low expectations to function as major traditional resource deposits (Kullerud et al., 2013). Hence, this fact underlines the strong geographical component within the connections of the actor-network of Arctic shipping routes.
The named cultural services affect all aspects of human well-being, particularly security-related parameters and the development of good social relations. These connections link back to the geography of places and the concept of intrinsic values.

To conclude, various connections evolve within the actor-network of Arctic shipping routes. Hereby, ANT-approaches and also the developed concept of Actor-network services have been used to highlight additional benefits, human beings create of Arctic shipping lanes. Furthermore, natural and social services have been connected with the mental sphere. Hence, aspects of physical geography and human geography have been merged in this case study.

However, the methodological concept of this thesis is not only a tool to describe the current situation, it also offers possibilities to explore future scenarios. In the case of Arctic shipping routes, three actors are especially responsible for the ongoing development of shipping in the High North: Firstly, the melting of sea-ice, secondly, the SAR-infrastructure and thirdly, the determined costs. In the following, possible prospective interdependencies between these actors are outlined. Hence, the next analyses involve additional time scales, while connecting them with current power-relations.

4.1.4 Connecting possible future scenarios with current power-relations

According to the Fifth Assessment Report of the IPCC, the annual mean extend of sea-ice in the Arctic decreased between the years 1979 and 2012. As the report states further, it is both very likely that this decrease ranges between 3.5 and 4.1% per decade and that the summer sea-ice minimum even decreased with a range of 9.4 to 13.6% per decade within the same period (Intergovernmental Panel on Climate Change (IPCC), 2014b). In September 2012, a record low sea ice extend was reached in the Arctic, with an extend of only $3.4 \cdot 10^6 km^2$ (Parkinson and Comiso, 2013).

In compliance with the IPCC scenario A1B, the ice-free season of the NSR will increase with an amount of three to six months and the shippable season of the NWP will enlarge between two and four months, by the end of the twenty-first century (Khon et al., 2010). The A1B scenario is determined globally by a rapidly growing economy and a convergence of states and regions that causes an assimilation of the per-capita income. This scenario also assumes a fast implementation of new technologies and a decreasing global population within the latter half of the 21st century. The A1B scenario is also characterized with a balanced resource usage (Intergovernmental Panel on Climate Change, 2007).
The increasing combat capabilities of the Arctic states suggest an increased conflict potential in the High North, an area which has been shaped by cooperation since the ending of the Cold War (Huebert, 2013). However, the intentions of the Arctic states to negotiate peaceful solutions for future problems remain predominate, so far. Therefore, the A1B scenario suits the situation of the Arctic, Besides, this statement is also supported by the previous outlining of the crucial role of new technologies and energy resources for development in the High North.

Based on simulations that represent the current sea ice and satellite observations remarkably well and also match with historical forcing, suggestions are made that Arctic routes from Europe to the Far East may outnumber the Suez Canal in terms of year-long travel costs with a value up to 15% by the end of this century (Khon et al., 2010). Shipping along the prospering NSR is therefore likely to increase during the 21st century. By 2020, the volume of traffic on the NSR is estimated to reach an amount 40 million tonnes of oil and gas per year (Arctic Council, 2009).
In contrast, although the sea ice is already vanishing, the Canadian Arctic Archipelago remains an area of persisting sea ice. This complex structure, paired with consequently difficult navigation, result in statements that it is not likely that the NWP will turn into a reliable trans-Arctic shipping option until 2020. Furthermore, the high operational costs reduce economic profits on this lane and the Canadian standards – in contrast to Russia's – do not match international rules and requirement, why enhancements are needed (Arctic Council, 2009) to turn the NWP into a prospering shipping lane.

Besides the rising global interest in Arctic shipping, maritime developments are still bonded to resource exploitation in the High North. Yet, it has to be considered that resource exploitation requires the completion of new production sites, which can take up to 30 years. Therefore, its effects on the amount of vessels that use Arctic shipping lanes will mainly increase on a long time frame (Østreng, 2012).

In terms of security-related uncertainties of shipping in the High North, the probability for major marine accidents is suspected to be low for the NSR. Still, in case of an emergency, the (ecological) consequences remain serious (Arctic Council, 2009). Hence, to further secure and strengthen the competitive ability of the NSR, Russia is planning to built 10 new SAR-centres along the shipping lane until 2015. As a consequence, Russia increases its seaport capacity by a factor of 50% (Humpert and Raspotnik, 2012b; Pettersen, 2011). In addition, the EU can support the development of an improved communication system and a reliable satellite coverage, if its Galileo and GMS satellite programs are involved (Steinicke and Albrecht, 2012).

To conclude, achieving safer travels in Arctic waters increase the profitability of Arctic routes, particularly since the shorter distance does not equalize reduce costs immediately, as demonstrated before. Besides, their liability and feasibility determine the economic outcome of the passages

(Humpert and Raspotnik, 2012a).

So far, cooperation continues along the NEP, while Canada is trying to assure their power over the NWP. The legal status of the TPP is so far untouched by national claims, since it runs merely through the High Sea. As pointed out, the link between natural, social and mental ANT-actors will dictate the development of Arctic shipping lanes and the NSR seems to be the most promising route under the current circumstances.

4.1.5 Conclusion – outlining the suitability of the developed methodological concept

Within this first case-study of the developed methodological concept, five steps are conducted:

1. Identifying connected actors of Arctic shipping routes and exploring initial network connections,
2. Investigating the remaining interdependencies within the network,
3. Applying the concept of Actor-network services,
4. Connecting possible future scenarios with current power-relations and
5. Outlining the suitability of the developed methodological concept.

As an outcome, eleven actors were identified that enable the action "Shipping in the Arctic" together. In addition, connections on different temporal and dimensional scales were outlined. Within this last step, the suitability of the developed methodological concept in terms of enabling geographers to work transdiciplinarily is outlined:

1. Investigations of Arctic shipping always involve spatial characteristics. Five of the identified actors are directly connected to space and the geographical position of the Arctic: Natural threats, natural premisses, infrastructure, economies and climate. Hence, the natural components of the supporting services of Arctic shipping routes are based on geographical circumstances. However, the developed theoretical approach is needed to identify additional characteristics of these geographical connections, especially if they link actors such as knowledge, science or the legal situation – hereby, focusing solely on spatial scales is not sufficient anymore.
2. Arctic shipping routes merge processes of climate change and processes of political geography. The involvement of the latter is primarily outlined by investigations of the actors

"Legal Situation", "Economies" and "Knowledge". Processes of climate change are represented through the actors "Climate", "Natural Threats" and "Natural Premisses". The developed methodological concept enabled a tagging of connections between these processes on local, regional and global dimensions, as well as on current and future time scales. Hereby, the novel definition of interdependencies which equalizes connections, functions particularly as a premiss to accomplish this essential step.

3. The actor-network of Arctic shipping routes involves actors that are originally located in different geographical subdisciplines. As examples: Climate – climatology, Economies – economic geography, Legal Situation – political geography. Therefore, it needs the cooperation between different geographical research fields, to investigate this network. Yet, such analyses require the developed methodological concept to identify connected network-members, since none of the subdiscplines achieves this initial step in the required way so far.
4. The developed approach analyses actors and connections. Particularly mental actors, such as knowledge or emotional factors, have been barely involved into investigations of Arctic shipping routes so far. However, the network-analyses in this case study have shown that mental entities are powerful ANT-actors. Hence, integrating them into geographical analysis enables a broader understanding of network-structures and the involved power-relations within Arctic networks.

To conclude (see Figure 17), the developed approach enables a novel understanding of Arctic shipping lanes as an actor-network with natural, social and mental components. As the investigations in this case study have outlined, especially the latter components are so far understated. Thus, to achieve a comprehensive understanding of the action "Arctic shipping", the involvement of all connected actors has to be taken into account of scientific surveys. Such a procedure does not only increase the local and regional comprehension of Arctic networks, but leads to a global appreciation of its network components.

The second case study links back to the last statement: the need to investigate the involvement of mental actors within Arctic networks. In fact, four of the identified network-members of Chapter 4.1 are directly connected with the resource of this second case study "Traditional Knowledge". These actors are "Climate", "Science", "Natural Threats" and "Natural Premisses". They not only affect Arctic shipping lanes, but determine the lives of indigenous peoples in the High North.

Hence, these actors determine the applicability and development of traditional knowledge which is possessed by indigenous peoples.

As an example, the actor "Economies" comprise the tourism sector and therefore the merchandise of the lifestyle of indigenous peoples which is intensely interwoven with traditional knowledge.

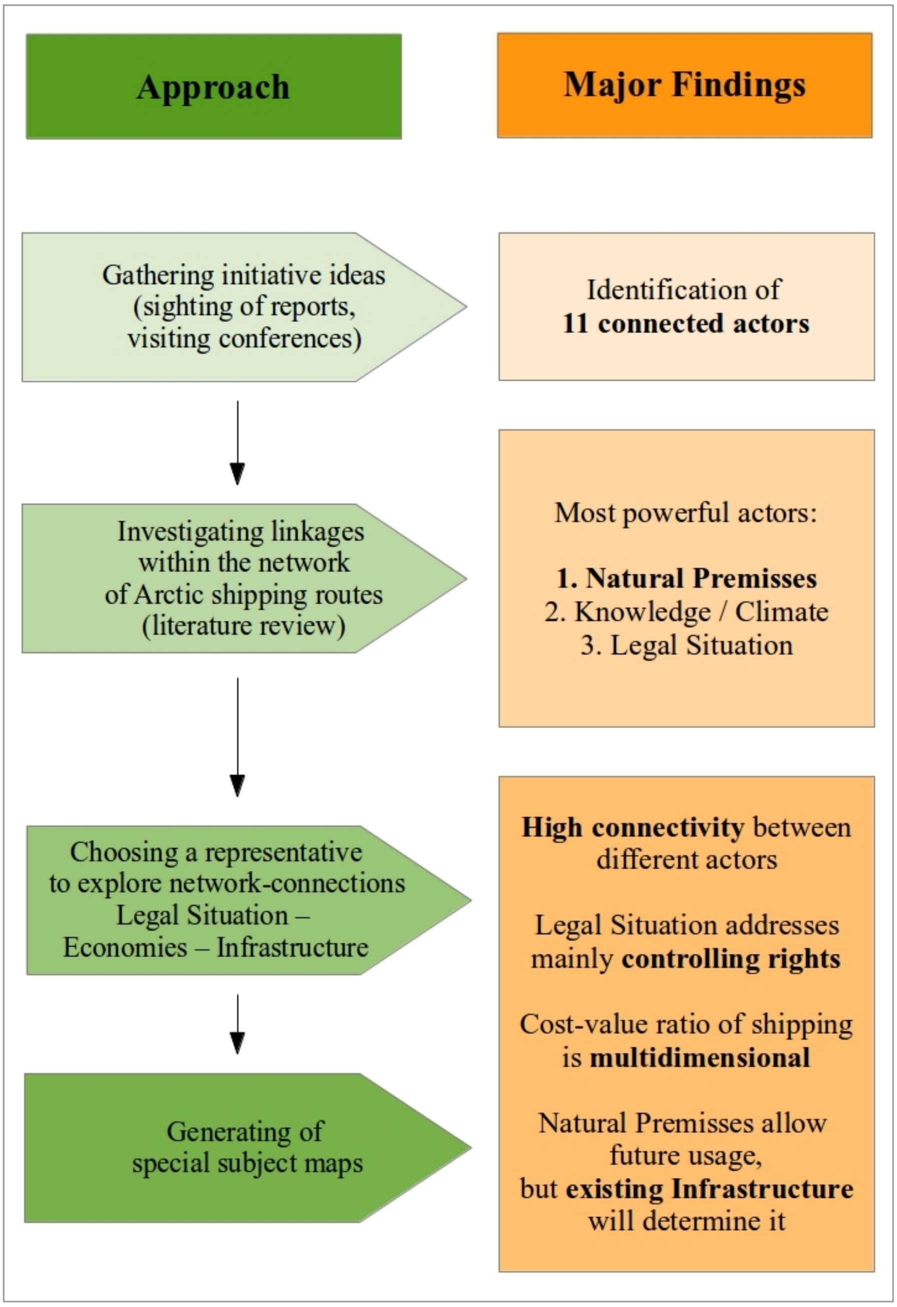


Figure 17: Conclusion of Chapter 4.1

Same applies to “Infrastructure” and “Knowledge about Shipping in Arctic Waters”. In contrast, newly installed infrastructure alters the environment and consequently the life of indigenous peoples, while traditional knowledge complements scientific knowledge about shipping in the Arctic. Such interconnections between the selected case studies further underline the argument of the need of a transdisciplinary approach.

4.2 Case study 2: Traditional knowledge – exploring mental resources

Abstract Case study 2

Objective 3:
Test the developed theoretical approach and the methodological concept

After investigating "Arctic shipping routes", the actor-network of a mental Arctic resource is explored: Traditional knowledge. Hereby, traditional knowledge is understood as an outcome of developments within the four conducted spheres (Arctic nature, global nature, Arctic social sphere and global social sphere). As an outcome of ANT-actions, traditional knowledge mediates flows within its actor-network and creates power-relations. (Powerful) actors and the connections between them are identified by qualitative literature review, semi-structured interviews and illustrated with supplementing GIS-data.
Most important outcomes:

1. *The actor-network of Arctic traditional knowledge consists of natural, social and mental actors.*
2. *The developed concept of Actor-network services enables the inclusion of additional actors and interdependencies without further adaptations.*
3. *The developed concept of Actor-network services does not provide reliable options to postulate future scenarios about the alterations of traditional knowledge.*

The first case study of "Arctic shipping routes" revealed the impact of mental actors within Arctic networks. Consequently, a mental resource is chosen as the second case study to test the developed methodological concept : Traditional knowledge.
Traditional knowledge belongs to the overall knowledge of indigenous peoples. Hence, the development and impacts of this certain part of knowledge are bonded to the native inhabitants of the High North (definitions and examples are given in Chapter 4.1.1 and 4.1.2).

As the second selected Arctic resource, the actor-network of "traditional knowledge" is outlined and analysed in this thesis. Analogue to the first case study, five concrete steps have been conducted to explore the actors that are connected with this mental resource:

1. Identifying connected actors of Arctic traditional knowledge,
2. Exploring interdependencies within the network,
3. Applying the concept of Actor-network services,
4. Connecting possible future scenarios with current power-relations and
5. Outlining the suitability of the developed methodological concept.

In order to identify contributing natural, social and mental actors, several ANT-methods are applied. Since traditional knowledge is tightly connected to its owners, the selected methods have to suit these essential characteristics:

1. A qualitative pre-literature review to gain initiatives for further investigations and interview questions,
2. Semi-structured interviews,
3. A second qualitative literature review to investigate the outcomes of the interviews and
4. Freely available (GIS) data to illustrate connected actors with the help of special subject maps, generated with ArcMap (ESRI). This method mainly fulfils supporting tasks, since the data about Arctic traditional knowledge is still fairly limited.

The findings of the second case study are outlined within the following sections. Hereby, a detailed description of the selected interview structure and the asked questions which are based on the initiative literature review are outlined as a beginning. Afterwards, it is illustrated how the outcomes of the interviews influenced and altered the second qualitative literature review.
Consequently, powerful actors of the actor-network of Arctic traditional knowledge are identified. The connected actors are inserted upon their first appearance in brackets, in capital letters and in italic type within the text. In addition, initial connections that evolve within the actor-network of Arctic traditional knowledge are characterized. Whenever a connection is mentioned within the text, the contributing actors are named in brackets and in italic type. The actor which overpowers the other actor during the process of maintaining the connection is typed in bolt style. If both actors are contributing to the connection equally, both are highlighted in bolt style. All identified actors and determined connections of Chapter 4.2 are illustrated in Figure 19.

4.2.1 Identifying connected actors of Arctic traditional knowledge

To identify actors within the actor-network of Arctic traditional knowledge, a qualitative literature review is conducted. This first literature review offers an insight into the contents of traditional knowledge, but it also rises questions, concerning the development and current adaptations of traditional knowledge. Particularly two questions evolve in the course of this first literature research:

1. What kind of knowledge is comprised by the term "traditional knowledge"?
2. Who are the knowledge-holders of traditional knowledge?

Hence, this case study needs supplementing methods which go beyond the analyses of written data: semi-structured interviews. Semi-structured interviews were particularly chosen, since they suit ANT, as pointed out in Chapter 2 and 3. Moreover, the intention was not only to clarify the two questions which are named above, but to explore network-connections of traditional knowledge in general. Hereby, the use of broad questions allows the interviewed person to express its own ideas, feelings, opinions and experiences towards / with traditional knowledge (Pfaffenbach, 2011).
However, there is still the risk that findings from the interviews are based on the interview-question alone or that an interviewee emphasises an actor due to his personal research interests. Therefore, a subsequent literature review has been done, in order to verify the actual importance of actors within the actor-network of Arctic traditional knowledge.

The interviews were conducted in March 2014 during a research stay in Montreal, Canada. Ten persons were interviewed who have experiences in working with traditional knowledge-holders in the High North. The work of the interviewees share a common focus on traditional knowledge. However, each interviewee concentrates on a different aspect of traditional knowledge.[4]
Seven broad questions were asked in every interview, closing each time with the invitation to add other comments or thoughts. According to the semi-structured style of the interviews, follow-up questions were asked, whenever needed. Written notes were taken during the interviews and later transcribed into digital files.[5]

1. How would you define TK?

4 Interviews with indigenous people could not be conducted during this thesis, due to organisational, temporal and financial reasons.
5 Since the majority of the interviewees asked to not get cited verbatim, the interviews were not recorded.

2. How is TK shared within the community?
3. Could you recognize gender influences on TK / on the practised sharing-methods?
4. Is the youth interested in TK? Do they practice their cultural tradition? If yes, how?
5. What are the most pressing (social, political, environmental) issues for indigenous communities today?
6. How do these issues affect TK?
7. How do scientists engage with indigenous communities during their work? (Do you think there is an "abuse" of TK by western scientists?)
8. Do you have any other comments or notes?

With the help of semi-structured interviews, different connections within the actor-network of traditional knowledge were identified. Moreover, the role of scientists and their work within the network evolved. The mean time of the interviews was 40 minutes (the shortest lasted for 25 minutes, the longest for 90 minutes).
Amongst these ten interviews, two supplementing interviews were conducted – also with persons who have experience either in working with traditional knowledge-holders or in working about interdependencies between politics and traditional knowledge. These complementary interviews enabled a modifying of the previous findings, due to newly identified connective possibilities within Arctic networks and the involvement of geopolitical interdependencies on different geographical scales.

The ever-changing structure of traditional knowledge, its dependence on the characteristics of the individual knowledge-holders and the strong connectivity between involved actors were emphasized during the interviews. Hence, an enlarged analyses of the knowledge-holders and possible definitions of traditional knowledge are chosen as the basis of exploring the network around this mental resource. Furthermore, the interviews revealed an ongoing controversy around the term "traditional" that is illustrated by the outlined definitions.

4.2.1.1 What kind of knowledge is comprised by the term "traditional knowledge"?

Mainly three expressions are present in the discussion about the knowledge of indigenous peoples: traditional knowledge (TK), traditional ecological knowledge (TEK) and Inuit Qaujimajatuqangit.

Although each expression refers to the knowledge of indigenous peoples, there are slight differences according to their meaning and definition. Out of these expressions, TEK is the most specific term, (Usher, 2000), while TK is the most broad one. In contrast, Inuit Qaujimajatuqangit refers to particularly one indigenous people (Huntington, 2005).

TEK includes every type of environmental knowledge, based on or originated from the experiences and traditions of a certain group of people (Usher, 2000). Usher (2000) names four different categories of TEK: knowledge about a) the environment as well as b) its use, c) its values and d) the underlying knowledge system. Methods to gather TEK include empirical observations of weather, animal behaviour, currents or ice condition (actor: *CHANGING HABITATS OF FLORA AND FAUNA*), the evolving of experiences an individual made, while observing a specific event, or the conduction of numerous observations and their generalised outcomes (actor: *CLIMATE*). Moreover, reinforcement by others through story telling or oral history is also common practice (Usher, 2000) (actor: *EXISTING KNOWLEDGE*).

Knowledge about the use of the environment is based on the general interest which indigenous people have in their surroundings as well as on the past and present traditional use of nature (actor: *ACCESS TO THE LAND*). Knowledge is again gained from a wide range of possibilities, such as personal experiences or oral history (Usher, 2000).

Values of the environment (c) refer to moral statements or ethnic rules. They affect, for example, how animals should be treated, how to behave within a community or how to support human health (Usher, 2000) (actor: *INTERNAL SOCIAL FACTORS*).

A), b) and c) assume an underlying knowledge system (d). Such a system is particularly needed to transform facts into knowledge. Consequently, the overall understanding of the three other knowledge categories is possible (Usher, 2000).

The definition of TEK underlines its mediative possibilities between the natural and social systems. Hence, it supports the postulation of traditional knowledge as a mental ANT-resource. Moreover, particularly (a) and (b) can be easily implemented into scientific surveys, since an expression in numbers, graphs and figures is feasible without further information or effort (actor: *SCIENCE*). The use of such data is also simple, for example by comparing it to already existing scientific data collections. Hence, TEK is translated and mediated by scientists and therefore implemented into political discussions. As a consequence, TEK mediates flows between processes of climate change

and processes of geopolitics.
However, TEK involves just some contents of traditional knowledge. Yet, TEK and TK are often used as synonyms, although they are certainly not. The concept behind TK is more broad than the idea of TEK (White, 2006). It further comprises, for example, knowledge about agriculture, medicine or genetic resources. Hence, TK is not limited to one specific (technical) field (Solomon, 2005).

In general, TK is evolved by shared common history leading to a certain political and social perspective, ethical knowledge and knowledge about the cosmos as well as local knowledge (Abele, 2007). It depends on the know-how, innovations, skills and practices a certain native group obtains and shares between generations through their traditional lifestyle (Solomon, 2005) (actor: *ACCESS TO "BASIC MATRIALS"*). Hence, indigenous knowledge is an understanding of the world and consequently a self-concept, rather than a collection of information (Huntington and Fox, 2007).
The connection between culture and the development of TEK and also TK in terms of crediting a meaning to the surrounding entities, is a crucial point if it comes to defining it (Wenzel, 1999). Some authors go as far as stating, that TK and TEK can only be understood from an indigenous point of view which requires the use of indigenous languages (White, 2006). Even the conversion from orally shared TK into a terminology which is easier to use for the majority of a state's society, contains therefore the risk of isolating the knowledge from its context (Simpson, 2001). Along with this comes the problem that the knowledge system behind TK is delicate to communicate with words only. Thus, the strong connection between the TK of a community and the local environment, can get lost, if it is transported outside of the latter (Taubman and Leistner, 2008).

TK as a whole knowledge system suits the developed theoretical approach through the involvement of different temporal and spacial scales. Hence, it even enlarges the impact potential of TEK on Arctic actor-networks. Apart from that, it reassembles two issues that have been outlined earlier: place identity and the translation of mental entities. The concept of TK illustrates perfectly, how mental entities interweave geographical places, the environment and the social sphere. As a consequence, it also combines parameters of physical geography and human geography which further demonstrates the need of transdisciplinary geographical research.
However, actor-networks are constantly changing and transforming. Used in both, TK and TEK, the term "traditional" can be misleading by suggesting a static, non-adaptive type of knowledge.

Contrariwise, indigenous knowledge stands out, by being highly adaptive to shifts since it is evolving and current (Huntington and Fox, 2007; Stoll and von Hahn, 2008; Taubman and Leistner, 2008; Usher, 2000). Continuity is therefore a decisive factor of TK (Ingold and Kurttila, 2000). Hence, it illustrates a perfect case study for an Arctic actor-network.

Yet, the way of how it is generated and used could be called "traditional" (White, 2006). Observing and imitating are, for example, two methods to share TK among the communities (Huntington and Fox, 2007). Taubmann and Leistner agree by arguing, that TK has been passed down from one generation to another and has therefore been kept in a traditional way (Taubman and Leistner, 2008). Consequently, to prevent the confusion affected by the term "traditional", the expression Inuit Qaujimajatuqangit (IQ) was implemented (White, 2006).
Yet, the idea behind "IQ" goes even further. Admiring to abandon the narratives connected with the term "TK" (Wenzel, 2004), the Inuktitut term "IQ" got popular in the course of the development of a Nunavut government (Tester and Irniq, 2008). Arnakak (2002) argues, that IQ comprises knowledge, experiences and values of Inuit people from the past, present and future (Arnakak, 2002). Therefore, IQ is based on a holistic concept – analogue to TK.

Also IQ comprises an actor-network similar to the one of TK. Yet, it is limited to one indigenous people, why the term TK is used instead in this thesis. Since the developed methodological concept is based on a theory which deals and moreover requires constantly changing interdependencies and actors, there is no risk to mistake TK for a static construction.

To conclude, traditional knowledge affects all parts of the life of indigenous peoples (Wenzel, 2004), by definition. Therefore, it creates multiple connections between the social, mental and natural sphere. Hence, it is located in the Hybrid-Arctic. In this thesis, traditional knowledge is considered in a holistic way, including pure facts and a believe system to interpret these actualities.
Although this knowledge has a strong connection to geographical space and places, the term "local knowledge" is not used as a synonym in this thesis, since TK refers to any regional knowledge that is possessed by human beings. The term "traditional knowledge" is further preferred, because it alludes particularly to indigenous peoples, their knowledge and its transformations.

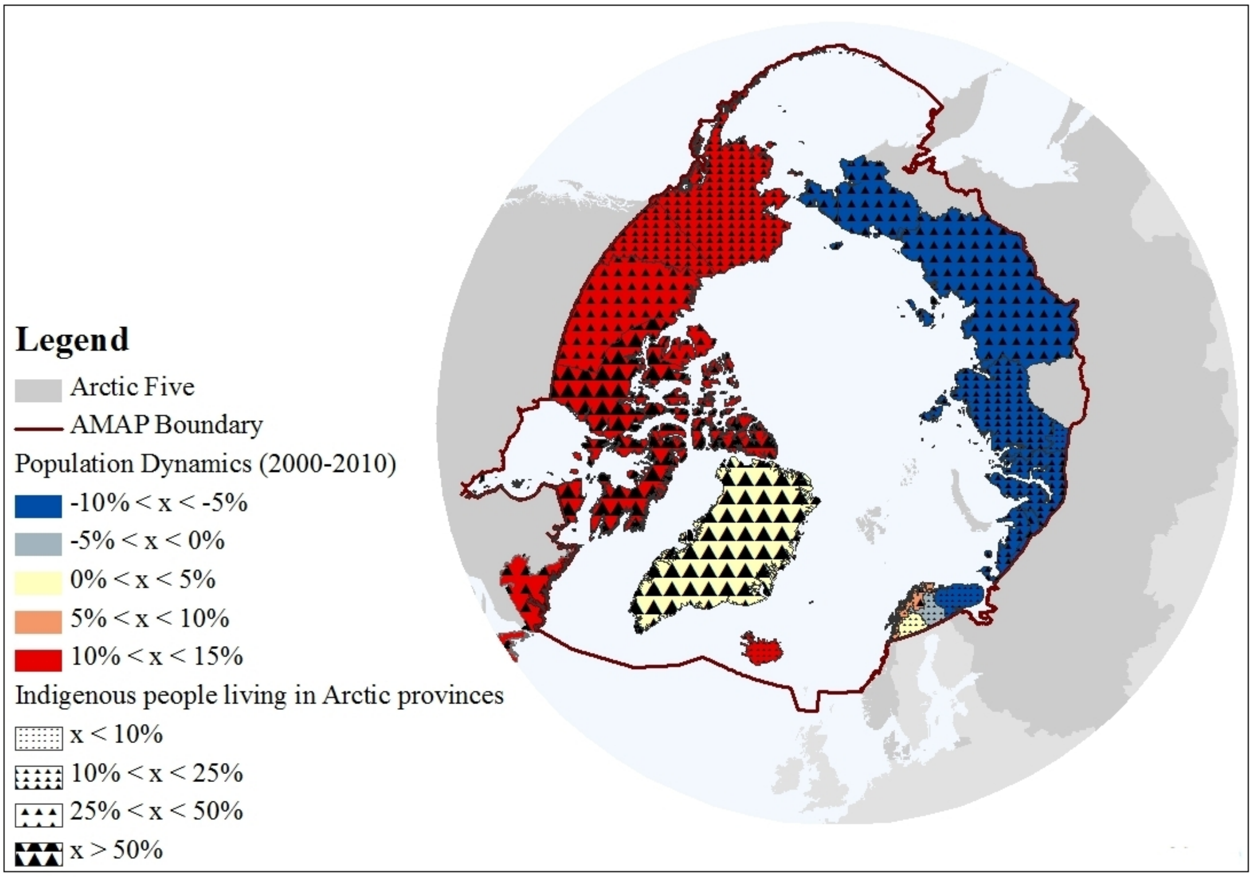


Figure 18: Population dynamics within the Arctic (2000-2010) and share of indigenous people

Please refer to footnote 2 (page 4) for an explanation why no scale is given within the figure.

References:

Background World Map: taken from ArcMap 10

AMAP Boundary: AMAP (http://www.amap.no/documents/doc/amap-area-gis/868)

Population and Indigenous people: inserted manually, based on the following reference and the references therein: Heleniak and Bogoyavlensky, 2015

With its strong correlation to space and places, traditional knowledge merges geographical circumstances with knowledge in general. Hereby, a certain geographically existent context is transformed into knowledge (Agnew, 2015).

The process of creating new knowledge, which consists of processed and internalised information, is particularly bonded to the socio-cultural characteristics of a geographical place, since they determine factors such as the creativity of the knowledge-holders. Besides, the ability to mediate information and to translate them into actions, are not ubiquitous. Therefore, new knowledge is only locally available in the beginning of its existence and time is needed, before it is widely available which results in geographical disparities of knowledge (Meusburger, 2013, 2004). These geographical differences further underline the spatial dimension of knowledge which also determines the process of knowledge sharing. Hereby, one actor is expressing information to another receiving actor. As has been pointed out in Chapter 2, the expression and interpreting of information, hence mental actors, depend on several subjective factors, such as the format of the information itself. The receiving actor can only transform information into knowledge, if it is able to understand, interpret, judge and compare the transmitted information. Yet, these abilities depend again on the socio-cultural context of the receiving actor and on its already existing knowledge. Therefore, the overall amount of knowledge of a certain actor can be interpreted as a complex function of space and time, which is particularly crucial to power-structures and adaptabilities within networks. Consequently, if an information is available everywhere, it becomes less important and therefore less meaningful (Meusburger, 2004, 2001).

Traditional knowledge is tightly connected to geographical areas and therefore also to the people living in these regions. Yet, analogue to the different ways of defining “traditional knowledge”, a concrete definition of the actual knowledge-holders is missing. Hence, a brief overview of different ways to define the term “indigenous people” is given in the following.

4.2.1.2 Who are the knowledge-holders of traditional knowledge?

About four million people live in the Arctic region. However, the accurate number depends on the chosen definition of the High North (AHDR, 2004). Out of this amount approximately 10% of the population belong to indigenous peoples (Anisimov et al., 2007) who are resident in each of the five Arctic states (see Figure 18 and also Table 7 for different calculations). Recent calculations determine the native population of the Arctic between 400,000 and 1,3 million people, with 68,300 people living in Russia (based on the census of 2010) (Anisimov and Nymand Larsen, 2013). The Inupiat, Yup'il, Alutiiq and Athapaskans are living in Alaska, while the Inuit are calling Canada and Greenland their home. The Saami form the indigenous population of Scandinavia and also inhabit the Kola Peninsula in the northwest of Russia. Apart from the Saami, various other groups of indigenous peoples are found in Russia: namely the Cukchi, Even, Evenk, Nenets, Nivkhi, Itelmen, Yukagir as well as Yup'ik along the east coast of Siberia (Nuttall, 2000).

The diversity of indigenous peoples in the High North is also illustrated by the different, regionally used terms to describe them. While “Native” is common in Alaska, the term “aboriginal peoples” is used in Canada (AHDR, 2004). Yet, the indigenous people of Alaska and Canada themselves, prefer to be called “First Nations” (AHDR, 2004; Cunningham and Stanley, 2003). Analogue to the different ways of how to address indigenous peoples, the establishment of a concrete definition is problematic (The World Bank, 2005).

Barnard and Spencer (1996) state that the term “indigenous people” tends to describe peoples living in a certain geographical area before the arrival of a larger population, historically usually Europeans. This definition can easily be applied to regions, such as South America. However, it complicates or even eliminates the identification of indigenous peoples in Europe and therefore also in the European Arctic (Barnard and Spencer, 1996).

Yet, it is possible to distinguish typical characteristics of indigenous peoples. Daes (1996) argues that members of an indigenous people identify themselves as being indigenous. Moreover, the members of indigenous peoples are acknowledged by other organisations, including groups or states, as an evident collectivity. They share a priority in time according to the usage and settlement history of a given territory. Besides, they have often suffered or are still suffering from discrimination, marginalization, subjugation, exclusion or dispossession (actor: *EXTRANEOUS SOCIAL FACTORS*). Furthermore, they maintain cultural particularities, such as language, spiritual rites or religious practices (Daes, 1996) (actor: *PRACTICES OF CULTURAL RITES AND EXCHANGE OF KNOWLEDGE*).

Stoll and von Hahn (2008) describe indigenous people as being strongly connected to nature and their ancestral homeland (actor: *NATURAL CONDITIONS*). In addition, natives share their own language which often differs from the official language of the state, they are resident in. Similar to Daes (1996), the authors underline a self-identification process of indigenous peoples, as well as their identification by outsiders. However, von Hahn (2004) stresses the fact that the economy of native groups is often subsistence-oriented (actor: *ECONOMIC STURCTURE*). Consequently, the author states that the lifestyle of indigenous peoples emphasizes the establishment of habitual institutions on a political and social level (von Hahn, 2004). Similar characteristics of indigenous peoples are named by the World Bank Operational Directive 4.10. However, it also refrains from giving one precise definition (The World Bank, 2005).

The concept of a missing concrete definition is also supported by several native groups, mainly due to the respect of their diverse lifestyles. With the intention to not neglect any indigenous community by definition, these groups hold on to their right of self identification. In contrast, a concrete definition might help to preserve the special needs and rights of native peoples on a political level (von Hahn, 2004) (actor: *POLITICAL RIGHTS*).

Table 7: Overview of indigenous people in the Arctic (based on the respective national census)

(Data taken and adapted from Heleniak and Bogoyavlensky, 2015; NMR publicering, 2013; Vahl et al., 2015)

Arctic regions in / on ...	Definition of “Indigenous”	Number of Indigenous People
The United States of Amerika	Includes American Indians and Alaska Natives	120,452 (in 2010)
Canada	Includes First Nations People, Métis and Inuit	1,172,785 (in 2006)
The Russian Federation	Includes several Arctic indigenous groups, such as Sámi, Nenets, Komi, Yakuts or Karelians	98,651 (in 2010)
Greenland	Defined by place of birth → Number of people born in Greenland is nearly equivalent to number of Natives / Inuits	50,113 (in 2013)
Norway	Includes Sámi. However, ethnicity is not recorded in national census	40,000 – 50,000 (in 2013)
Finland	Includes Sámi. However, ethnicity is not recorded in national census	7,000 – 8,000 (in 2013)
Sweden	Includes Sámi. However, ethnicity is not recorded in national census	17,000 – 20,000 (in 2013)
Iceland	Defined by place of birth. However, there were no indigenous people, by the time the Norwegian Vikings arrived on Iceland	286,453 (in 2013)
Faroe Islands	Defined by place of birth. However, there were no indigenous people, by the time the Norwegian Vikings arrived on the Faroe Islands	40,967 (in 2013)

To conclude, being indigenous is determined by the process of self-identification which is based on the common cultural beliefs, rites and habits of a certain group. Being indigenous comprises therefore the adaptation of a certain lifestyle. As an outcome of this unique lifestyle, native people

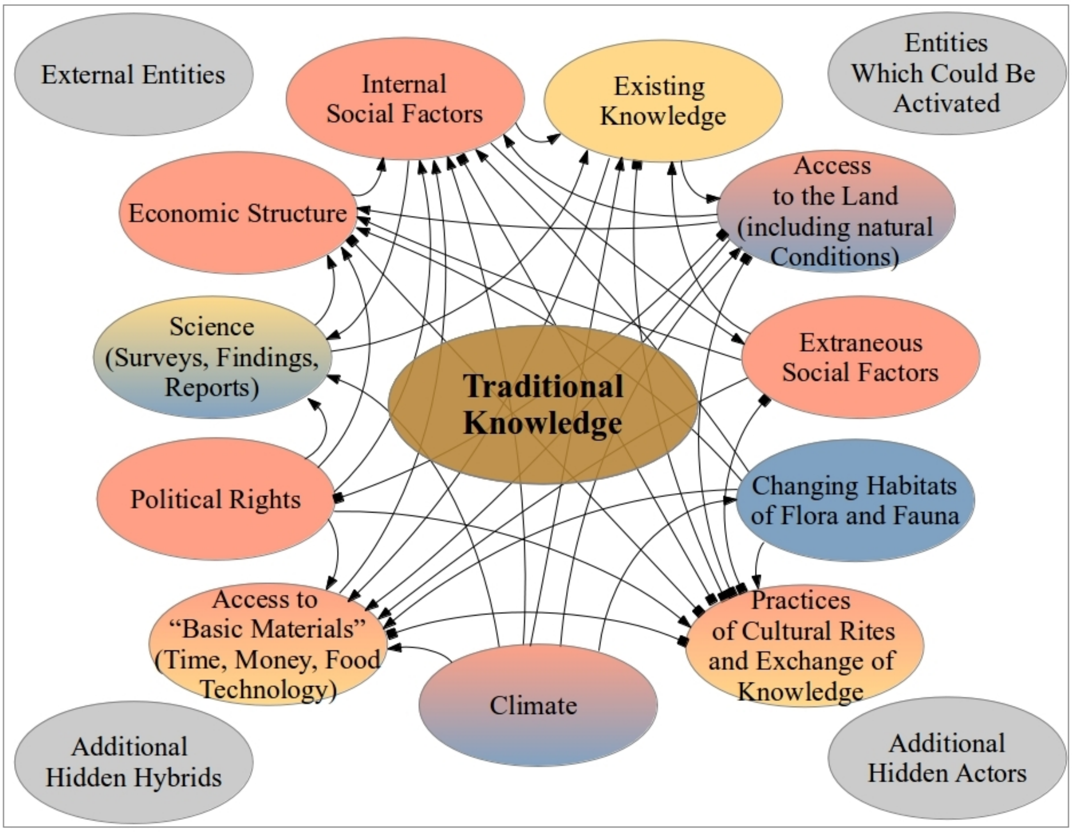


Figure 19: Identified actors and connections of the actor-network of Arctic traditional knowledge

The identified actors are marked in colours, representing the main sphere of their origin (blue = natural sphere, red = social sphere, yellow = mental sphere). Connections between the actors are shown by thin black lines. The arrow indicates the direction of the connection, leading from the most powerful actor to the actor, it is overpowering. If both actors contribute equally to a connection, the interdependency between them is marked with two squares. However, all connections have to be regarded as interdependencies. Therefore, Figure 19 highlights powerful actors in two ways: Firstly, the simple number of connection, an actor is contributing to and secondly, the number of connections an actor is dominating.

The additional light grey items indicate actors which have not been identified in this chapter or entities which have not been activated and connected to the actor-network by the identified actors, yet. Hence, Figure 19 does not illustrate the complete actor-network of Arctic traditional knowledge (see Chapter 2).

possess a special kind of knowledge: traditional knowledge.

By defining traditional knowledge and indigenous people, eleven actors of the actor-network of Arctic traditional knowledge were identified. These ANT-actors are illustrated in Figure 19 which represents an essential part of the actor-network around traditional knowledge – but does not claim to be exhaustive nor complete (see Chapter 2 for detailed explanations). The chosen colours demonstrate belongings to the social (red), natural (blue) or mental (yellow) sphere. Important hybrid-structures are marked with the merging of two colours. Besides, Figure 19 outlines the network-connections that are identified in Chapter 4.2. Hence, it allows the postulation of powerful actors of the network of "Arctic traditional knowledge" firstly, by identifying the connections an actor is contributing to and secondly, by identifying the connections, that lead from a certain actor to other actors within the network. According to the first criterion, powerful actors contribute to more connection than over-powered actors. Hence, the following ranking occurs: "Internal Social Factors" (highest number of connections), "Access to "Basic Materials"" / "Practices of Cultural Rites and Exchange of Knowledge", "Existing Knowledge" / "Economic Structure" / "Access to the Land and Natural Conditions", "Political Rights" / "Climate", "Changing Habitats of Flora and Fauna" / "Science" / "Extraneous Social Factors" (lowest number of connections). According to the second criterion, connections lead from powerful actors to over-powered actors. Thus the following ranking results: "Climate" and "Political Rights" (with all connections leading from these actors to other actors), "Extraneous Social Factors", "Changing Habitats of Flora and Fauna", "Practices of Cultural Rites and Knowledge Exchange", "Access to the Land and Natural Conditions" (with a majority of connections leading from these actors to other actors), "Existing Knowledge", "Science", "Internal Social Factors", "Economic Structure" and "Access to "Basic Materials" (with a majority of connections leading to these actors from other actors).

By combining both used criteria, the identified power-relations of the network of Arctic traditional knowledge are illustrated in the following ranking, starting with the most powerful actor: Practices of cultural rights and knowledge exchange / political rights / climate, access to the land and natural conditions / internal social factors / extraneous social factors / changing habitats of flora and fauna, existing knowledge, access to "Basic Materials" / economies and science. Hence, this final ranking emphasised the importance of mental actors, but also the tight connectivity between all Arctic spheres which is outlined in the following chapters.

4.2.2 Exploring interdependencies within the network

According to the conventional definitions, as they are given above, traditional knowledge mediates flows between the natural, social and mental sphere. Simultaneously, it is being created and transformed by such interdependencies itself. Whereas some of the identified shifts occur in the Arctic, others evolve on a global or at least regional scale. Therefore, the concept of traditional knowledge includes different spatial scales. Furthermore, the existent traditional knowledge has been passed down for generations which implies the involvement of different temporal scales. Consequently, the developed methodological concept suits the investigation of this Arctic resource and of its network-connections that interweave of physical geography and human geography.

In order to analyse interdependencies within the network of Arctic traditional knowledge, climate (change) is selected as a starting point. Climate change is a key factor that determines the development and alteration of traditional knowledge, since it changes the environment of the knowledge-owners. However, before outlining the strong bond between climate and traditional knowledge, it has to be underlined that also non-climatic parameters, such as poverty, globalization and socio-cultural shifts are challenging the peoples and their knowledge in the High North (Ford, 2012).

The lifestyle of indigenous peoples is tightly bonded to their surrounding environment, because natives use resources from the land on a day to day basis, resulting in a constant interaction between people and nature (connection: ***Access to the Land and Natural Conditions*** – *Access to "Basic Materials"*). In doing so, indigenous are forced to respond to even slight environmental changes which they identify through the action "reading the land" and the recognizing of unusual shifts (connection: ***Existing Knowledge*** – *Access to the Land and Natural Conditions*). Although most indigenous people are able to identify such variations, particularly younger members with less experience need the help of elders to frame their observations. In this course, observations are translated into new knowledge. Hence, a strong link between the generations is essential within a community (Davidson-Hunt and Berkes, 2003). Shaping the younger people's perception, of what is important when observing the land and how to observe it, is also a crucial possibility for elders to share their traditional knowledge (Berkes, 2009) (connection: ***Internal Social Factors*** – ***Practices of Cultural Rites and Knowledge Exchange***).
This particular component of traditional knowledge, namely to interpret knowledge as a process, rather than an accumulation of pure information, is significant with regards to climate change – simply because no knowledge is existing about global warming that could have been passed down from earlier generations (connection: *Existing Knowledge* – ***Climate***). Therefore, processes of

climate change function as examples to analyse the adaptive capacity of TK and of its knowledge-holders (Berkes, 2009).

Moreover, the strong dependence on the land implies that environmental risks are inseparable connected with socio-cultural changes and therefore also with the community wellness (Flint et al., 2011) (connection: *Internal Social Factors* – ***Access to the Land and Natural Conditions***). Due to shifting weather, snow and ice conditions and a changing place-identity, the mental health of indigenous peoples is endangered (Cunsolo Willox et al., 2014). As an example, when the Innu settled down in Labrador (Canadian Arctic), instead of continuing to practice a nomadic lifestyle, a decrease of the physical and mental health of the community members was registered (Samson and Pretty, 2006). Overall, particularly the rising consumption of modern, fabricated food lead to multiple aggravations of the health situation of the indigenous population in the Arctic (Bersamin et al., 2006).

Following up the interview-questions (Is the youth interested in TK? Do they practice their cultural tradition? If yes, how?), demonstrates that an integration of the youth in this constantly changing relationship between climate change and traditional knowledge is crucial – also to scientists. Analogue to elders, young members of indigenous groups have lived on the land for their whole life and are therefore able and moreover predestinated to not only identify current shifts, but also to be aware of adaptive strategies. Furthermore, the youth also witnesses from socio-cultural changes that challenge their communities and question the identity of natives (Petrasek MacDonald et al., 2013) (connection: *Science* – ***Internal Social Factors***).
To complement the interview question: Besides the youth, also elders are highly affected by climate change, particularly in terms of guaranteeing their human rights (Begum, 2012) (connection: *Internal Social Factors* – ***Political Rights***). Consequently, a strong bond between the youth and the elders, as well as an implementation of the needs of both groups, are essential to face current challenges and to maintain the aspired lifestyle of indigenous peoples in the Arctic.

To conclude under ANT aspects: Humans as ANT-actors link the Arctic resource "Traditional knowledge" and the ANT-actor "climate change". Indigenous peoples whose lifestyle is determined by both are predestinated to establish this connection. However, everyone, having access to traditional knowledge, is theoretically able to bond it to climate change. Still, the scientific focus is so far laid on the First Nations, since they are the original owners of the traditional knowledge about the High North.

Due to global warming, the Arctic's environment is constantly changing, forcing the knowledge-holders to adapt their mental resources to the novel situation. However, with any adaptation comes the gaining /activation of new, but also the loss / inactivation of old knowledge. For example, if a certain skill is no longer applicable or a geographical place is not suitable for hunting anymore, the knowledge about it will not be passed on to the following generations. Hence, it gets disconnected from the actor-network and is therefore lost. In addition, existing knowledge will also get disconnected from networks, if people are willing to adapt it, but simply lack the time to practise and live the knowledge-content (connection: *Existing Knowledge* – ***Internal Social Factors***).

As briefly touched above, within the globally rising interest in the recently changing climate lies a growing scientific potential of traditional knowledge (connection: *Science* – ***Climate***). Yet, different factors, such as power imbalances or limited access to it, have lead to confined participation of indigenous peoples within climate change science (Cochran et al., 2013) (connection: *Science* – ***Political Rights***).

In ANT-terms: scientists function – on the positive side – as spokespersons for indigenous peoples of the High North. Scientific findings illustrate Arctic changes which are originally caused outside of the northern polar region (connection: ***Science*** – *Existing Knowledge*). Hence, science communicates the induced environmental and social shifts to people who are responsible for these developments and the caused (financial) aftermaths to protect the Arctic from such alterations (connection: ***Science*** – *Economic Structure*). On the negative side, scientists spread the image of indigenous peoples as solely being an object of scientific studies (Martello, 2008).

However, combinations of traditional knowledge and conventional scientific methods have the possibility to benefit both: indigenous peoples and scientists (Green and Raygorodetsky, 2010; Weatherhead et al., 2010). Hence, such combinations increase their impacts on politics, economics, social and environmental developments, since they merge different ways of thinking.

Traditional knowledge offers particularly possibilities to function as baseline data or as historical climate data. Furthermore, it has to be regarded as knowledge of experts on a local scale that supports the formulation of prospering research questions and appropriate hypotheses. Besides, traditional knowledge also functions as a community based monitoring process. Hence, it enables the identification of evolving impacts on Arctic communities and their adaptation capacity on long time scales (Riedlinger and Berkes, 2001).

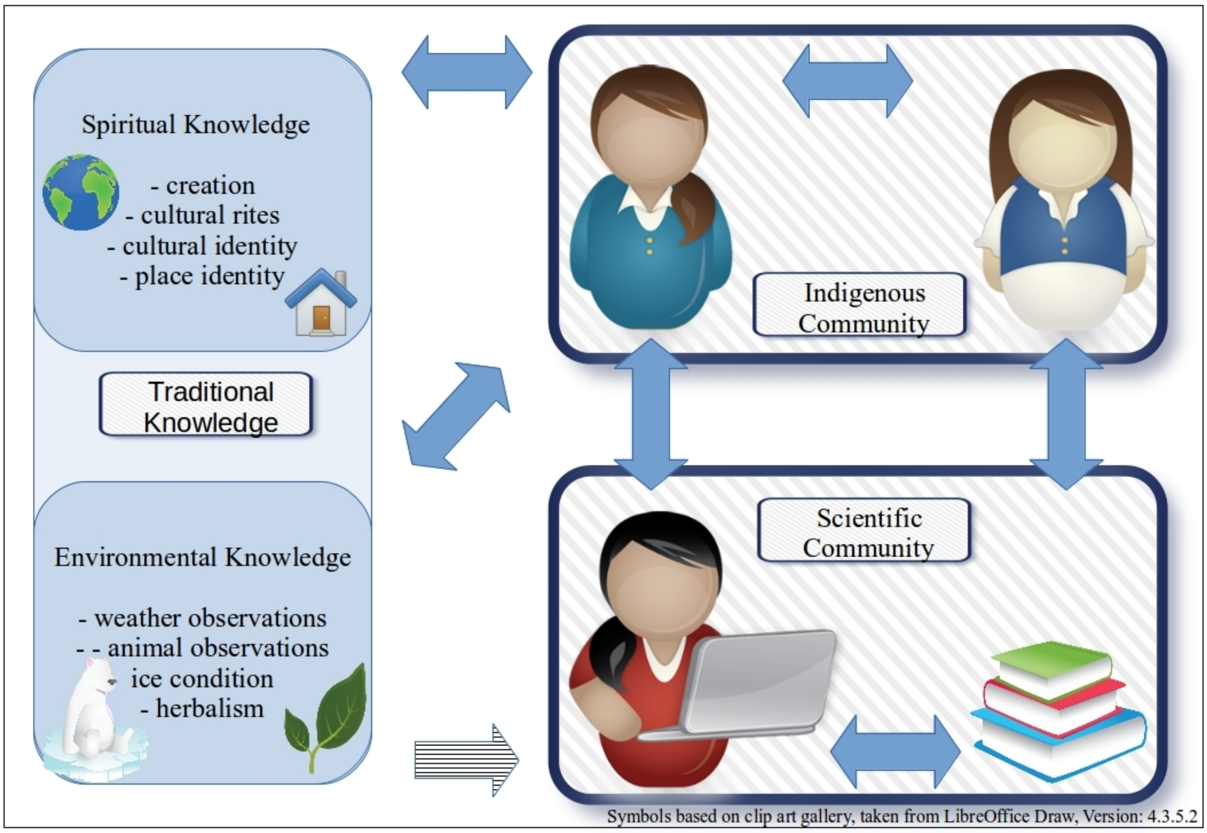


Figure 20: Sharing of traditional knowledge within the indigenous and scientific community

Traditional knowledge can be interpreted as a merging of spiritual and environmental knowledge. Hereby, environmental knowledge involves for example observations of the environment, by indigenous people and scientists. In contrast, spiritual knowledge has to be shared through mainly personal contact, as for example through talks or dances. A scientist can get access to this particular part of traditional knowledge, if a knowledge-holder is expressing it to the scientist, who than translates it into written documents, for example. Vice versa, a scientist and / or (written) translations of traditional knowledge affect indigenous communities, since they interpret and spread the mental knowledge of natives.

However, traditional knowledge does rarely exist as written documents, yet. Hence, it is primarily necessary to translate the existing knowledge into a form which is manageable and easily exchangeable, in order to simplify its implementation into scientific processes. So far, a prior study is often required, before traditional knowledge can be implemented into scientific surveys. As a consequence, methods of social science are needed for the pre-studies, for example to create suitable questionnaires or interview structures. Other methods include the organisation of workshops or collaborative field projects (Huntington, 2000). The outcomes of these methods have then to be translated, to get applied in natural science. Hence, according to ANT the mental resource traditional knowledge gets mediated by at least five actors: the knowledge-holder, the scientist who assembles the data during a prior study, the second scientist, who applies the data, the resulting scientific report which combines the data in a new way (which might not suit the original intentions of the knowledge-holders) and the readers of this report. Furthermore, the investigation and appliance of traditional knowledge requires a merging of physical geography and human geography and therefore the developed methodological concept.

When traditional knowledge is shared with scientists (see Figure 20), it enters a foreign contexts – on a legal but moreover on a social scale (connection: ***Practices of Cultural Rights and Knowledge Exchange – Extraneous Social Factors***). However, particularly natural scientists seem to measure the value of cooperation with indigenous peoples in output oriented units. Social scientists, in contrast, tend to focus on the social characteristics of the relationship between knowledge-holders and researchers, by using for example political or social frameworks (Williams and Hardison, 2013). Yet, a combination of both value systems is often missing so far.

In addition, there are other ways, in which a merging of traditional knowledge and science is difficult. Firstly, traditional knowledge is based on a holistic way of interacting with and observing the environment, while scientific methods use hypotheses to translate natural processes (Lewis et al., 2009). Hence, the direct comparison of traditional knowledge and research findings is problematic, since the observations are usually not undertaken under similar time frames or spatial scales. Therefore, scientific findings and traditional knowledge often differ from one another. Yet, to label one of them as being wrong should not be the intention. Contrariwise, diverging results enable the identification of new and prospering research fields or at least novel insights into analysed topic (Huntington et al., 2013, 2004a, 2004b). Secondly, although community engagement is often aspired, there are still multiple situations, in which research priorities and community interests differ significantly. This resultes in solely a slight increase of community engagement during the latter half of the century. Hereby, indigenous influences varies amongst different research fields, organizations and geographical areas (Brunet et al., 2014). Thirdly, in some cases, the lack of cooperation between scientists and knowledge-holders lead to the feeling of shared knowledge being abused to benefit the people who "stole" it from the indigenous owners (Smith, 1999). Consequently, not only the methodological and technical aspects of the collected data and its management have to be considered, the underlying philosophy, namely its social, cultural, political,

environmental and economic characteristics, require recognition as well (Pulsifer et al., 2014).
To evolve a prospering relationship between a researcher and members of the community, several parameters are essential – an important one is the dedicated time. It determines the level of presence of the researcher within the community and his ability to communicate with, listen to, respect and understand the native population. As a result, the feeling of trust can evolve. Paired with genuine collaborative efforts, it leads at first to a productive exchange of knowledge and therefore to knowledge gain on both sides (Tondu et al., 2014).

To conclude, traditional knowledge benefits scientists, global society and of course native Arctic peoples. However, knowledge itself is described as an ongoing and ever-changing process. Hence, these mental entities are forced to adapt to novel situations, particularly on local levels. As has been pointed out, climate change is particularly responsible for such adaptations of the mental sphere's parameters. Since the latter is always connected to human beings, access to (traditional) knowledge determines the vulnerability and adaptive capacity of Arctic peoples. Therefore, the following outlines, how these two factors interweave the natural, social and mental sphere.

Vulnerability and adaptive capacity are contrary outcomes of the exposure of a community to (natural) hazards, including climate change, on the base of the existing ecological, social, political and economic conditions (Ford et al., 2006). Hence, the vulnerability of a community is determined by its exposure to risks which is caused by both: Global warming and the communities adaptive capacity to handle such threats (Ford and Smit, 2004). Hereby, traditional knowledge possess a key role, particularly in connection with the health of indigenous peoples (Ford, 2012) (connection: ***Climate*** *– Internal Social Factors*).
The development of adaptive strategies to prevent a community from getting exposed to hazards, is therefore essential to reduce its vulnerability. So far, Arctic communities share a long history in successfully adapting to climate change and environmental shifts. Therefore, their tested strategies function as an accumulation of information, engagement and solutions (Maldonado et al., 2013) (connection: ***Existing Knowledge*** *– Access to "Basic Materials"*). However, recent climate change might overburden the Arctic's population, due to its fast and deep reaching transformations (Ford and Smit, 2004). Moreover, their ability to adept to former environmental shifts does not guarantee effective adaptation to future alterations (Berkes and Jolly, 2002).
In addition, a high adaptive capacity does not automatically implement the establishment of

effective adaptation actions. As an example, a lack of political engagement to delve into climate-induced impacts on a local level is often found (Ford et al., 2011). While, in general, governments tend to implement adaptation strategies in terms of long-term planning, adaptations from individual or households are characterised as reactive responses towards existing stimuli. Hence, the latter approach is referring to actual climatic variabilities (Berrang-Ford et al., 2011). Paired with the missing political engagement of indigenous peoples, these different approaches open up potential to initiate actions that do not meet the actual needs of the native population (connection: ***Political Rights*** – *Access to "Basic Materials"*).

Identified responses of community members are often behavioural, leading to a minimization, sharing or avoiding of threats. While most of these strategies have been used before by indigenous peoples, they are now forced to apply them more often than they used to, causing an increase of their significance on a daily life base (connection: ***Existing Knowledge – Practices of Cultural Rites and Knowledge Exchange***). Consequently, the ultimate ability of a community to adapt to climate change induced risks depends on seven factors, amongst them the communities' access to traditional knowledge and land-based skills, such as hunting. Furthermore, the social structure of the group, as well as their flexibility in terms of gaining food from the land determine their adaptability. Moreover, the flexibility in the groups' overall resource use, the existing economic support and institutional assistance are crucial in this context (Ford et al., 2007, 2008).

Hereby, institutional aid is particularly crucial. However, it requires purposeful procedures that are determined by observations and the needs of the native population. Moreover complaisant implementation, since such actions intervene into the daily lifestyle of Arctic peoples (Cameron, 2012). Consequently, the cultural dimension of climate change and especially the way it alters the sense of places have to be respected and integrated into future prosperous adaptation planning (Adger et al., 2012) (connection: ***Political Rights*** – *Practice of Cultural Rites and Knowledge Exchange*). Moreover, there is also a lack of sufficiently investigations of the effectiveness, consistency and feasibility of the undertaken efforts. Hereby, particularly parameters such as the connection to various existing stressors, different policy priorities and effectiveness on long time frames have to be taken into account (Ford and Pearce, 2010).

To conclude, particularly the concepts of vulnerability and adaptation offer new insights into the network connections around Arctic traditional knowledge. Their tight bond between recent and future challenges also underline the connectivity of mental resources on different time scales.

Furthermore, these two concepts enable the illustrating of traditional knowledge through applying the Actor-network services approach. Hence, Figure 21 outlines the various services that are provided by Arctic traditional knowledge.

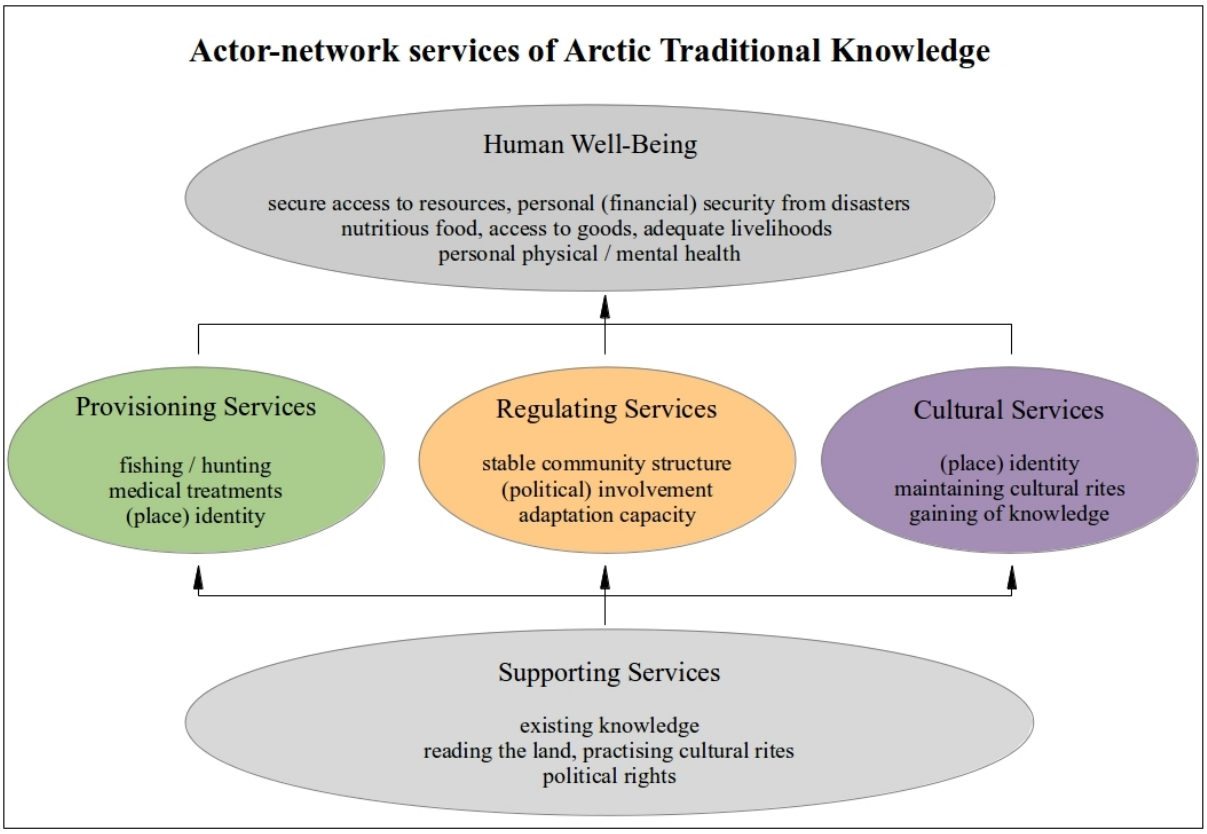


Figure 21: The actor-network services of Arctic traditional knowledge

By enlarging the traditional ecosystem-services approach with benefits, provided by the social and mental system, the methodological concept of Actor-network services is created.

4.2.3 Applying the concept of Actor-etwork services

Figure 21 complements Figure 19 by visualizing the wider connectivity of traditional knowledge within the concept of Actor-network services. Global warming always functions as a driving factor, but it also interacts with social, political, economic and cultural shifts that simultaneously affect the lifestyle of indigenous peoples in the High North. For example, the cited literature in this chapter often connects climate change with future food security and the mental health of indigenous peoples. Consequently, the argumentation to focus on interdependencies between natural and social factors, instead of solely climate change, to investigate the vulnerability and adaptive capacity of the First Nations is comprehensible.

The supporting services which enable the development, adaptation and applicability of traditional knowledge are direct conclusions from the given definitions: the overall ability and the general possibility to “read the land” and the “practising of cultural rites”. These two factors shape the existing traditional knowledge and are therefore essential to the Actor-network services, provided to its knowledge-holders and society in general by this mental resource.

Although it has been outlined how traditional knowledge and science interact and how the indigenous community itself is determined by the existing knowledge, this mental resource has been labelled mainly as a local resource so far. In order to support the previous statement that resources must involve interdependencies on different geographical scales, two examples are given according to the applicability of traditional knowledge: hunting activities and tourism in the High North. Hereby, the concept of actor-network services of traditional knowledge describes the remaining connections that are illustrated in Figure 19 and particularly their interdependencies with human well-being. Furthermore, a global geopolitical context is involved into the outlined analyses. Hence, with this step, all four spheres which affect Arctic resources are involved: global nature, Arctic nature, the Arctic social sphere and the global social sphere.

4.2.3.1 Hunting in the Arctic and the EU Seal Ban – connections between Arctic spheres and the global social sphere

Hunting is labelled as a provisioning service of traditional knowledge in the Arctic in this thesis. Successful hunting provides a community with food and enables the practices of cultural rites (connection: ***Practice of Cultural Rites and Knowledge Exchange** – **Access to “Basic Materials”***). Moreover, it contributes to the stability of the community structure (connection: ***Access to “Basic Materials”*** – *Internal Social Factors*) and shapes the economic potential of indigenous peoples. However, in nowadays (2015) hunting activities are not only altered by climate change induced environmental shifts and the resulting differing applicabilities of existing knowledge (connection: *Access to “Basic Materials”* – ***Climate*** and connection: *Access to the Land and Natural Conditions* – ***Climate***). Today (2015), hunting requires knowledge and skills, time, money and a legal base.

Marine mammals maintain to be an important (food) resource for indigenous communities as well as for non-indigenous people in the Arctic. Due to climate change, the habitats of these species change (connection: ***Changing Habitats of Flora and Fauna*** – *Access to "Basic Materials"*) which has deep impacts on the practised hunting methods and the livelihood of the hunters and their families as a consequence (Hovelsrud et al., 2008) (connection: ***Changing Habitats of Flora and Fauna*** – *Practice of Cultural Rites and Knowledge Exchange*). Factors including the currently rising air / water temperature and the variable sea ice conditions challenge native marine mammals in the High North. This includes different whale and seal species that serve as traditional hunting prey. The competition of local species for habitats is simultaneously intensified by seasonally migrating species which are able to survive in Arctic habitats for a longer period under recent circumstances (Moore and Huntington, 2008) (connection: ***Climate*** – *Changing Habitats of Flora and Fauna*).

Hunters adapt their strategies according to the season. As an example, Inuits trace and track caribous and seals in summer. On the contrary, the seal hunt during winter is mainly determined by observing a seal's blowhole, while the caribous spend this season outside of the Arctic region. Consequently, the whole lifestyle of hunters is adapted to this seasonality. Hence, Inuits are being detached from the settlements in summer and centred around their residential villages in winter (Wenzel, 2000) (connection: *Internal Social Factors* – ***Changing Habitats of Flora and Fauna***).
Moreover, hunting is a precious cultural experience, where the relationship between the hunter and the animal is often regarded as being collaborative, with the latter giving itself to the hunter and therefore deserving a respectful treatment in return (Fienup-Riordan, 1994). Consequently, an alteration of the environment leads – again – to shifts of the socio-cultural system of indigenous peoples and therefore to a transformation of existing traditional knowledge. If regarded as an evolving system, the gathering, sharing, interpreting and applying of traditional knowledge is significant for the co-management and adaptive management of marine mammals on a local (community), municipal and national level (Dale and Armitage, 2011; Danielsen et al., 2014) (connection: ***Changing Habitats of Flora and Fauna*** – *Economic Structure*).

Besides the actor "climate change", the European Union caused a major political and social impact on the seal hunt in 2009, when it adopted the European Seal Trade Ban ("Regulation (EC) No. 1007/2009 of the European Parliament and of the Council of 16 September 2009 on trade in seal products," 2009). The European Seal Trade Ban applies to all seal products that are produced within or imported into the EU (Hossain, 2013). By prohibiting for example meat, skin, fur or blubber, the ban affects mainly three exporting states: Canada, Norway and Iceland (Fitzgerald, 2011). In addition, Greenland's inhabitants and its economy are also impacted (connection: *Economic Structure – **Political Rights***).

In ANT-terms: The European Seal Trade Ban, as a political instrument, influences particularly the actors: Political rights, access to the land, practice of cultural rites and exchange of knowledge, changing habitats, internal and extraneous social factors and access to "Basic Materials". In this thesis, the ban is used as an example to interweave an essential cultural activity with environmental changes and altering global leitmotifs.

Besides endangering the general international trade between the EU and Canada (de Ville, 2012), the ban is responsible for a vanishing of the international seal product market. Such products were / are for example produced by Canadian Inuits. Although the recent ban includes a specific clause, which excludes the purchase of seal products that benefits the Inuit communities, it is still likely that the ban restricted their economic and cultural rights (Cambou, 2013) (connection: ***Economic Structure – Practices of Cultural Rites and Knowledge Exchange***).

Hereby, particularly the missing definition of "indigenous" hinders the appliance of the ban, simply because it is not clarified, who is indigenous and therefore exempted from the regulations (Sellheim, 2014). Yet, it is worth to mention that the Canadian government has often supported and advocated the traditional hunting methods of Inuits on a global level (Fergurson, 2011).

However, conflicts between seal hunters and seal protectors existed in Canada decades before the current EU ban was established. Especially the dependence of some Inuit communities on the selling of ringed seals' (*Phoca hispida*) skin intensified such conflicts since the end of World War II (Wenzel, 1987). By selling the skin, natives ensured to possess the financial funds to maintain their traditional lifestyle in a modernized Arctic, where money as a monetary unit gained essential importance within indigenous communities. Besides, the drastic economic and cultural impacts on the Inuits subsistence system have already been demonstrated by the implementation of the European Union Sealskin Ban in 1983 (Wenzel, 1996) which lead to a first collapse of the international sealskin market (Pelly, 2001).

In general, hunting is expensive today (2015). It costs not only money, but also time and requires suitable circumstances and adaptable knowledge (Wenzel, 2005). Therefore, selling hunting products to earn cash and practising an indigenous lifestyle are merged within the same process: subsistence hunting. Hence, it has to be considered that hunting for money involves also cultural rites. As an example, providing food from the land enables sharing activities amongst the community and avoids the need to buy expensive food in stores. In addition, mental resources such as knowledge about the land, self-esteem and mental health are gained and shared amongst the community (Condon et al., 1995). Besides, hunters shape the community they live in. Hence, particularly the hindering of earning money through this traditional activity ultimately handicaps social and cultural benefiting (connection: *Internal Social Factors* – ***Economic Structure***).

Yet, one activity may be excluded from this postulation: sports hunting of polar bears (*Ursus maritimus*), which live in all five Arctic states. Trophy hunting not only offers financial opportunities to Inuit communities (Freeman and Wenzel, 2006), it also links traditional knowledge with the another factor, created by - amongst others – Germans and other Europeans: tourism.

4.2.3.2 Traditional knowledge and tourism in the Arctic – additional connections between Arctic spheres and global spheres

The particular branch of tourism which is influenced by traditional knowledge is determined by the ANT-actors: political rights, access to the land, practice of cultural rites, changing habitats, access to basic materials. The media and its important role in promoting tourism are neglected in the next sections, since it does not influence the connection between traditional knowledge and tourism directly. However, the media alters indeed the picture, people possess about native Arctic peoples.
Regarding the Actor-network services of traditional knowledge demonstrates that tourism belongs to the provisioning services of this mental Arcitc resource. Tourism provides the native population with an income and enables the sharing of their lifestyle and culture. Therefore, it is tightly interwoven with aspects of human well-being, including the enabling of access to basic materials for good life or security from personal disasters and a stable community structure.
In order to link tourism and traditional knowledge, solely some types of tourism can be taken into account. The next sections therefore highlight ways, in which tourists directly affect indigenous peoples, for example by providing economic values.

The international tourism sector is growing throughout the whole Arctic, except for the Russian Arctic and some Canadian parts (see Table 8 for overnight stays in selected Arctic regions in 2014) (CAFF, 2013; United Nations Environment Programme and International Ecotourism Society, 2007). An international tourist is defined, in general, as a person, who visits a foreign country for a time period between one night and one year. Hereby, the main activity cannot involve the fulfilling of a remunerated activity which is financed by an organisation or a person at the chosen destination. The same criteria apply to a visitor, except that his travels do not exceed 24 hours in length. A domestic tourist on the other hand travels within his country of residence (Hall and Saarinen, 2010; World Tourism Oranization, 1991).

Table 8: Overnight stays in hotels and guesthouses in selected Arctic regions in 2014

(Data from Official Statistics of Finland (OSF), 2014; State of Alaska et al., 2015; Statistics Greenland et al., 2015; Statistics Iceland, 2015; Statistics Norway, 2015; The Swedish Agency for Economic and Regional Growth and Statistics Sweden, 2015)

	Number of overnight stays
Alaska	9,663,000 (Assuming every visitor stays 5 nights, number of visitors 1,932,600)
Norway (Finnmark, Nordland, Troms, Svalbard)	2,367,149
Iceland	2,787,254
Sweden (Norbotton)	2,191,442
Finland (Lapland)	1,708,497
Greenland	209,715

The areas, in which indigenous peoples live, are mostly remote and peripheral, why they offer unique potential to the tourism sector. Such areas provide the image of untouched nature, vastness and loneliness, exploratory spirit and inimitable experiences that many tourists seek for (Fay and Karlsdóttir, 2011; Hall and Saarinen, 2010; Mason et al., 2000a; Stewart et al., 2005). Further capabilities to develop indigenous tourism lie in the precious heritage and history of indigenous peoples, as well as in the production of marketable handicrafts (Smith, 1996) (connection: ***Internal Social Factors*** – *Extraneous Social Factors* and connection: *Economic Structure* – ***Access to the Land and Natural Conditions***).

So far, important tourist regions, for example in the Canadian north are owned or claimed by the native population. This can have huge impacts on the economic aspects of tourism and its co-management system in these areas. Hence, there is an explicit possibility that native communities profit directly from visitors and tourists (Notzke, 1999a) (connection: ***Extraneous Social Factors*** – *Economic Structure*).

Again, economic profit has the potential to support a traditional lifestyle and therefore the application and maintaining of traditional knowledge. However, indigenous tourism is still a niche product, depending on effective market realism, for example through the promotion as a conceptual theme of a complete region. Its noteworthiness also requires a high level of professionalism, to successfully compete with other tourism sectors. Moreover, suppliers of indigenous tourism have to be integrated into the indigenous networks. Hence, they have to obey to the rules and rites of the natives of the High North (Notzke, 2004) (connection: ***Extraneous Social Factors*** – *Access to "Basic Materials"*).

Today (2015), especially two branches of tourism depend on the traditional knowledge of the Arctic's indigenous peoples: sport hunting and wildlife spotting. Since both recreations require similar knowledge, they can substitute each other, in the absence of one activity (Chanteloup, 2013). Although it seems logical in the first place, developing ecotourism can create difficulties between the tourists and indigenous hosts in this case, due to different views on nature and its relationship with humans (Hinch, 1998).

To trophy hunt polar bears (*Ursus maritimus*) was promoted in Canada since the 1970s and got fully established within indigenous communities as a result of the vanishing market for seal products (Notzke, 1999b). In 1968 a quota was set for the polar bear hunt in Canada. Hereby, the overall number is shared between the communities. However, the quota does not represent a fixed number. Instead, it gets adjusted to the actual hunting results on a yearly basis (Wenzel, 2008) (connection: ***Political Rights – Access to the Land and Natural Conditions***).

As an example, the Nunavut community Clyde River hosts hunters from Mexico, Israel, European countries, such as Spain and particularly from Germany (Freeman and Wenzel, 2006). Hereby, the trophy hunt does not only provide financial support for a community, it also strengthens the existing traditional knowledge. The guidance of tourists requires not only the actual hunting skills, but also knowledge about travelling and survival methods on the land (connection: ***Extraneous Social Factors*** – *Existing Knowledge* and connection: ***Access to the Land and Natural Conditions*** –

Practice of Cultural Rites and Knowledge exchange). Consequently, it contains a high level of cultural rewarding (Notzke, 1999b).

The given examples of interdependencies between the EU and an Arctic mental resource on a political and economic level provide an insight into the wider actor-network of Arctic traditional knowledge. Furthermore, the high connectivity of the knowledge-holders and their surrounding environment gets further emphasized.

Yet, especially the seal ban pinpoints a development which rapidly changed the daily life routine of indigenous peoples. The lifestyles of native Arctic peoples depend on political, social, economic and ecological parameters. Therefore, the discussion, if the developed theoretical approach suits investigation of traditional knowledge is based on exactly these parameters. In this course, it is also outlined, if the methodological concept creates valuable options to develop possible scenarios for the future alteration of traditional knowledge.

4.2.4 Discussion and conclusion

Explorations of the actor-network around traditional knowledge started with a qualitative literature review. Based on the outcomes of this review, eight interview questions were designed that followed a semi-structured interview style. In March 2014, ten interviews were conducted in Montreal, Canada. As two major outcomes, the different definitions of indigenous people and the different definitions of traditional knowledge were selected to serve as the foundation to identify actors. Afterwards, the concept of actor-network services was applied to investigate the various definitions within the network. So far, the theoretical framework offered valuable possibilities to identify and investigate connections and power relations between involved actors (see Figure 19). However, there is still a lack of statements about the future development of traditional knowledge.

4.2.4.1 Developing future scenarios for alterations of traditional knowledge

ANT and the developed theoretical approach are not suitable to develop future scenarios, per se, as has been discussed in Chapter 2. However, the methodological concept identifies current and past interdependencies between the social, mental and natural spheres. In respect to the actor "Traditional Knowledge", particularly historical developments comprise crucial importance.

The knowledge of indigenous peoples is depending essentially on their daily lifestyle which can be interpreted as a heritage from their past. Climate has always been a key factor for a successful life in the Arctic and will continue to determine possibilities to practice and maintain indigenous cultures in the future. Hence, exploring past climatic circumstances offers possibilties to identify similarities between past, recent and prospective developments.
The ancestors of today's indigenous peoples took favour of specific climatic circumstances to reach the High North. Although the Arctic is often described as a harsh environment to live in, people settled there already during the Late Pleistocene, as archaeological discoveries on the Yana River in Siberia have shown (Pitulko et al., 2004).

4.2.4.2 Reaching the Arctic – a changing climate enables the first peopling of the High North

Several ways were and / or are available for humans to enter Arctic regions without travelling on water. One possibility is to cross the European continent in order to reach Scandinavia and northern Europe. During the Riss-Würm interglacial – the Eemian – a warming lead to a spreading of coniferous forests, being able to grow as far north as the Arctic Ocean reached south under these climatic conditions. Although the northern parts of West Siberia were submerged, coniferous forests reached the shores of the Arctic Ocean throughout Russia and Scandinavia. This transformed northern Europe into an area where people who were originally not adapted to Arctic environments could settle, as archaeological sites in Northwest Russia proved (Kozlowski and Bandi, 1984).
Another Russian province – Siberia – represents the destination for people travelling into the Arctic via Asian routes. First evidences of human presence in Siberia during the Upper Paleolothic can be dated back to 43.0 to 39.0 thousand years before present. In contrast, around 13.0 thousand years ago whole northern Asia was colonized (Vasil'ev et al., 2002).
Besides, from 43.0 to 12.0 thousand years ago, Siberia and Alaska were connected by an ice-free strait: the Beringian refugium. The lower levels of the Bering and the Chukchi Sea lead to an enlargement of the Siberian subcontinent in its northeast, enabling theoretically the peopling of the Americas (Volodko et al., 2008). However, archaeological sites date the first peopling of Northern Alaska, Northern Canada and Greenland to only 6.0 thousand years from present (Raghavan et al., 2014).
Yet, the existence of an ice-free corridor is being said to be responsible for human migration into the Americas which turns Beringia and the northeast of Siberia into key-regions of understanding

human's ways into the New World (Slobodin, 1999).
However, also coastal routes might be possible as an alternative travel path (Vasil'ev et al., 2002). This statement is also supported by found evidences of travel routes from the Aleutian Islands to the Americas (Raghavan et al., 2014).
Although the Beringia refugium enabled travels from Asia to North America, it was disconnected from Central North America around 11.0 thousand years from now (Kitchen et al., 2008). Hence,

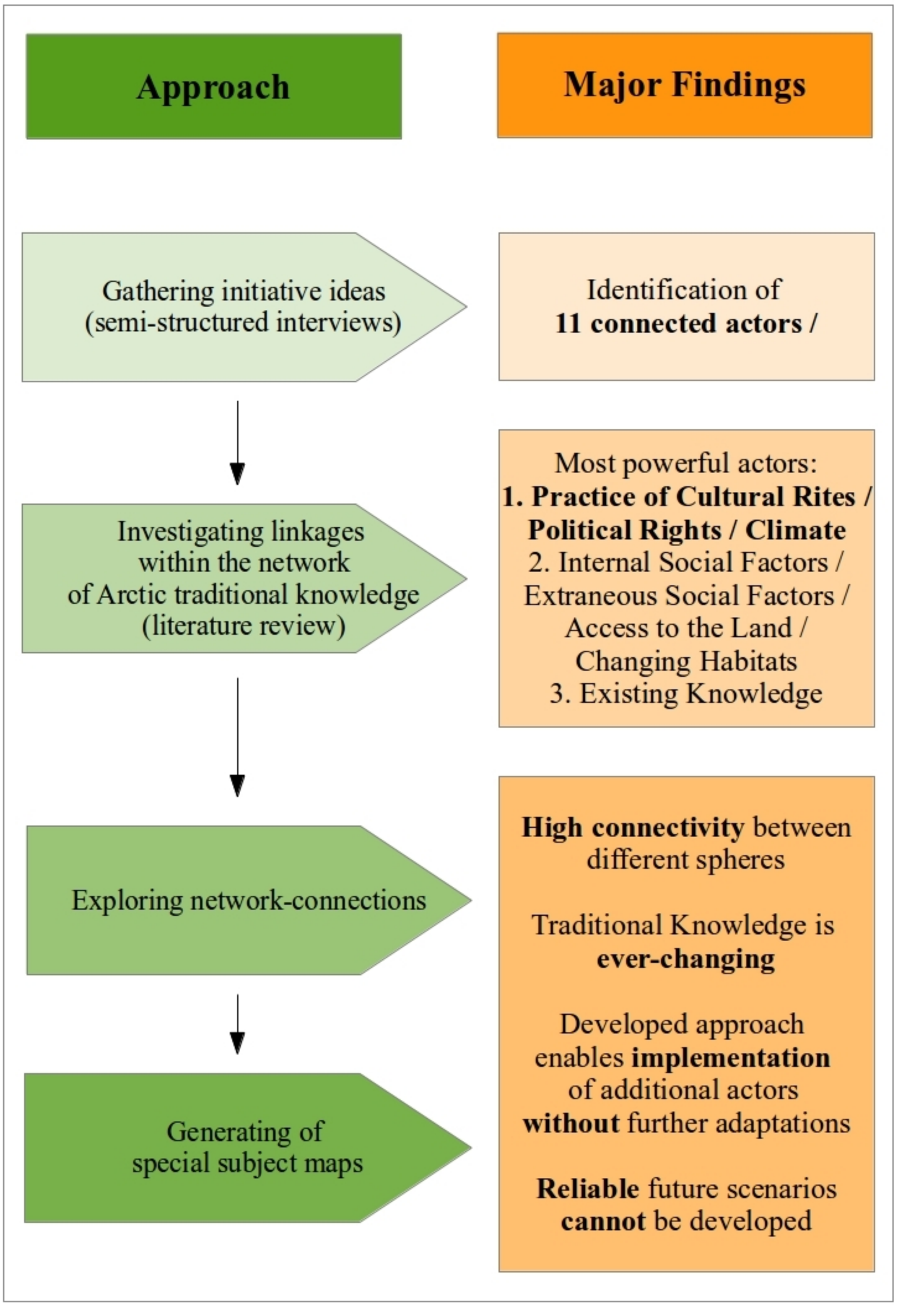


Figure 22: Conclusion of Chapter 4.2

the people were forced to continue moving eastwards into the Canadian Arctic and towards coastal Greenland which were colonized about 5.0 thousand years before present (Dixon, 2001). Yet, it is not exactly clarified when Paleoindians arrived on the continent and how the remaining part of the Americas, especially the southward areas, got peopled (Fiedel, 2002).

The named travel routes into the High North have a clear connection to the predominant climatic circumstances. The latter is responsible for the creation of land bridges that enable humans to conquer new living space. Simultaneously, a change of the Arctic's environment, due to a warmer climate, eases the adaptation of the lifestyles of peoples which life originally in areas south of the Arctic. In addition, the cited dates prove that the peoples, living in the High North, had to adapt their way of life to constantly changing climates – particularly to a warming of the Arctic.

To conclude (see Figure 22), the methods, used in this thesis – namely working with literature and conducting semi-structured interviews – offer a deep insight into the actor-network of traditional knowledge and disclose power relations, but they do not enable the development of future scenarios. Based on the findings of this Chapter, it is questionable if reliable scenarios can be developed after all:

Firstly, the identification of any method that provides the postulation of future scenarios in this context could not be fulfilled in this thesis. Even if researchers work closely together and personally with indigenous peoples, scientists can only record present and past adaptations. Although researchers also identify the needs and requirements of a community, they are solely able to recommend certain actions or developments. As has been emphasized during the conducted interviews, to generalise the dealing of an indigenous community with its knowledge is impossible. Even within communities, people have more or less interest and appreciation for their cultural heritage and their knowledge. Therefore, interviewing knowledge-holders is also not a suitable method to sufficiently forecast what will happen to traditional knowledge in the future.

Secondly, knowledge is an ever-changing construct. It is created through the constant loss and gaining of mental entities. As has been pointed out earlier, the inclusion of new knowledge is part of traditional knowledge. In contrast, contents of traditional knowledge which are not applicable anymore, will be let forgotten. For example, if the existing knowledge does not provide the ability to "read the land" or to forecast the weather and therefore loses its suitability for hunting, there is no need in passing it on. While such developments implement the loss of knowledge, they also contain the creation of new mental entities that get shared amongst the community. Hence, as long as the knowledge-holders possess mental entities which are connected to their mental heritage – which they have to be – traditional knowledge will exist in the High North. It is not possible that it vanishes completely.

Thirdly, the multi-dimensionality of this network creates unpredictable and extremely fast alterations within the connected spheres. As an anthropologist explained in his interview (corresponding quotation): While hunters used to utilise dog sledges, they are now driving with snow mobiles to their hunting grounds. On the one hand the technology allows them to arrive there in a shorter amount of time, but on the other hand it is also more expensive and so is the munition for the gun that is used to shoot the animals. Consequently, indigenous people need to earn money, in order to practice their hunting skills. However, having a job results in having less time to go on the land and less time on the land results in poorer hunting skills, because the hunter lacks the constant training. Hence, traditional knowledge gets lost. Another suitable example has been given in this thesis by the outlining of the aftermaths of the European Seal Trade Ban. Yet, the impact factors of such (spontaneous) shifts cannot be implemented in any methodological concept beforehand.

Particularly the given second and third statements link back to the developed methodological concept. While most conventional methods tend to reduce the complex aspects and diverse content of traditional knowledge, the developed theoretical approach enables the identification of its multi-dimensionality. By respecting the connected actors and interdependencies, the novel methodological concept creates at least awareness for the complexity of this mental resource on local, regional and global scales. Hence, it contributes to the wider understanding of its actor-network which not only benefits researchers, but indigenous peoples as well, particularly if it is applied to sensitise stakeholders.

Yet, it is not denied that personal contact with indigenous peoples will release additional actors and interdependencies which could not be identify within this thesis. However, a theoretical approach and a methodological concept have been developed that have the possibility to integrate new network-members without further adaptations.

4.3 Case study 3: Agricultural production as an emerging Arctic resource

Abstract Case study 3

Objective 3:

Test the developed theoretical approach and the methodological concept

The resource "Agricultural production" is selected to test the developed theoretical approach, because it is merely characterised by its absence within vast Arctic areas and as a consequence its dependence on global production lines. Yet, climate change currently alters agricultural activities in the High North which simultaneously rises and threatens the political, social, cultural and economic independence of Arctic inhabitants.
The actor-network of "Arctic agricultural production" is explored with a qualitative approach. Hereby, eleven (powerful) network members of this network are identified. Due to the lack of scientific publications about the recent development of agriculture in the Arctic, illustrations of GIS-data solely fulfil minor supporting tasks.

Most important outcomes:

1. *The actor-network of Arctic agricultural production mediates flows between the natural, social and mental sphere.*
2. *The ability of the concept of Actor-network services to develop possible future scenarios for the resource "Agricultural production" is fairly limited – partly due to a lack of scientific data.*
3. *The concept of Actor-network services identifies a high connectivity between the three selected resources.*

The first and second case studies focused on global and regional present Arctic resources. To further involve local importances and future impact potentials, "Agricultural production" serves as the third and last case study to apply the developed theoretical approach and methodological concept.
Agriculture is an essential and traditional resource all over the world – except the Arctic. In the

High North agriculture is not practised as intensively as in other areas, due to the determining temperature conditions and permafrost existence. However, in the course of climate change, such limiting factors are decreasing, which creates possibilities to cultivate plants, for example. Furthermore, the agricultural potential of the Arctic gets enlarged, if livestock, fishing, herding, gathering and hunting are also regarded as components of this resource.

A linkage between shipping and fishing, hence marine agricultural activities, has been drawn before in Chapter 4.1. Therefore, the following concentrates on terrestrial agricultural activities, namely on farming and animal husbandry. This decision offers additional insights into the network of agricultural production of the High North and evolves also possibilities to link agriculture and traditional knowledge in the Arctic. Besides, the activities farming and animal husbandry exemplify bonds between processes of climate change and processes of political geography and geopolitics – hence, they strengthen again the demand for transdisciplinary research between physical geography and human geography. Hence, the following further enlarges the overall understanding of Arctic actor-networks.

Analogue to the previous case studies, four concrete steps are conducted to analyse the actor-network of "Arctic agricultural production":

1. Identifying connected actors of Arctic agriculture,
2. Exploring interdependencies within the network,
3. Applying the concept of Actor-network services and
4. Outlining the suitability of the developed methodological concept.

The identification of social, natural and mental actors which are connected to agriculture in the High North are interwoven with local circumstances. However, agricultural production has to be regarded as an emerging resource of the Arctic. Therefore, most of the previously used methods do not suit this novel constellation. Hence, the impulses were solely gained from four broad literature reviews with different focuses:

1. A qualitative literature review to gain initiatives for the following investigations,
2. A second literature review to identify local areas and their agricultural potential,
3. A third literature review to identify local areas and their potential for animal husbandry and
4. A fourth literature review to outline the future potential of this Arctic resource.

The following sections outline the outcomes, starting with a detailed description of the initiative literature review. Based on its findings, connected actors within the actor-network of Arctic agricultural production are identified.
Such identified actors are named in italic type and capital letters within brackets on their first appearance in the following. Reasonable clusters of actors will be made, whenever constructive. Additionally, interdependencies between the actors are outlined. Whenever a connection is mentioned within the text, the contributing actors are named in brackets and in italic type. The actor which is over-powering the connection is highlighted in bolt style. All identified actors and determined connections of Chapter 4.3 are illustrated in Figure 25. Analogue to the previous case studies, the outlined actor-network does not claim to be complete.

4.3.1 Identifying connected actors of Arctic agricultural production

First valuable initiatives about the actor-network of Arctic agricultural production in general were gained from a qualitative literature review of the ACIA (2004). Based on these references, keywords were chosen for a first quantitative literature review, which included "Arctic*", "agricultur*", "farm*", "husbandr*", "cultivat*" and "cropp*".
The search listed 98 hits in November 2014. With a consideration of titles and abstracts, suitable articles that dealt with Arctic agricultural production were selected. Yet, the majority of these articles referred to fisheries, aquaculture and commercially grown fish species. Hence, the used keywords were modified, which provided 24 results at the same date from the same data base. However, the majority referred again to fisheries, aquaculture and commercial grown fish species (see Table 9 for an overview of fisheries of European Arctic states in 2013).
Since this approach did not lead to sufficient results, a different method of literature review has been chosen: Hereby, the ACIA (2004) and the AHDR (2004) were scanned again for initiatives about terrestrial agricultural production in the Arctic. Whenever suitable references were identified within the reports, they were scanned for additional references. The scanned material offered further hints for different literature resources and so on.
However, there is – in general – only a very restricted amount of scientific publications about Arctic farming in particular. In contrast, public media, including newspapers, regularly report about this development. Yet, this identification underlines its urgency, but also the current lack of scientific involvement. Particularly the latter is also responsible for the clearly limited availability of GIS-

data. Hence, creating special subject maps only fulfils minor supporting tasks in the following.

Table 9: Fisheries of European Arctic states in 2013

(Data taken and adapted from *Nordic Council of Ministers, 2014)*

	Economic value (in million €)	Fisheries (in 1,000 tonnes)	Most important product and percentage of total catch
Norway	1,595.4	2,081.2	47.83% Codfishes
Iceland	927.0	1,339.9	62.35% Sea water fishes (excluding Cod- and Flat fishes)
Denmark	405.8	668.4	75.9% Sea water fishes (excluding Cod- and Flat fishes)
Greenland	114.0	100.7	46.57% Crustaceans and molluscs
Faroe Islands	284.0	487.2	61.15% Sea water fishes (excluding Cod- and Flat fishes)

In contrast to Arctic shipping and traditional knowledge, farming and terrestrial animal husbandry in the High North have mainly local importance and are, with exception of general political requirements on a European level, regulated by the respective state. Hence, the following merely concentrates on local impacts, for example in Greenland, Norway and Russia. Yet, one additional example has been selected that links global agricultural production with processes of climate change and processes of political geography in the Arctic: the Global Crop Diversity Trust's Svalbard Global Seed Vault. Conxequently, all four contributing spheres (global nature, Arctic nature, Arctic society and global society) are involved into the analysis of this chapter.

Two basic agricultural systems are distinguished in the Arctic: Firstly, productions on a large scale with commercial purpose and secondly, subsistence agriculture. In the High North, commercial agriculture supplies areas with high population density and therefore regions which are accessible by surface infrastructure. In addition, remote Arctic areas depend on this agricultural system as well, although they also benefit from subsistence systems (Juday et al., 2005) (actor: *SOCIAL STRUCTURE*).

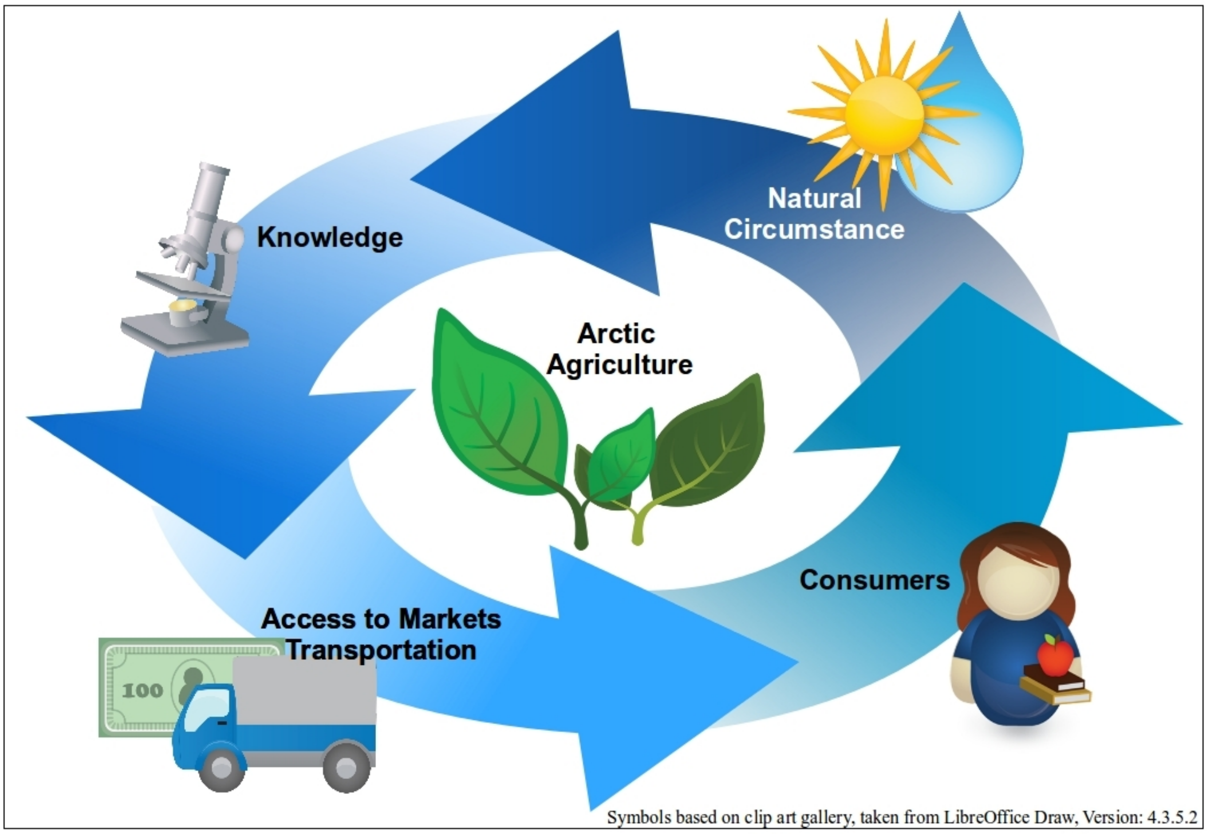


Figure 23: Selected components of Arctic agricultural production

This first system is dominated by livestock in general. Hereby, mainly cattle, sheep, goats, lambs, hogs, poultry and reindeer are raised to provide meat, wool and diary products. Cool-season crops, such as alfalfa or clover, are cultivated to supply animal feed or to be directly consumed by humans. Other products involve small grains, such as wheat, and oilseeds. Vegetables, including potatoes, beans or peas, fruits and raw products which are used to produce spices or beverages, are moved within this system (actor: *CULTIVATED SPECIES*). Hence, the systems' customers are supplied with a great variety of food which is merely produced outside of the High North (Hovelsrud et al., 2011; Juday et al., 2005).

Yet, such a variety can only be granted with a constantly increase of the food production, followed by vast and deep reaching changes of the former natural environment. In conclusion, such systems cause major environmental damage, for example by the intensive use of fertilisers. Particularly the used fertilisers evolve feedback loops within the natural sphere which even harm the existing agricultural production itself (Foley, 2005). Besides, these arguments link back to the socio-economic metabolism and the involved concept of the colonisation of nature. Yet, it also

demonstrates how important flexible system-boundaries are for the applies methodological concept and therefore strengthen the decision to enlarge this approach from human ecology.
In addition, if genetically engineered crops with a higher temperature tolerance (actor: *TEMPERATURE*) are introduced to Arctic systems, their impact on the original environment could be huge. As already pointed out in Chapter 4.1, cultivated species alter the marine ecosystems in the High North – hence, analogue terrestrial developments are likely.

In addition, a worldwide operating system has multiple ways to be influenced by climate change (actor: *CLIMATE CHANGE*), either during the production lines or during transportation efforts (Rosenzweig and Parry, 1994) (actor: *ECONOMIC STRUCTURE*). Hereby, the tight connectivity between local and global social and environmental processes are highlighted again. Agriculture is an excellent example, to point out that Arctic societies depend heavily on global shifts. Since the majority of the consumed goods are produced outside of the High North, the Arctic's population is determined by global developments – analogue to processes of climate change (see Figure 23).

Yet, although global production lines serve the majority of the people living in the Arctic, it is the subsistence agriculture, which dominates the agricultural production within the High North (Juday et al., 2005). The term "subsistence production" refers – by definition – to a system or unit which produces all needed goods, without using services from external consumers or producers. The produced outcomes are then consumed by the systems compartments, without selling any of it. Such an idealistic system would represent the purest form of subsistence and is hardly found anywhere in the world, particularly not in the Arctic (Hovelsrud et al., 2011).
Instead, it is more realistic to recognise different degrees of subsistence production or commercialisation of agricultural systems (Wharton, 1970). Barnett et al. (1996) define subsistence agriculture as a system with hardly any monetary output and just minor purchased input. The authors further state that the main output of farming and associated activities is directly consumed and fulfilled by the producers, for example by a family or a household (Barnett et al., 1996). Yet, the direct consumption of outputs always leads to a lack of surplus which is mainly responsible for ongoing and constant efforts that are taken in a subsistence system to maintain food security throughout the year (Lee, 1998).

Subsistence systems are often linked to traditional lifestyles, which are connected to indigenous peoples in the High North (actor: *MENTAL AND TECHNOLOGICAL EQUIPMENT*). Hence, agriculture always involves traditional hunting and gathering activities. Consequently, the components which create these traditional activities, such as access to the land, the economic system or the community structure, are involved within the actor-network of "Traditional Knowledge", as demonstrated in Chapter 4.2. Hereby, it has also been outlined that investigations of such Arctic resources have to involve an entire (not necessarily western influenced) social, spiritual and economic system (Wolfe and Walker, 1987) (actor: *SOCIAL STRUCTURE*).

In the Arctic, a mixture between subsistence and commercial systems is often found. Although both systems differ, Arctic people tend to move regularly between one or the other. Hereby, the nexus between time, money and maintaining the skills which are needed to live in subsistence are – again – crucial (Berman, 1998). Especially since people prefer to live in subsistence systems, when certain traditional lifestyles are maintained (Juday et al., 2005).

Hence, approaches to investigate agricultural activities in the High North, have to respect the flexibility of its inhabitants. Selected methods have to be adaptable to global production lines, but also to the requirements of people, practising subsistence agriculture.
The developed methodological concept of Actor-network services fulfils these postulations. It has proven its adaptability during the previous case studies in which components of subsistence systems were already integrated. Besides, this methodological concept suits the aspired investigations and the needed comparison of global and local agricultural alterations.
To further outline its suitability, terrestrial farming and animal husbandry are serving as examples of Arctic agricultural production. Hereby, the involvement of the different spheres and the tight interdependencies between them are further emphasized.

4.3.2 Exploring interdependencies within the network – Farming and animal husbandry in the Arctic

Particularly farming represents a small business sector of the Arctic's economy in general. However, it has to be regarded as being fundamental for Arctic Eurasian settlements and the people of southern Greenland (Hovelsrud et al., 2011; Thostrup and Rasmussen, 2009). With respect to regional differences, global warming has the potential to influence Arctic agricultural production in a positive way, although the overall alteration of the latter will be minor for the Arctic's economic sector (Eskeland and Flottorp, 2006; Hovelsrud et al., 2011; Larsen et al., 2014) (connection: ***Climate Change*** – *Economic Structure*).

The recently induced increasing of temperatures in the High North leads to a northward enlargement of areas, suitable for farming and animal husbandry (actor: *AGRICULTURAL AREA*). Consequently, such movements include a spreading of crop suitability zones and also a rising crop production of northern agricultural areas (connection: ***Temperature*** – *Agricultural Area*).
Besides warmer temperatures, improved water management is projected for Northern Europe, due to higher precipitation (actor: *PRECIPITATION* and connection: ***Climate Change*** – *Precipitation*). This further optimizes agricultural processes in polar regions, for example by reducing the dependence on irrigation (Falloon and Betts, 2010) (connection: *Economic Structure* – ***Precipitation***). Increased precipitation also intensifies the runoff that alters the distribution of nutrients and the nutrient cycle in general, which has the potential to cause advantages for agricultural systems (Bjerke and Tømmervik, 2008; Hovelsrud et al., 2011).

Furthermore, the growing season will be lengthened, in areas, where the snow cover (actor: *ICE AND SNOW COVER*) is reduced and / or with an earlier melting of snow (Hovelsrud et al., 2011) (connection: *Cultivated Species* – ***Ice and Snow Cover***). In addition, if a stable snow cover does not exist up to a length of at least 120 days, fungi will not develop. Missing fungi reduce crop harming, which will therefore benefit farming activities in these regions (Hovelsrud et al., 2011) (connection: ***Ice and Snow Cover*** – *Economic Structure*).
Yet, the term “growing season” refers to the particular time of the year, in which plant growing can occur theoretically and is therefore not synonymous to “growing period”, when plant growing actually takes place (Linderholm, 2006). However, if the theoretical ability for plant growing is enlarged, the potential for the actual growing phase to increase is provided as well.

Yet, climate change induced shifts also comprise negative effects on Arctic agriculture. As has been outlined before, interactions and connections within the four contributing spheres (global nature, Arctic nature, Arctic society and global society) cannot be labelled as advantages or disadvantages per se. Instead, it is actor based, if an alteration has positive or negative outcomes. The interdependencies between Arctic agricultural production and processes of climate change highlight this statement again. Hereby, the need for the methodological concept is demonstrated, since it identifies connections, without having to label and judge them beforehand, which is also demonstrated in Figure 25.

A growing of the precipitation increases floods and rain-on-snow events (Grønlund, 2009; Hovelsrud et al., 2011; Juday et al., 2005). In alliance with intensified runoff from glaciers, snow melting, refreezing of snow and thawing of permafrost (actor: *PERMAFROST* and connection: ***Climate Change*** – *Permafros*t) rise frost damage and consequently economic loss (connection: ***Permafrost*** – *Economic Structure*) (Aalheim et al., 2009; Grønlund, 2009; Hovelsrud et al., 2011; Putkonen and Roe, 2003). Besides, a missing snow cover cannot fulfil its sheltering and isolation purposes which causes an increased exposure of plants to factors, such as warm or cold winds and further contributes to frost damage (Bjerke and Tømmervik, 2008; Grønlund, 2009; Hovelsrud et al., 2011; Michelsen et al., 2014) (connection: ***Ice and Snow Cover*** – ***Temperature***).
An intensified runoff, in connection with changing nutrient cycles, can also be responsible for a higher transportation of contaminants into water systems, including lakes, rivers or the sea itself (Bjerke and Tømmervik, 2008; Hovelsrud et al., 2011). Furthermore, all named factors contribute to soil erosion (Grønlund, 2009; Hovelsrud et al., 2011; O'Brien et al., 2006; Øygarden, 2003).
The overall altering of the drainage system supports effects of soil waterlogging. These lead to anaerobic conditions and consequently to a reduction of plant growth (Bradley et al., 2005). In addition, wet soils challenge agricultural machinery (connection: ***Precipitation*** – *Mental and Technological Equipment*) and moreover support compaction damage of machined soil (Eitzinger et al., 2007; Finlayson et al., 2002; Hovelsrud et al., 2011; Montanarella, 2007; Webb et al., 2005).

Apart from nature induced impacts, a seclusion from markets, infrastructural deficits, the rather small population and issues concerning landownership (actor: *POLITICAL STRUCTURE*) challenge the emerging agricultural sector in the Arctic (Juday et al., 2005). Particularly the rising land fragmentation which is caused by a growing population in the Arctic contributes to such political challenges (connection: ***Social Structure*** – ***Political Structure***). As an additional outcome, environmental degradation is further increased (Morton, 2007).

To conclude, Schmidhuber and Tubinello (2007) point out that climate change will ultimately impact different dimensions of food security, including the availability of, the access to, the utilization of and the continuity of the provided food supply. Yet, the authors also stress the point that the development of food security will differ across time and regions and that it depends essentially on the socio-economic status of an affected country (Schmidhuber and Tubiello, 2007) (connection: ***Social Structure*** – ***Economic Structure***).

The Arctic consists of a diversity of social, political, ecological as well as economic systems. Hence, the different systems have to be investigated separately to identify their (future) potential in terms of agricultural activities. In the case of farming in the High North, Greenland serves as a suitable example. Greenland is characterised by outstanding climatic and social alterations, which are caused through a strong native population and a fast increase of air and soil temperatures, lately. Hence, vast changes of Greenland's agricultural system are possible.

4.3.2.1 First regional example: Farming in Greenland

Southern Greenland represents one of the regions in the High North, where the agricultural sector is expected to grow. It is projected that by the end of this century, conditions in Greenland can be compared to a climate which last occurred during the last interglacial period and therefore about 125,000 years ago. In alliance, the IPCC scenario A1B projects an annual warming of 5°C in the Arctic, with an across-model range of 2.8°C to 7.8°C (Christensen et al., 2007; Intergovernmental Panel on Climate Change (IPCC), 2014b; Masson-Delmotte et al., 2012).

Already today, there is a significant mass loss and acceleration of the Greenland ice sheet which even increased during the last decades (Intergovernmental Panel on Climate Change (IPCC), 2014b; Masson-Delmotte et al., 2012) (connection: ***Climate Change*** – *Ice and Snow Cover*). Extremely warm temperatures, occurring for example in 2012, lead to a maximum of 95 % of this ice sheet being affected by surface melting (Häkkinen et al., 2014). Consequently, an increasing of the overall mass loss, with a linear trend of 280 ± 58 GT/yr was observed in the southeast of Greenland during 2003 and 2013. In alliance, the highest acceleration with a linear trend of an amount of 25.4 ± 1.2 GT/yr^2 occurred in the southwest of the island during the same time period (Velicogna et al., 2014). Such a loss is essentially important for the coupled global climate system and especially for the global sea-level rise (Fyke et al., 2014).

Although recent climate change induced impacts increases possibilities for agricultural production in Greenland fjords, particularly during Arctic summers, farming and animal husbandry have already a long tradition on the island. These reaches back to the Norse who started farming around 985 AD. Beginning with Erıkur Rauðe Þorvaldsson (Erik the Red), Norse farmers fed a population of 3,000 to 6,000 people at its height. Their agricultural activities, such as rising sheep, cattle, horses or pigs, lasted until the beginning of the Little Ice Age which lead to the ultimate devise of the Norse. Since 1920, modern Greenland agriculture got initiated with the reintroduction of sheep farming (Bichet et al., 2013; Gauthier et al., 2010; Hansen, 1991) and recently, different groceries are grown in Southern Greenland. However, the therefore suitable area represents only one percent of Greenland's surface ("Greenland," 2014) (connection: *Cultivated Species* – ***Agricultural Area***).
Today (2015), potato and forage grass are the most important products, while cabbage and turnips bear only minor meaning (Michelsen et al., 2014). Experimenting with growing methods of different berries, such as strawberries or blueberries, is also undertaken (Markussen, 2012) (connection: ***Cultivated Species*** – *Economic Structure*). Besides, forestry is a common agricultural practice (AHDR, 2004).

With the beginning of 2013, the Chairman of Naalakkersuisut, the Government of Greenland, Kuupik V. Kleist stated that agriculture is a key-factor to the self supply of Greenland, particularly with vegetables (Kleist, 2014) (connection: *Cultivated Species* – ***Political Structure***). This statement does not only highlight the potential value of Greenland's agriculture, but also underlines its importance to Greenland's economic independence which is particularly needed to achieve the aspired independence from Denmark (Nuttall, 2008) (connection: *Economic Structure* – ***Political Structure***).

In order to achieve this goal, Greenland improved its agricultural sector. So far, potatoes are produced between 60° N and 61.5 °N, mainly in the southwestern parts of the island (de Neergaard et al., 2014). However, the cultivated area comprises a size of only 20 ha (Bach, 2013).
After being planted around the end of May until mid-June, potatoes can be harvested in about a month long period between mid-August to the middle of September (de Neergaard et al., 2014). In order to guarantee a successful seed germination, a minimum soil temperature of 7.2 °C is needed,

while the optimum germination temperature has a value of 18.3 °C (Isleib, 2012). The sort, cultivated most commonly, is called “solist” (Markussen, 2012) (*Solanum tuberosum L. cv. Solist*). It is round in shape, has a light yellow colour (“The European Cultivated Potato Database,” 2014) and above all, is an early sprouting potato (Markussen, 2012). In 2012, with its mild climate during spring and summer, over 100 tonnes of commercially grown potatoes have been harvested in the south of Greenland, doubling the production of 2008 (Scrutton, 2013) (connection: ***Temperature*** – *Cultivated Species*) (see Table 10 for an overview of agricultural crop and grain production in European Arctic States in 2013).

The currently rising agricultural production is further supported by the absence of serious plant diseases, such as potato late blight. In general, the low temperatures during winter and the microorganisms which are living in the local soils, are responsible for the non-appearance of such diseases. As a consequence, Greenland's farmers abstain from using pesticides and there is only limited crop rotation (Michelsen et al., 2014; Michelsen and Stougaard, 2011) (connection: ***Cultivated Species – Mental and Technological Equipment***).

Table 10: Five most important crops and grains of agricultural production in European Arctic States in 2013

The given numbers refer to the total agricultural production of the named states[6]. The respective potato production is marked in grey colour.

(Data taken from Nordic Council of Ministers, 2014)

	Denmark	Norway	Iceland	Sweden	Finland
1. Product (in 1,000 tonnes)	Ley and other fodder crops (25,114)	Ley and other fodder crops (2,409)	Ley and other fodder crops (366)	Ley and other fodder crops (4,873)	Ley and other fodder crops (7,371)
2. Product (in 1,000 tonnes)	Wheat / Barley (3,997)	Barley (480)	Potatoes / Barley (6)	Sugar beets (2,326)	Barley (1,904)
3. Product (in 1,000 tonnes)	Sugar Beets (1,994)	Potatoes (320)	no data	Wheat (1,869)	Oats (1,197)
4. Product (in 1,000 tonnes)	Potatoes (1,646)	Oats (214)	no data	Barley (1,862)	Wheat (869)
5. Product (in 1,000 tonnes)	Oleiferous plants (688)	Wheat (199)	no data	Oats (852)	Potatoes (622)

6 Please note that Denmark stands out in this ranking, due to its geographical position and the resulting dominance of its agricultural sector.

Potato fields are covered with acryl foil during the whole growth season (connection: *Mental and Technological Equipment* - ***Temperature***), such as the agricultural land around Narsaq (nearby Narsarsuaq), and Nanortalik. Both fields are located in fjords in the southwest of Greenland which are characterised by favourable climatic conditions. With this method, the mean air temperature underneath the foil constituted 9.8 °C in 2010 and 7.8 °C in 2011 which created a mean soil temperature of 13.6 °C in 2010 and 12.6 °C in 2011 (Michelsen et al., 2014; Neergaard et al., 2009). In comparison, the average air temperature in Narsarsuaq (Nanortalik) represents values between a minimum of 5.2 °C (4.0 °C) in May and a maximum of 10.3 °C (7.0 °C) in July (August) during the growth season (Danmarks Meteorologiske Institut, 2014; Müller, 1996).

When following the A1B scenario of the IPCC with its projected temperature rise (connection: ***Climate Change*** – *Temperature*), the growth season in these two towns could enlarge for a period of at least two months – one month before and one after the recent growth season. Additionally, April (mean temperature of -0.1 °C / 0.7 °C in Narsarsuaq / Nanortalik), June (mean temperature of 8.3 °C / 5.5 °C in Narsarsuaq / Nanortalik), July (6.5 °C in Nanortalik), August (mean temperature of 9.3 °C in Narsarsuaq), September (mean temperature of 5.5 °C / 5.8 °C in Narsarsuaq / Nanortalik) and October (mean temperature of 0.4 °C / 2.7 °C in Narsarsuaq / Nanortalik) (Danmarks Meteorologiske Institut, 2014; Müller, 1996) exceed the required germination temperature – at least part-time –, why the covering foil might not have to persist during the entire growth season (connection: *Mental and Technological Equipment* – ***Climate Change***).
Moreover, the projected temperature rise will not only enlarge the growth season, but also the area, suitable for agricultural production (connection: ***Temperature*** – *Economic Structure*). Such an increasing of the suitable area depends particularly on the previously named withdrawal of the ice sheet (connection: ***Ice and Snow Cover*** – *Agricultural Area*) and the mentioned thawing of permafrost (connection: *Permafrost* – ***Temperature*** and connection: ***Permafrost*** – *Agricultural Area*). As a consequence, also edibles which require higher temperatures in general, could be cultivated in these regions. Hereby, existing correlations between different macroclimatic parameters, including the mean annual temperature and the precipitation, further support the given statements (Rosbakh and Poschlod, 2014).

Yet, agricultural processes will continue be limited to fostered zones in Greenland, such as fjords. However, while farming is strictly limited to particular small regions with certain characteristics, other aspects of Arctic agriculture require several connected regions, each of them with different attributes. Animal husbandry, as an example, is determined by flexibility and frequently needed adaptations. Hence, additional connections around the activity "animal husbandry" in the High North are identified, in order to provide a wider understanding of the actor-network of Arctic agricultural production.

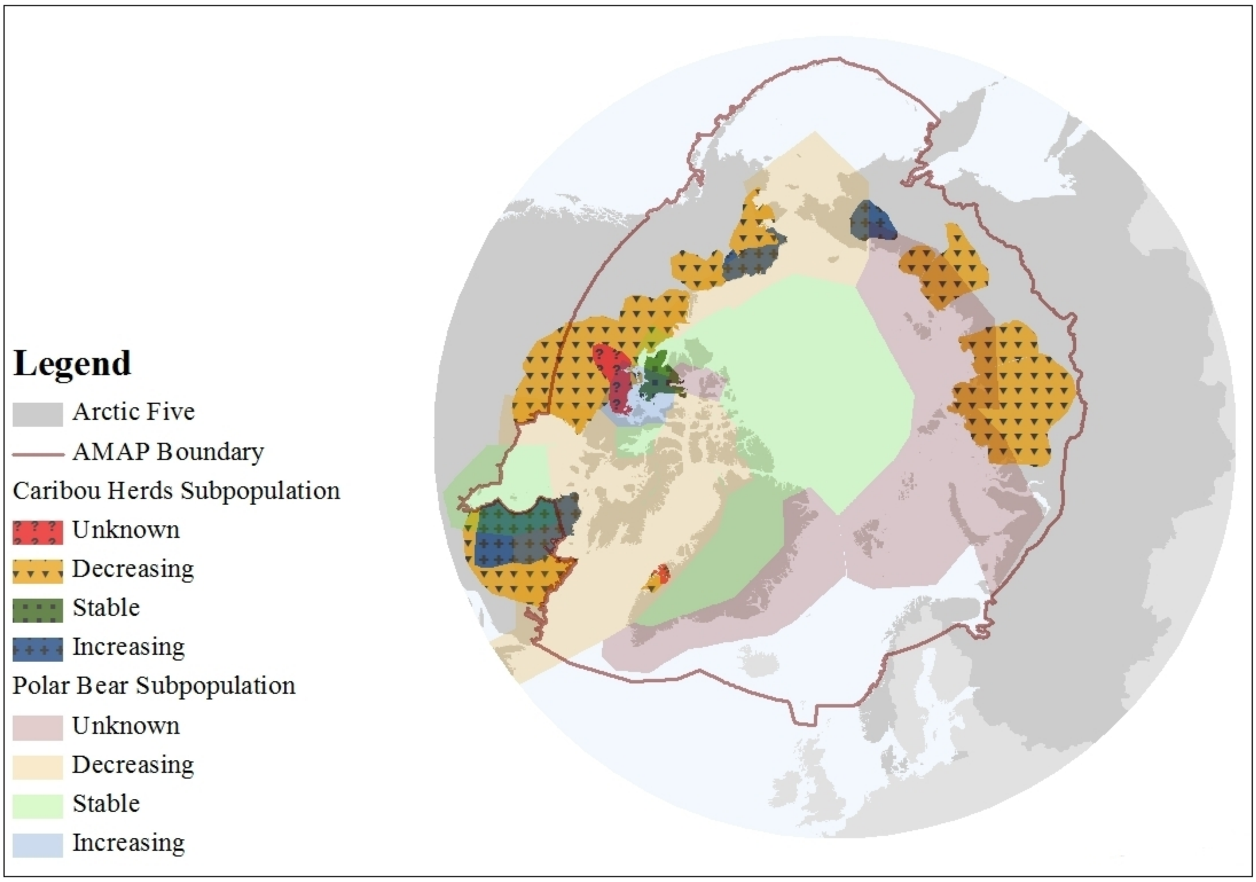


Figure 24: Population of polar bear and caribou

Please refer to footnote 2 (page 4) for an explanation why no scale is given within the figure.

References:

Background World Map: taken from ArcMap 10

AMAP Boundary: AMAP (http://www.amap.no/documents/doc/amap-area-gis/868)

Polar Bear: Conservation of Arctic Flora and Fauna (CAFF www.caff.is) working group of the Arctic Council, CAFF 2010 Arctic Biodiversity Trends: Selected indicators of change http://geo.abds.is/geonetwork/srv/eng/main.home?uuid=1f4afeae-8a06-4ac3-a01e-971b139a0f93

Caribou: Conservation of Arctic Flora and Fauna (CAFF www.caff.is) working group of the Arctic Council, CAFF 2010 Arctic Biodiversity Trends: Selected indicators of change http://geo.abds.is/geonetwork/srv/eng/main.home?uuid=4eaa2ba0-430d-4219-b5ef-30587a6afa19

4.3.2.2 Exploring additional interdependencies within the network – Terrestrial animal husbandry in the Arctic

Besides aquacultures and fisheries, particularly one animal is being present in the entire circumpolar north and represents therefore an important biological resource of the Arctic's terrestrial animal husbandry: caribou or reindeer (*Rangifer tarandus*). With a population of 8.8 million individuals, wild caribou as well as semi-domesticated reindeer contribute significantly to the economic, spiritual and social well-being of northerners and moreover to their overall cultural identity (Johnsen et al., 2010) (connection: ***Cultivated Species*** – ***Social Structure***). Additionally, this agricultural activity constitutes a valuable tourism branch in the European North (Vladimirova, 2011).

Large caribou and reindeer herds can be found in all Arctic states, including Iceland, Sweden and Finland. Both, wild and semi-domesticated herds migrate between the tundra, where they spend summer and fall, and the boreal forests (winter), which are located in sub-Arctic areas. Yet, exceptions of herds wintering on the tundra and therefore within the Arctic exist (CAFF, 2013). Hereby, wild and semi-domesticated herds compete directly for the same habitats, why a distinction between wild and domesticated groups cannot always be confirmed. Hence, it is possible that semi-domesticated individuals join wild herds (Syroechkovski, 2000) or that entire feral herds develop (Baskin and Miller, 2007). Such processes are supported lately by the intensity, with which reindeer husbandry is undertaken in the High North. Consequently, developments that create or transform existing herds are a result of the engrossed geographical space (CAFF, 2013) (connection: ***Economic Structure*** – ***Agricultural Area***).

While climate change is considered to have – in general – positive effects on Arctic farming, it is suspected to harm reindeer husbandry in contrast (see Figure 24 for habitats of caribou and polar bear). Such economic or cultural harming is particularly expected to take place during winter (Rees et al., 2008; Weladji and Holand, 2003) (connection: ***Climate Change*** – *Social Structure*). Possible consequences cover the full range from changing travel routes, to decreasing body conditions, to mass starvation and even to the extinction of local populations (Tyler, 2010; Vors and Boyce, 2009) (connection: ***Climate Change*** – *Agricultural Area*).

Moreover, warmer temperatures combined with a resulting higher forest productivity will restrict the availability of the main natural food resource of caribou and reindeer during winter: lichens. There is a strong negative correlation between lichens and the crown cover which determines the amount of light, reaching the ground. Higher forest productivity causes a rising density of the crown cover that reduces the ground light. Consequently, the competition with other species, including mosses which adapt to lower light saturation and ground moisture more successful than lichens, is intensified (Moen, 2008; Pharo and Vitt, 2000) (connection: ***Climate Change*** – *Cultivated Species*).
Another key parameter, restricting the forage of caribou and reindeer, is snow. Hence, changing winter weather (connection: *Precipitation* - ***Temperature***) has direct negative effects on the caribou density, especially if the population is growing during this phase or if the winter is characterised with high or low North Atlantic Oscillation (NAO) indices (Garcia et al., 2014; Tyler et al., 2008) (connection: ***Precipitation*** – *Agricultural Area*).
Particularly rain-on-snow events (connection: *Ice and Snow Cover* – ***Precipitation***), whose appearance are coupled with the NAO and the Pacific-North American pressure pattern (Rennert et al., 2009; Wallace and Gutzler, 1981), as well as seasonal melting have the potential to seriously harm the caribou and reindeer populations. They affect the animal's access to food, particularly during winter (Bartsch et al., 2010), when the caribou and reindeer suffer from an overall lack of food and the mortality rate is consequently increased (Helle and Kojola, 2008).
In the Arctic, eatable lichens are covered with snow most of the year, why caribou and reindeer are forced to dig for them. Therefore, the characteristics of the existent snow cover and the resulting difficulties, when digging for food, determine the size and demography of the animal population (Kumpula and Colpaert, 2009). After rain-on-snow events or melting processes, snow refreezes and therefore changes its structure, for example by compaction or by the development of ice crusts. Not only is digging through ice tiring the animal, it can also damage its hooves, making it vulnerable to infections (Rees et al., 2008). In addition, reindeer decrease their efforts to dig for lichens, if the snow cover exceeds one meter in depth (Bartsch et al., 2010) (connection: *Cultivated Species* – ***Precipitation***).

Since rain-on-snow events are linked to meteorological phenomenons on meso-scales, the affected areas are vast, in general (Bartsch et al., 2010). However, due to global warming, the region, impacted by such events, is projected to increase with a factor of 40% by 2080-2089, compared to 1980-1989. This results in an area with a size of $14{,}5x10^6$ km^2. Notably, western Russia and

Scandinavia, where reindeer herding is practised by indigenous peoples, belong to the key regions of increasing rain-on-snow events (Putkonen and Roe, 2003).
Hence, particularly the herders in these areas are going to be challenged. Therefore, regional examples of reindeer husbandry in Fennoscandia and Russia are outlined, in order to illustrate the existing economic structure and possible future impacts.

4.3.2.3 Second regional example: Reindeer husbandry in Fennoscandia and Russia

Eurasia's North and its ecosystems have been determined by reindeer for at least two million years (Forbes, 2010). Analogue to agriculture in general, reindeer husbandry contributes only minor to the Gross Regional Product, but is essential to reindeer herders, such as the Fennoscandian Sámi or the Russian Nenets (Hovelsrud et al., 2011). Hence, it is of great importance to indigenous peoples.

The Sámi population alone covers between 75,000 and 100,000 people, depending on the used definition, out of which 20,000 live in Sweden. 5 to 10 % of the Swedish Sámi are full-time or part-time reindeer herders (Kaiser et al., 2013). Yet, the centre of Sámi reindeer herding lies in the North of Norway, around Guovdageaidnu, where about 1,700 people and 93,500 reindeer are involved in this traditional industry – making Guovdageaidnu to one of the worlds largest reindeer herding region (Eira et al., 2013).
In contrast, the Yamal Nenets Autonomous Okrug in western Siberia is inhabited by approximately 600,000 reindeer and more than 14,500 people are working in this business (Magga et al., 2011). Already between 500 and 1100 AD, the Nenets and their ancestors began to harness reindeer on Yamal which turned into intensive reindeer herding after 1600 AD (Amstislavski et al., 2013). Yamal is currently prospering, with a growing reindeer population and rising numbers of nomadic people – the estimate of the latter even tripled during the last 300 years (Forbes et al., 2009).

However, such an increase of herding also requires natural and technical alterations – for example in terms of the provided forage. While reindeer used to eat natural forage, which grew within the areas of their travel routes, supplemental feeding, particularly during winter, is common practice today. In Finland, for example, this practice is undertaken since 1974 (Helle and Kojola, 1993). In addition, Finnish herders transformed their intensive herding system into extensive and loose free range herding, being capable since the 1960s, due to the usage of snow mobiles (Helle and

Jaakkola, 2008) (connection: ***Mental and Technological Equipment*** – *Economic Structure*). Yet, especially these changes in reindeer herding caused the animals to become wilder which lead, in combination with a persistent ice cover, hard snow and distinctive summers to serious losses of reindeer in 1972 and 1974 (Vuojala-Magga et al., 2011).

As has been outlined above, particularly rain-on-snow events support such a correlation of negative drivers that abet reindeer losses. The importance of weather and especially of the snow condition for reindeer herding is also underlined by the various expressions – over 300 are documented (Ryd and Rassa, 2007) – indigenous people use to describe the snow cover and its characteristics (Eira et al., 2013) (connection: ***Ice and Snow Cover*** – *Mental and Technological Equipment*). According to Sámi herders it is, for example, essential to identify the conditions around the first fall of stable snow – is it wet or dry, warm or cold – to reliably forecast grazing conditions during the upcoming winter (Riseth et al., 2011).

Yet, the indigenous ability to forecast the weather conditions are altering, due to global warming. For example, in the Yamal Nenets Autonomous Okrug an average rise of the mean temperature of 1-2 °C has been observed during the last 30 years. As aftermaths, unusual events, such as a premature break-up of the Se-Yakah River in spring 2005 or an icing event in spring 1999 put stress on animals and their herders which lead to a rise of the animal's mortality rates (Forbes et al., 2009). In addition, industrial development which is also enabled through warmer temperatures, involves an intensified blocking of traditional travel routes and consequently leads to the loss of grazing grounds or sacred cultural sites. Hereby, the installation of the Bovanenkovo field on Yamal serves as an illustrative example, where industry and herders compete for land and for its access (Degteva and Nellemann, 2013; Gazprom, 2014).
Hence, agricultural activities link culture and economy on different scales within the High North what further increases the multidimensionality of this actor-network. In alliance, Russian herders are facing an additional challenge since 1991: the reconstruction of rural economy which causes significant losses of reindeer in the majority of Russian herding areas. Except for the Yamal region, large declines have been identified throughout entire Russia. Numbers are analogue to data from Chukotka, where the former reindeer population of 500,000 shrank to only 130,000 remaining animals. However, from 1999 onwards a stabilisation, yet a partial improvement has been registered. Wild reindeer even proved to be less affected by human influence, mainly because their

Russian territory is large enough to avoid competition with domestic herds and also the confrontation with hunters. Still, declines remain to be particularly crucial, since reindeer continue to be one of the major local food supply in Russia's North (Baskin, 2005, 2000).

To conclude under ANT-aspects: With changing agricultural possibilities come altering social, political, ecological and economic parameters. As a consequence, herders have to develop adaptation strategies which develop from a merging of reliable and novel procedures, to cope with these shifts. Hereby, their traditional knowledge and its practical appliance is crucial to master such upcoming challenges (Vuojala-Magga et al., 2010). Particularly the detailed knowledge about reindeer behaviour, including their eating habits (Inga and Danell, 2012), will determine this development. Furthermore, the mental system behind traditional knowledge transforms the animal from solely being an economic object into a partner which implements the animal's personality and therefore a spiritual and cultural dimension (Vitebsky and Alekseyev, 2014) (connection: ***Social Structure – Mental and Technological Equipment***).
However, within the herder's traditional knowledge and mental system lies also additional potential for social and political conflicts, as examples from the northeast of Finland have demonstrated. Hereby, herders and nature conservationists have contrary opinions towards herding and the occupied space. Since nature conservation is highly politicised, such developments add new components to the actor-network of Arctic agricultural production. Consequently, the vulnerability of herders is an outcome of interactions within the network of climate change, traditional knowledge and political instruments (Heikkinen et al., 2012; Tyler et al., 2007).

In order to further demonstrate the involvement of (global) political processes within this network, a third regional example is chosen: The Global Crop Diversity Trust's Svalbard Global Seed Vault. Although this example goes far beyond regional political activities which concern reindeer herding, it links to an aspect, which has been named before: food security.

4.3.2.4 Excursion: The Global Crop Diversity Trust’s Svalbard Global Seed Vault – an Arctic agricultural project with global meaning

Food security is one of the recent challenges, mankind is facing in the Arctic, but moreover on a global scale. Increasing the agricultural production is a key-factor, the FAO (Food and Agricultural

Organization of the United Nations) names in their proposal of an integrative strategy to further reduce global food insecurity (FAO et al., 2014). In order to reach this aim, the knowledge about cultivable species and about the conservation of their seeds has to be enlarged. Hereby, DNA-storages provide necessary information through mediums, such as plant seeds. The manipulation and reading of the seed's DNA contributes to the development of novel (agricultural) methods, while at the same time, the world's most important agricultural plants are preserved. Apart from agricultural purposes, ex situ conservation has significant potential in preserving endemic (Arctic) plants, to ensure that they will not extinct. Another, also cost-minimizing, advantage of this approach is that the stored medium does not rely on active maintenance, as long as it is kept in a cold, dark and dry environment (Alsos et al., 2013; Anchordoquy and Molina, 2007; Bonnet et al., 2010; Fowler, 2008a; Goldman et al., 2013; Khoury et al., 2010) – such as the Arctic naturally provides.

In 1989 Norway launched its idea to install an international seed vault in Svalbard's natural permafrost and its thick rock with the purpose to conserve plant seeds as a global genetic resource (Middleton, 2011; Qvenild, 2008) (connection: ***Permafrost*** *– Mental and Technological Equipment*). Nearly twenty years later, on February 26, 2008, the Global Crop Diversity Trust's Svalbard Global Seed Vault began to operate as a preservation centre (Fowler, 2008b; Global Crop Diversity Trust, 2014; Sachs, 2009) which stores particularly seeds of plants that are listed on the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO, 2009; Li and Pritchard, 2009) (connection: ***Permafrost*** *– Cultivated Species*).

Although it was initiated and mainly financed by the Norwegian Government, the vault is currently co-managed by the Norwegian Ministry of Agriculture, the Global Crop Diversity Trust and the Nordic Genetic Resource Centre. It is located 130 meters up a mountainside (Hopkin, 2007) outside the village Longyearbyen and consists of a tunnel, 120 meters in length, connecting three separate vaults within an ice mountain. Its position shall not only secure the DNA-storage mediums, but also the vault itself, particularly from the projected climate change induced sea-level rise (Hopkin, 2007).
The storage has the capacity to conserve sample seeds of 4.5 million species (Swaminathan and Kesavan, 2012). Under the given circumstances – a natural low temperature of -6 °C which is artificially further reduced to -18 °C, and dry storage – the conserved seeds can be viable for several

hundred or even several thousand years. Hence, the conserved seeds represent the genetic diversity of species by the time, they were stored (Walck and Dixon, 2009). In ANT-terms: current (2015) natural conditions enable genetic diversity. Hence, the vault connects agriculture to an additional temporal scale: the future.

However, climate change might challenge the construction of the storage ultimately. Public media reported already in 2008 that the warming of the mountainside caused an enlarged thawing of permafrost and consequently a raising instability of the building (Seidler, 2008).
Particularly such reports link global spheres within a regional context. Hereby, global warming endangers a project with global political, economic and social meaning. However, the project is bonded to a regional geographical place, which shifts this development into a matter of geographical science and therefore into the need of the appliance of the developed methodological concept.

Moreover, the scope of the project adds a global meaning to agricultural processes in the Arctic, since even Germany has stored seeds in the vault on Svalbard (Westengen et al., 2013). Although the conservation of agricultural plants and plants in general does not directly improve Arctic agriculture, providing a secure access to seeds is still fundamental to any agricultural process. In addition, Arctic agriculture is with no doubt, part of the global agriculture and might prosper from this installation in the future. Hence, the vault connects the ANT-actor "Agricultural Production" with the Arctic and has therefore to be interpreted as an ANT-hybrid, mediating interdependencies between global agriculture and the Arctic. Therefore, it is now possible to illustrate the enhanced actor-network of Arctic agricultural production.

Figure 25 illustrates eleven ANT-actors and actor-groups within the network around Arctic agricultural production, with the latter being restricted to farming and terrestrial animal husbandry. Yet, the figure does not claim to be exhaustive nor complete (see Chapter 2 for detailed explanations). Analogue to the previous caste studies powerful actors are defined through the connections a certain actor is contributing to and through the connection that lead from this actor to other actors within the network. According to the first criterion, powerful actors contribute to more connection than over-powered actors. Hence, the following ranking occurs: "Cultivated Species" and "Economic Structure" (highest number of shared connections), "Climate Change",

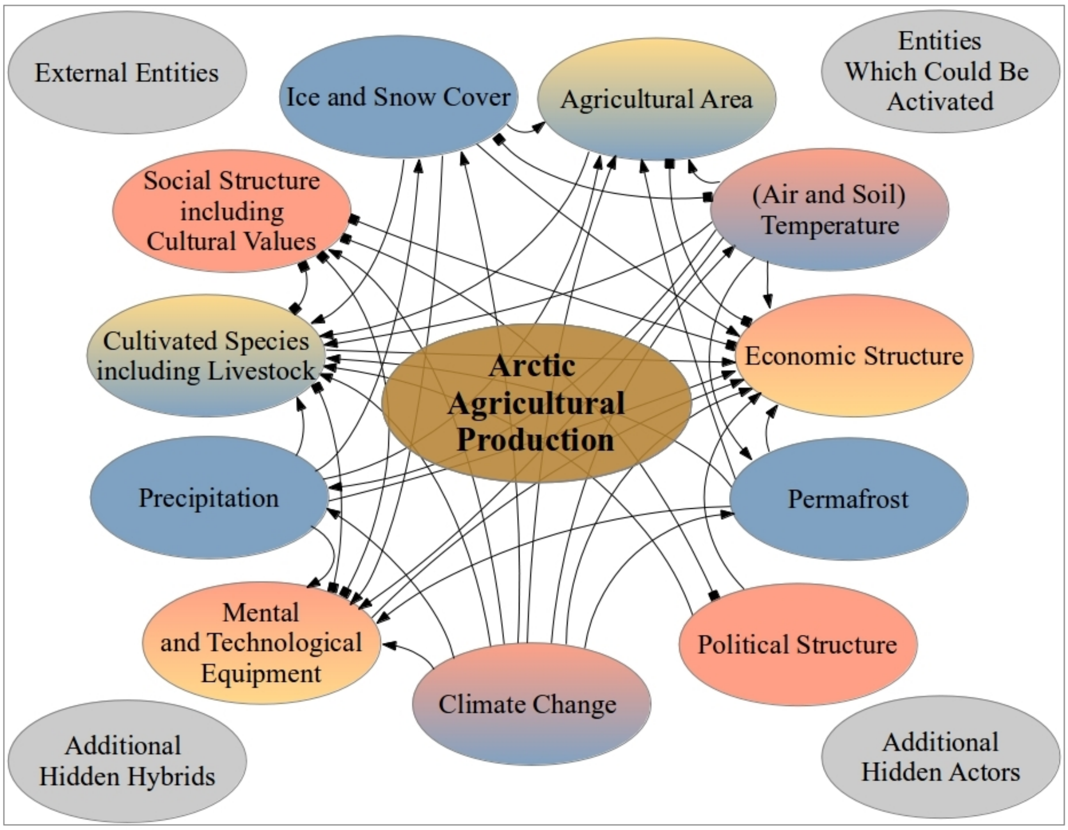


Figure 25: Identified actors and connections of the actor-network of Arctic agricultural production

The identified actors are marked in colours, representing the main sphere of their origin (blue = natural sphere, red = social sphere, yellow = mental sphere). Connections between the actors are shown by thin black lines. The arrow indicates the direction of the connection, leading from the most powerful actor to the actor, it is overpowering. If both actors contribute equally to a connection, the interdependency between them is marked with two squares. However, all connections have to be regarded as interdependencies. Therefore, Figure 25 highlights powerful actors in two ways: Firstly, the simple number of connection, an actor is contributing to and secondly, the number of connections an actor is dominating.

The additional light grey items indicate actors which have not been identified in this chapter or entities which have not been activated and connected to the actor-network by the identified actors, yet. Hence, Figure 25 does not illustrate the complete actor-network of Arctic agricultural production (see Chapter 2).

"Temperature" / "Mental and Technological Equipment", "Agricultural Area", "Ice and Snow Cover" / "Precipitation", "Permafrost", "Social Structure", "Political Structure" (lowest number of shared connection). Regarding the possibility to over-power other actors the following ranking occurs: "Climate Change" and "Political Structure" (with all connections leading from this actor to other actors), "Temperature", "Permafrost", "Social Structure", "Ice and Snow Cover" and "Precipitation" (with a majority of connections leading from these actors to other actors), "Mental

and Technological Equipment", "Cultivated Species" "Agricultural Area" and "Economic Structure" (with a majority of connections leading to these actors from other actors).
By combining both used criteria, the identified power-relations of the network of Arctic agricultural production are illustrated in the following ranking, starting with the most powerful actor: Climate change, temperature, permafrost / cultivated species / political structure, mental and technological equipment / ice and snow cover / precipitation, economic structure, social structure and agricultural area. This final ranking clearly demonstrates that the importance of naturally determined actors is essential within the actor-network of Arctic agricultural production. However, it also outlines that mental actors are active within this actor-network, although their meaning cannot be quantified as easily as in the previous case studies.

4.3.3 Applying the concept of Actor-network services

The outcomes of the illustrated actor-network allow the categorisation of the Actor-network services of "Arctic agricultural production" (see Figure 26). Analogue to the previous case studies, the identified actors are categorised into supporting, provisioning, regulating and cultural services. In addition, their importance for human well-being is outlined, which merely consists of secure access to resources / goods and health parameters. However, this method reveals again actors and connections that have been unrecognised before, including for example "Trampling of Soil" and "Eating of Plants".

Both actors belong to the regulative services and are related to reindeer husbandry and wild caribou. Travelling herds are grazing on vast Tundra plains. Hence, the preferred diet of the animal determines on the existing vegetation, but the extensive grazing simultaneously shapes this ecosystem. As an example, the distribution of evergreen shrubs on Yamal benefits from intensive grazing, while mosses do not have a linear response to such activities (Yu et al., 2011). Another example from the Bering Sea Island shows that grazed lichens were substituted by vascular plants in the course of intensified grazing (Klein and Shulski, 2011). In its most intensified form, caribou and reindeer grazing can even cause overgrazing (Bernes et al., 2013).
Yet, effects of overgrazing in the Arctic have been locally restricted so far and were often of temporary extend only. Such non-permanent evidences of overgrazing have been found, for example, in Sweden, Finland and Norway (Bernes et al., 2013).
In addition to altering the Tundra vegetation through grazing, reindeer and caribou are trampling the

soil during the snow free season. This harms particularly lichens, since they are highly sensitive towards disturbances (Bernes et al., 2013).

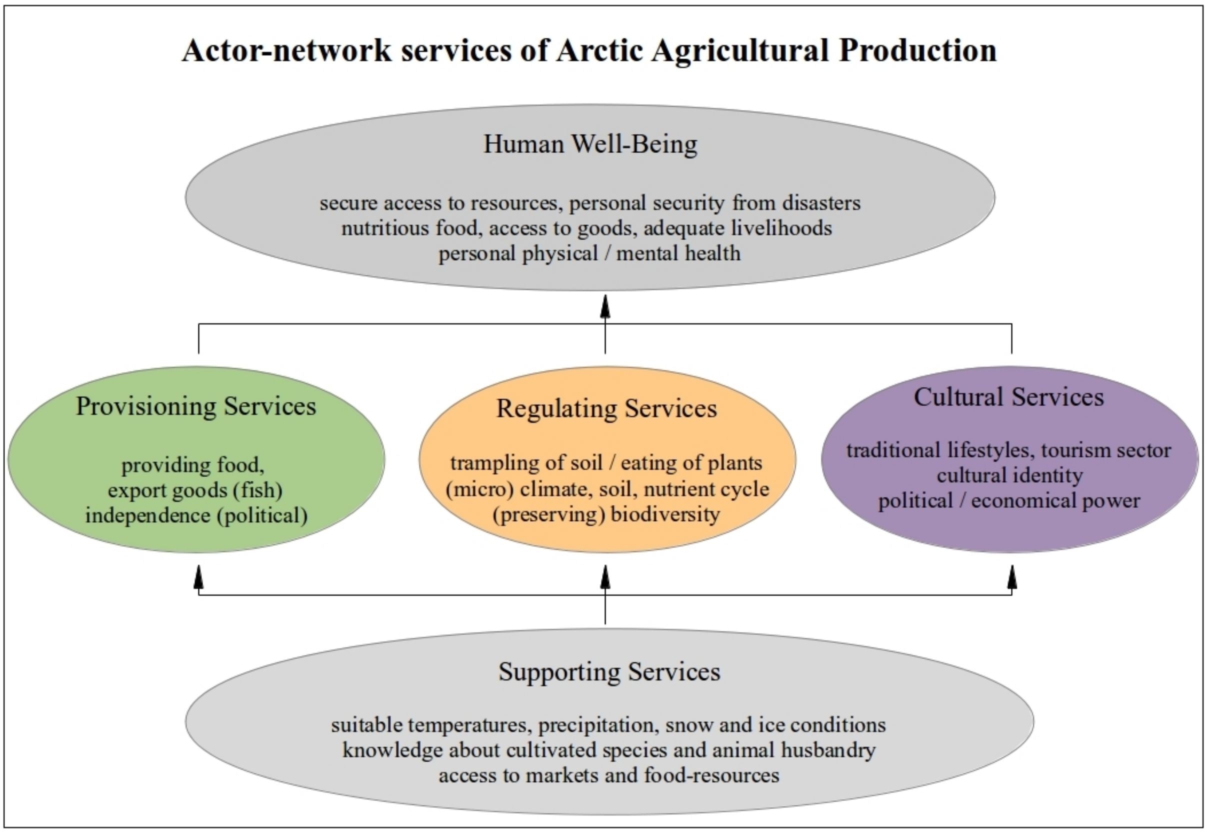


Figure 26: The actor-network services of Arctic agricultural production

By enlarging the traditional ecosystem-services approach with benefits, provided by the social and mental system, the methodological concept of Actor-network services is created.

To conclude, reindeer and caribou regulate the Tundra vegetation. Their grazing habits determine, which plants are most dominate throughout this geographical area. Hence, caribou and reindeer alter the biodiversity of the Tundra.

If a certain place suffers from overgrazing, herders have to move their animals, in order to provide enough food for them. Recently (2015), climate change forces herders and animals to adapt their travel routes and strategies (Bernes et al., 2013) which will have multiple impacts on the current Arctic vegetation and the future regulative function of reindeer and caribou.

Besides these services, Figure 26 illustrates the tight connectivity between the three resources, which have been selected as case studies: “Arctic shipping”, “Traditional knowledge” and “Arctic agricultural production". Furthermore, the bonds between processes of climate change and processes of political geography and geopolitics are highlighted. Particularly the latter outcomes link back to the statement that geography needs transdisciplinary approaches, including the one, developed in this thesis.

4.3.4 Conclusion – Outlining the suitability of the developed methodological concept

The actor-network around "Arctic agricultural production" is explored in this chapter (see Figure 27). Hereby, four concrete steps were conducted:

1. Identifying connected actors of Arctic agriculture,
2. Exploring interdependencies within the network,
3. Applying the concept of Actor-network services and
4. Outlining the suitability of the developed methodological concept.

Eleven actors (actor-groups) were identified which mediate flows within the network that consists of the natural, social and mental sphere. In addition, this third case study fully revealed the tight interdependencies between the three chosen resources themselves (Arctic shipping, Arctic agricultural production and Arctic traditional knowledge).

In contrast to the other case studies in this thesis, "Arctic agricultural production" has so far only minor impact potential on global scales. This postulation is mainly based on the chosen exclusion of fisheries and aquaculture. However, even with respect to those exclusions, the developed theoretical approach and methodological concept revealed the tight bonds between agriculture in the High North, shipping and traditional knowledge. Hence, Arctic agricultural production is indeed connected to global scales and fulfils as a consequence the requirements to become an ANT-resource.

Secondly, Arctic agriculture is particularly of importance to the native (local) population and their cultural identity. Yet, the analyses in this thesis outlined the significant role of climate change within this fragile network. Farming can, in general, prosper from higher temperatures and a milder climate, while reindeer husbandry is challenged by it. Hence, to label consequences as advantages or disadvantages depends again on the point of view of the actors and is therefore an outcome of multiple, yet contrariwise interdependencies between actors within this network. As outlined, the developed theoretical approach identifies such connections without an a priori labelling. Consequently, the conducted analyses are not depending on a certain point of view of a particular actor, but assemble different actors, despite their aims or goals. Hence, this methodological concept creates a wider and broader understanding of Arctic networks.

Thirdly, the restricted scientific data, particularly the one about recent farming activities in the Arctic, clearly limit the informative value of this chapter. Although connected actors have been identified, the needed capacities to gather sufficient quantitative information about them were not given. Hence, the outlined investigations are solely creating a foundation for future quantitative and qualitative case studies.

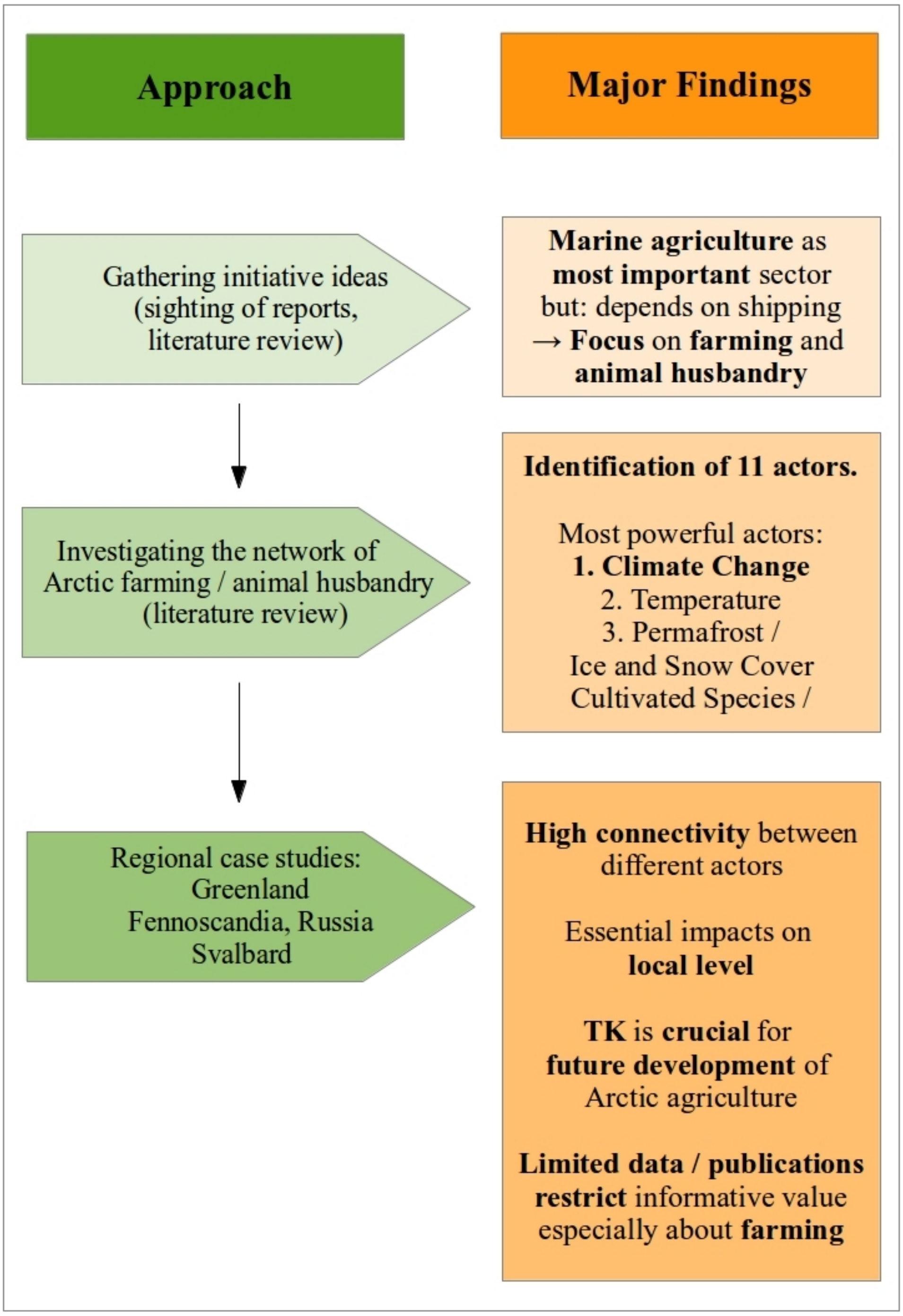


Figure 27: Conclusion of Chapter 4.3

5 Discussion and conclusion

The core-idea of this thesis is the development of a theoretical and methodological concept that enables transdisciplinary geographical research between physical geography and human geography. Therefore, different theoretical and methodological approaches were combined and extended in order to cope with recent global challenges which are determined by multiple parameters of environmental, economic, social, political and mental origin. Hereby, three objectives have been formulated as milestones of this thesis (see Table11):

> Objective 1: Develop a theoretical approach that covers natural and social / political developments
>
> Objective 2: Identify actors and develop a methodological approach to analyse interdependencies between them
>
> Objective 3: Test the developed theoretical approach and the methodological concept

As has been demonstrated in Chapter 1, processes of climate change and processes of political geography and geopolitics are closely linked within the Arctic. The High North is deeply affected by climate change which alters not only natural Arctic systems, but also the social, cultural, political and economic structure of this geographical region. Particularly melting and thawing processes and the resulting shifts of resource availabilities rise human interests in the Arctic. However, such processes are traditionally either investigated by physical geographers or human geographers. Therefore, Objective 1 has been set as the first milestone of this thesis: *Develop a theoretical approach that covers natural and social / political developments.*

The foundation for the developed theoretical approach is the concept of socio-metabolic systems. Within this concept, nature and society are interpreted as overlapping spheres which exchange flows of material and energy between them. These flows are stirred through elements of the overlapping zone that comprise natural and social characteristics. Hence, the elements of the overlapping zone can be interpreted as hybrids, leading to an even broader theoretical approach: Actor-network theory. With this theoretical background, four spheres have been identified that mediate flows between processes of climate change and processes of political geography and geopolitics: The global natural sphere, the Arctic natural sphere, the Arctic social sphere and the global social sphere. Yet, the chosen theoretical background did not limit mediative actions between these spheres to natural and social entities. Despite, mental entities revealed their importance within networks of interdependencies between processes of climate change and processes of political geography and geopolitics in the Arctic. Hence, elements of the overlapping zone always have to be hybrids between natural, social and mental characteristics. This new concept revealed particularly one group of entities as predestinated entities of the overlapping zone: resources. Hereby, resources merge firstly natural aspects, such as their physical representation or position, with secondly, social parameters, such as human interest in this entity, and with thirdly, mental characteristics, such as the knowledge about a resource. Hence, investigations of the actor-network of Arctic resources will always abound interdependencies between processes of climate change and processes of political geography and geopolitics.

Although the theoretical background enabled the identification of entities of the overlapping zone, it does not offer a methodological concept that could be applied to the particular situation of the Arctic. Therefore, Objective 2 served as the next milestone: *Identify actors and develop a methodological approach to analyse interdependencies between them*.

As a first step, concrete Arctic resources were identified according to the new ANT-definition. These included, for example, oil and gas, rare earths, shipping routes, agricultural production, woodland, strategical places or traditional knowledge. In a second step, three resources were picked as case studies for this thesis: Firstly, shipping routes – a resource with global impact potential, secondly, traditional knowledge – a mental resource of the Arctic and thirdly, agricultural production – a local resource whose importance is directly depending on current regional change.
Focusing at first solely on the natural dimension of these resources suggested the application of the ecosystem services concept. This concept investigates which services ecosystems provide to humans and how these services affect human well-being. Hence, the ecosystem-services approach combines natural parameters with social, cultural and mental aspects. Consequently, it already deals with parts of the investigated interdependencies within the actor-network of Arctic resources. In order to fully integrate such interdependencies, the concept of ecosystem-services got enlarged with the benefits, social and mental systems create. This holistic methodological concept is called Actor-network services.

After selecting three resources as case studies and the development of a methodological concept, the actual investigations of the actor-network of these resources and therefore also investigations of interdependencies between processes of climate change and processes of political geography and geopolitics were undertaken. Hereby, Objective 3 functioned as a milestone: *Test the developed theoretical approach and the methodological concept*.

In order to fulfil Objective 3, Arctic resources were interpreted as ANT-actions that are enabled through the cooperation of several Arctic actors. Due to this premiss, the three case studies revealed numerous actors that determine the actor-networks of Arctic shipping routes, Arctic traditional knowledge and Arctic agricultural production. These actors are: Climate / Climate Change, Political Structure / Political Rights / Legal Situation, Natural Conditions including natural threats, Economic Structure, Infrastructure including access to the land, Knowledge / Knowledge Exchange including emotions, Cultivated Species, Social Structure including cultural values, Science, Media and Equipment including access to materials. Particularly the actor "Climate / Climate Change" belonged to the most powerful actors of all conducted case-studies. Besides, actors referring to the natural condition of the High North comprised great power. Other powerful actors can be subsumed as political and social structure of the Arctic as well as knowledge about Arctic entities. Hence, the three case studies proved that Arctic networks consist indeed of natural, social and mental actors.

Table 11: Results, used methods and keywords of this thesis

	Results	Used theories, methods and keywords
Objective 1 and Objective 2	1. The concept of Actor-network services: A theoretical and methodological transdisciplinary geographical concept to analyse Arctic networks 2. Identification of actors that are involved in Arctic networks = resources 3. Identification of mental entities as important actors within networks	<u>Theories and Methods:</u> Socio-metabolic systems, Actor-Network theory Ecosystem services approach <u>Keywords:</u> Actor Natural, social and mental sphere Overlapping zone = Hybrid Arctic (Eco-) System services Human well-being
Objective 3	1. The developed theoretical and methodological concept enables transdisciplinary geographical research 2. Identification of the actor-networks of three Arctic resources	<u>Methods:</u> Actor-network services <u>Keywords:</u> Actor Connection Power-relation

However, there are still some aspects that need further adjustments:

1. The decision to conduct information merely through literature review limited the results of the case studies. Particularly the outcomes of Chapter 4.3 are affected by a lack of freely available scientific information about this resource – especially if it comes to the creation of special subject maps with GIS-data. Yet, new scientific evidences and data from follow-up studies can be implemented into the theoretical and methodological concept of Actor-network services. Hence, this concept ensures the capability to adapt to upcoming natural and social developments.

2. In this thesis, a holistic approach to investigate Arctic actor-networks has been chosen. Therefore, temporal, financial and logistical efforts limited the applied methods. However, the developed concept of Actor-network services creates a theoretical foundation for follow-up studies which focus on solely one Arctic resource and allows therefore a deeper methodological procedure. The analogue applies to the connection within the selected actor-networks. In this thesis, interdependencies have been described particularly on a qualitative level. Hence, with this foundation, follow-up studies could analyse quantitative aspects of the identified interdependencies – hence, their monetary value or defining indicator sets, for example.

2. The developed theoretical approach hardly offers any potential to create possible future scenarios of the interdependencies within Arctic actor-networks. This is mainly caused by ANT itself, since ANT is only a descriptive theory. Hence, ANT retraces connections which are already maintained. Therefore, ANT cannot offer any information about their future development. Whereas, the concept of Actor-network services can – at least to some extent. If projections about the future development of connected Arctic actors exist, they can be integrated into the methodology without further adjustments. Hereby, the identified power-relations within such actor-networks are a helpful tool. Yet, as the last case study has demonstrated, particularly projections about the actors of Arctic resources are still highly discussed within the scientific community and therefore not always reliable.

3. As pointed out: The involvement of multiple actors creates the need for researchers to combine different states of knowledge. While there might be sufficient research about some Arctic actors and connections, there are only insufficient or even no information about others. Hence, the chosen theoretical and methodological concept highly depends on available information. Although ANT states that connections, independent of their actual

characteristics, can be compared to each other, the identification of power-relations is based on comparable data. If these are missing, the overall informative value of the developed approach is hindered.

Yet, the theory and methodology which have been developed in this thesis identify Arctic actors of natural, social and mental origin. Apart from resources, on which the analysis of this work focuses, any Arctic entity can be implemented and investigated without further theoretical adaptations. Hence, this thesis contributes to the overall understanding of networks in the High North and moreover to transdisciplinary geographical research between human geography and physical geography in general.

Bibliography

Aalheim, A., Dannevig, H., Ericsson, T., van Oort, B.E.H., Innbjør, L., Rauken, T., Vennemo, H., Johansen, H., Tofteng, M., Aall, C., Groven, K., Heiberg, E., 2009. Konsekvenser av klimaendringer, tilpasning og sårbarheti Norge - Rapport til Klimatilpasningsutvalget, CICERO Report.

Abele, F., 2007. Between respect and control: Traditional indigenous knowledge in Canadian public policy, in: Orsini, M., Smith, M. (Eds.), Critical Policy Studies: Contemporary Canadian Approaches. UBC Press, Vancouver, pp. 233–256.

Abele, F., 1997. Traditional knowledge in practice. Arctic 50, iii–iv.

ACIA, 2004. Impacts of a warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, U.K. ; New York, N.Y.

Adger, W.N., Barnett, J., Brown, K., Marshall, N., O'Brien, K., 2012. Cultural dimensions of climate change impacts and adaptation. Nat. Clim. Change 3, 112–117. doi:10.1038/nclimate1666

Agnalt, A.-L., Pavlov, V., Jørstad, K.E., Farestveit, E., Sundet, J., 2011. The Snow Crab, Chionoecetes opilio (Decapoda, Majoidea, Oregoniidae) in the Barents Sea, in: Galil, B.S., Clark, P.F., Carlton, J.T. (Eds.), In the Wrong Place - Alien Marine Crustaceans: Distribution, Biology and Impacts. Springer Netherlands, Dordrecht, pp. 283–300.

Agnew, J., 2015. The Geopolitics of Knowledge About World Politics: A Case Study in U.S. Hegemony, in: Meusburger, P., Gregory, D., Suarsana, L. (Eds.), Geographies of Knowledge and Power. Springer Netherlands, Dordrecht, pp. 235–246.

Agnew, J., Muscarà, L., 2012. Making political geography, Second Edition. ed. Rowman & Littlefield Publishers, Plymouth (UK).

AHDR, 2004. Arctic Human Development Report. Stefansson Arctic Institute, Akureyri.

Airoldi, A., 2008. The European Union and the Arctic: policies and actions. Nordic Council of Ministers, Copenhagen.

Alcock, J., 1972. The Evolution of the Use of Tools by Feeding Animals. Evolution 26, 464. doi:10.2307/2407020

Alfred-Wegener-Institut, 2014. Stationen in der Arktis und Antarktis [WWW Document]. Station. Arktis Antarkt. URL http://www.awi.de/de/infrastruktur/stationen/ (accessed 10.28.14).

Alsos, I.G., Müller, E., Eidesen, P.B., 2013. Germinating seeds or bulbils in 87 of 113 tested Arctic

species indicate potential for ex situ seed bank storage. Polar Biol. 36, 819–830. doi:10.1007/s00300-013-1307-7
AMAP, 2013. AMAP Assessment 2013: Arctic Ocean Acidification. Arctic Monitoring and Assessment Programme (AMAP), Oslo.
AMAP, 2012. Arctic Climate Issues 2011: Changes in Arctic Snow, Water, Ice and Permafrost. SWIPA 2011. AMAP, Oslo, Norway.
AMAP, CAFF, SDWG, 2013. Identification of Arctic marine areas of heightened ecological and cultural significance: Arctic Marine Shipping Assessment (AMSA) IIc. Arctic Monitoring and Assessment Programme (AMAP), Oslo.
Amsterdamska, O., 1990. Surely you are joking, Monsieur Latour! Sci. Technol. Hum. Values 4, 495 – 504.
Amstislavski, P., Zubov, L., Chen, H., Ceccato, P., Pekel, J.-F., Weedon, J., 2013. Effects of increase in temperature and open water on transmigration and access to health care by the Nenets reindeer herders in northern Russia. Int. J. Circumpolar Health 72. doi:10.3402/ijch.v72i0.21183
Anchordoquy, T.J., Molina, M.C., 2007. Preservation of DNA. Cell Preserv. Technol. 5, 180–188. doi:10.1089/cpt.2007.0511
Anderson, B., Harrison, P., 2006. Questioning affect and emotion. Area 38, 333–335.
Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C., Gren, Å., 2014. Reconnecting Cities to the Biosphere: Stewardship of Green Infrastructure and Urban Ecosystem Services. AMBIO 43, 445–453. doi:10.1007/s13280-014-0506-y
Andreoni, J., 1990. Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving. Econ. J. 100, 464. doi:10.2307/2234133
Anisimov, O.A., Nymand Larsen, J., 2013. Polar regions, in: Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fith Assessment Report of the Intergovernmental Panel on Climate Change.
Anisimov, O.A., Vaughan, D.G., Callaghan, T.V., Furgal, C., Marchant, H., Prowse, T.D., Vilhjálmsson, H., Walsh, J.E., 2007. Polar regions (Arctic and Antarctic), in: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth As-Sessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp. 653–685.
Arctic Council, 2015. The Arctic Council: A backgrounder [WWW Document]. Arct. Counc. URL

http://www.arctic-council.org/index.php/en/about-us (accessed 2.10.15).
Arctic Council, 2014. The Arctic Council Secretariat [WWW Document]. Arct. Counc. URL http://www.arctic-council.org/index.php/en/about-us/arctic-council/the-arctic-council-secretariat (accessed 12.10.14).
Arctic Council, 2011a. Chairmanship Introduction [WWW Document]. Arct. Counc. URL http://www.arctic-council.org/index.php/en/about-us/arctic-council/canadian-chairmanship/222-chairmanship-introduction (accessed 12.9.14).
Arctic Council, 2011b. Observers [WWW Document]. Arct. Counc. URL http://www.arctic-council.org/index.php/en/about-us/arctic-council/observers (accessed 12.11.14).
Arctic Council, 2011c. Agreement on cooperation on aeronautical and maritime search and rescue in the Arctic.
Arctic Council, 2009. Arctic Marine Shipping Assessment 2009 Report, 2nd printing. ed.
Arctic Council, 1996. Declaration on the Establishment of the Arctic Council (Ottawa-Declaration).
Arctic Council, Protection of the Arctic Marine Environment (PAME), 2015. Status of Implementation of the AMSA 2009 Report Recommendations, April 2015. Proj. Rep. Prot. Arct. Mar. Environ. Work. Group.
Arctic Council, Protection of the Arctic Marine Environment (PAME), 2011. Status of Implementation of the AMSA 2009 Report Recommendations, May 2011. Proj. Rep. Prot. Arct. Mar. Environ. Work. Group.
Arnakak, J., 2002. Incorporation of Inuit Qaujimanituqangit, or Inuit traditional knowledge into the Government of Nunavut. J. Aborig. Econ. Dev. 3, 33–39.
Ashik, I., 2012. Recent Russian Marine Research Activities in the Arctic Ocean, in: Wasum-Rainer, S., Winkelmann, I., Tiroch, K. (Eds.), Arctic Science, International Law and Climate Change. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 59–66.
Aufenvenne, P., Steinbrink, M., 2014. Säulen der Einheit: Zur Stellung integrativer Autor_innen in der deutschsprachigen Geographie. Geographische Revue 23–55.
Baccini, P., Brunner, P.H., 2012. Metabolism of the anthroposphere: analysis, evaluation, design, 2. edition. ed. MIT Press.
Bach, I., 2013. Sygdomsfrie kartofler i Grønland [WWW Document]. URL http://www.science.ku.dk/presse/nyhedsarkiv/2013/gronlandske_kartofler/ (accessed 11.19.14).
Bagstad, K.J., Johnson, G.W., Voigt, B., Villa, F., 2013. Spatial dynamics of ecosystem service

flows: A comprehensive approach to quantifying actual services. Ecosyst. Serv. 4, 117–125. doi:10.1016/j.ecoser.2012.07.012

Baker, B., 2010. Law, Science, and the Continental Shelf: The Russian Federation and the Promise of Arctic Cooperation. Am. Univ. Int. Law Rev. 25, 251–281.

Barnard, A., Spencer, J. (Eds.), 1996. Encyclopedia of social and cultural anthropology. Routledge, London; New York.

Barnett, T., Blas, E., Whiteside, A., 1996. AIDS briefs for sectoral planners and managers: Subsistence agriculture, commercial agriculture. Geneva WHO.

Barry, A., 2013. The Translation Zone: Between Actor-Network Theory and International Relations. Millenn. - J. Int. Stud. 41, 413–429. doi:10.1177/0305829813481007

Bartsch, A., Kumpula, T., Forbes, B.C., Stammler, F., 2010. Detection of snow surface thawing and refreezing in the Eurasian Arctic with QuikSCAT: implications for reindeer herding. Ecol. Appl. 20, 2346–2358.

Baskin, L.M., 2005. Number of wild and domestic reindeer in Russia in the late 20th century. Rangifer 25, 51–57.

Baskin, L.M., 2000. Reindeer husbandry/hunting in Russia in the past, present and future. Polar Res. 19, 23–29.

Baskin, L.M., Miller, F.L., 2007. Populations of wild and feral reindeer in Siberia and Far East of Russia. Rangifer 27, 227–241.

Bateman, I.J., Harwood, A.R., Mace, G.M., Watson, R.T., Abson, D.J., Andrews, B., Binner, A., Crowe, A., Day, B.H., Dugdale, S., Fezzi, C., Foden, J., Hadley, D., Haines-Young, R., Hulme, M., Kontoleon, A., Lovett, A.A., Munday, P., Pascual, U., Paterson, J., Perino, G., Sen, A., Siriwardena, G., van Soest, D., Termansen, M., 2013. Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom. Science 341, 45–50. doi:10.1126/science.1234379

Beck, B.B., 1980. Animal tool behavior: the use and manufacture of tools by animals. Garland STPM Pub.

Beck, B.B., 1972. Tool use in captive hamadryas baboons. Primates 13, 277–295. doi:10.1007/BF01730574

Begum, S., 2012. Climate Change and Vulnerability of the Arctic Elderly: An Assessment from Human Rights Point of View. CES Work. Pap. 459–479.

Benedict, M.A., McMahon, E.T., others, 2002. Green infrastructure: smart conservation for the 21st century. Renew. Resour. J. 20, 12–17.

Berkes, F., 2009. Indigenous ways of knowing and the study of environmental change. J. R. Soc. N. Z. 39, 151–156. doi:10.1080/03014220909510568

Berkes, F., Jolly, D., 2002. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. Conserv. Ecol. 5, 18.

Berkman, P.A., Young, O.R., 2009. Governance and environmental change in the Arctic Ocean. Science 324, 339–340.

Berman, M.D., 1998. Sustainability and subsistence in Arctic communities. Institute of Social and Economic Research, University of Alaska Anchorage.

Bernes, C., Bråthen, K.A., Forbes, B.C., Hofgaard, A., Moen, J., Speed, J.D., 2013. What are the impacts of reindeer/caribou (Rangifer tarandus L.) on arctic and alpine vegetation? A systematic review protocol. Environ. Evid. 2 6.

Berrang-Ford, L., Ford, J.D., Paterson, J., 2011. Are we adapting to climate change? Glob. Environ. Change 21, 25–33. doi:10.1016/j.gloenvcha.2010.09.012

Bersamin, A., Luick, B.R., Stern, J.S., Zidenberg-Cherr, S., 2006. Diet quality among Alaska Natives living in the Yukon Kuskokwim River Delta is low: the CANHR pilot study. J. Am. Diet. Assoc. 106, 1055–1063.

Bhatt, U.S., Walker, D.A., Walsh, J.E., Carmack, E.C., Frey, K.E., Meier, W.N., Moore, S.E., Parmentier, F.-J.W., Post, E., Romanovsky, V.E., Simpson, W.R., 2014. Implications of Arctic Sea Ice Decline for the Earth System. Annu. Rev. Environ. Resour. 39, 57–89. doi:10.1146/annurev-environ-122012-094357

Bichet, V., Gauthier, E., Massa, C., Perren, B., Richard, H., Petit, C., Mathieu, O., 2013. The history and impacts of farming activities in south Greenland: an insight from lake deposits. Polar Rec. 49, 210–220. doi:10.1017/S0032247412000587

Bijker, W.E., Law, J., 1994. General Introduction, in: Bijker, W.E., Law, J. (Eds.), Shaping Technology/building Society: Studies in Sociotechnical Change. MIT Press, Cambridge, Mass.

Bjerke, J.W., Tømmervik, H., 2008. Observerte skader på nordnorske planter i løpet av vår og sommer 2006: omfang og mulige årsaker. Blyttia 66, 90–96.

Blaauw, R.J., 2013. Oil and Gas Development and Opportunities in the Arctic Ocean, in: Berkman, P.A., Vylegzhanin, A.N. (Eds.), Environmental Security in the Arctic Ocean. Springer Netherlands, Dordrecht, pp. 175–184.

Bloom, E.T., 1999. Establishment of the Arctic council. Am. J. Int. Law 712–722.

Bloor, D., 1999. Anti-latour. Stud. Hist. Philos. Sci. Part A 30, 81–112.

Blunden, M., 2012. Geopolitics and the northern sea route. Int. Aff. 88, 115–129.

Bodkin, J., Ballachey, B., Coletti, H., Esslinger, G., Kloecker, K., Rice, S., Reed, J., Monson, D., 2012. Long-term effects of the "Exxon Valdez" oil spill: sea otter foraging in the intertidal as a pathway of exposure to lingering oil. Mar. Ecol. Prog. Ser. 447, 273–287. doi:10.3354/meps09523

Bondi, L., 2005. Making connections and thinking through emotions: between geography and psychotherapy. Trans. Inst. Br. Geogr. 30, 433–448.

Bonnet, J., Colotte, M., Coudy, D., Couallier, V., Portier, J., Morin, B., Tuffet, S., 2010. Chain and conformation stability of solid-state DNA: implications for room temperature storage. Nucleic Acids Res. 38, 1531–1546. doi:10.1093/nar/gkp1060

Borgerson, S.G., 2008. Arctic meltdown: the economic and security implications of global warming. Foreign Aff. 63–77.

Bradley, M.J., Kutz, S.J., Jenkins, E., O'Hara, T.M., 2005. The potential impact of climate change on infectious diseases of Arctic fauna. Int. J. Circumpolar Health 64, 468–477.

Breum, M., 2012. When the Arctic Council speaks. How to move the Consil's Communication into the Future, in: Axworthy, T.S., Koivurova, T., Hasanat, W. (Eds.), The Arctic Council: Its Place in the Future of Arctic Governance. Presented at the The Arctic Council: its Place in the Future of Arctic Governance.

Brigham, L.W., 2013. Environmental Security Challenges and the Arctic Council's Arctic Marine Shipping Assessment, in: Berkman, P.A., Vylegzhanin, A.N. (Eds.), Environmental Security in the Arctic Ocean. Springer Netherlands, Dordrecht, pp. 157–173.

Bringezu, S., Schütz, H., Moll, S., 2003. Rationale for and interpretation of economy-wide materials flow analysis and derived indicators. J. Ind. Ecol. 7, 43–64.

Broll, G., 2011. Folgen des Klimawandels für terrestrische Ökosysteme der Arktis und Subarktis. Geogr. Rundsch. 63, 20–25.

Brunet, N.D., Hickey, G.M., Humphries, M.M., 2014. The evolution of local participation and the mode of knowledge production in Arctic research. Ecol. Soc. 19. doi:10.5751/ES-06641-190269

Brunotte, E., Gebhardt, H., Meurer, M., Meusburger, P., Nipper, J. (Eds.), 2001a. Lexikon der Geographie in vier Bänden, Zweiter Band Gast bis Ökol. Spektrum, Akad. Verl., Heidelberg.

Brunotte, E., Gebhardt, H., Meurer, M., Meusburger, P., Nipper, J. (Eds.), 2001b. Lexikon der Geographie in vier Bänden, Dritter Band Ökos bis Wald. Spektrum, Akad. Verl., Heidelberg.

Budzik, P., 2009. Arctic oil and natural gas potential, US Energy Information Administration, Office of Integrated Analysis and Forecasting, Oil and Gas Division.

Buhasz, L., 2006. Northern underexposure. Globe Mail.

Buixadé Farré, A., Stephenson, S.R., Chen, L., Czub, M., Dai, Y., Demchev, D., Efimov, Y., Graczyk, P., Grythe, H., Keil, K., Kivekäs, N., Kumar, N., Liu, N., Matelenok, I., Myksvoll, M., O'Leary, D., Olsen, J., Pavithran.A.P., S., Petersen, E., Raspotnik, A., Ryzhov, I., Solski, J., Suo, L., Troein, C., Valeeva, V., van Rijckevorsel, J., Wighting, J., 2014. Commercial Arctic shipping through the Northeast Passage: routes, resources, governance, technology, and infrastructure. Polar Geogr. 1–27. doi:10.1080/1088937X.2014.965769

Burgess, J., Clark, J., Harrison, C.M., 2000. Knowledges in action: an actor network analysis of a wetland agri-environment scheme. Ecol. Econ. 35, 119–132. doi:10.1016/S0921-8009(00)00172-5

CAFF, 2013. Arctic Biodiversity Assessment. Status and trends in Arctic biodiversity. Conservation of Arctic Flora and Fauna, Akureyri.

Callon, M., 1999. Actor-network theory—the market test. Sociol. Rev. 47, 181–195. doi:10.1111/j.1467-954X.1999.tb03488.x

Callon, M., 1990. Techno-economic networks and irreversibility. Sociol. Rev. 38, 132–161. doi:10.1111/j.1467-954X.1990.tb03351.x

Callon, M., 1986. Some Elements of a Sociology of Translation. Domestication of the Scallops and the Fishermen of St. Brieuc Bay, in: Law, J. (Ed.), Power, Action and Belief. A New Sociology of Knowledge? Routledge & Kegan Paul, London, p. 67.

Callon, M., Courtial, J.-P., Turner, W.A., Bauin, S., 1983. From translations to problematic networks: An introduction to co-word analysis. Soc. Sci. Inf. 22, 191–235. doi:10.1177/053901883022002003

Callon, M., Latour, B., 1992. Don't throw the baby out with the bath school! A reply to Collins and Yearley, in: Pickering, A. (Ed.), Science as Practice and Culture. The University of Chicago Press, Chicago, London, pp. 343 – 368.

Callon, M., Latour, B., 1981. Unscrewing the big Leviathan: how actors macro-structure reality and how sociologists help them to do so, in: Knorr-Cetina, K., Cicourel, A.V. (Eds.), Advances in Social Theory and Methodology: Toward an Integration of Microand Macro-Sociologies.

Routledge & Kegan Paul, Boston, London and Henley, pp. 277–303.
Callon, M., Law, J., 1997. After the Individual in Society: Lessons on Collectivity from Science, Technology and Society. Can. J. Sociol. Cah. Can. Sociol. 22, 165–182. doi:10.2307/3341747
Cambou, D., 2013. The Impact of the Ban on Seal Products on the Rights of Indigenous Peoples: A European Issue. Yearb. Polar Law 5, 389–415.
Cameron, E.S., 2012. Securing Indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. Glob. Environ. Change 22, 103–114. doi:10.1016/j.gloenvcha.2011.11.004
Carlson, J.D., Hubach, C., Long, J., Minteer, K., Young, S., 2013. Scramble for the Arctic: Layered Sovereignty, UNCLOS, and Competing Maritime Territorial Claims. SAIS Rev. Int. Aff. 33, 21–43. doi:10.1353/sais.2013.0033
Chanteloup, L., 2013. Wildlife as a tourism resource in Nunavut. Polar Rec. 49, 240–248. doi:10.1017/S0032247412000617
Chen, J.S., 2014. Tourism stakeholders attitudes toward sustainable development: A case in the Arctic. J. Retail. Consum. Serv. doi:10.1016/j.jretconser.2014.08.003
Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C.G., Räisänen, J., Rinke, A., Sarr, A., Whetton, P., 2007. Regional Climate Projections, in: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K. ; New York, N.Y, USA.
Christiansen, J.S., Mecklenburg, C.W., Karamushko, O.V., 2014. Arctic marine fishes and their fisheries in light of global change. Glob. Change Biol. 20, 352–359. doi:10.1111/gcb.12395
Cochran, P., Huntington, O.H., Pungowiyi, C., Tom, S., Chapin, F.S., Huntington, H.P., Maynard, N.G., Trainor, S.F., 2013. Indigenous frameworks for observing and responding to climate change in Alaska. Clim. Change 120, 557–567. doi:10.1007/s10584-013-0735-2
Collins, H.M., 1990. Artificial experts: social knowledge and intelligent machines. MIT Press, Cambridge, Mass.
Commission on the Limits of the Continental Shelf, 2009. Summary of the Recommendations of the Commission on the Limits of the Continental Shelf in redarg to the Submission made by

Norway in respect of Areas in the Arctic Ocean, the Barents Sea and the Norwegian Sea on 27 November 2006.

Corell, H., 2009. Arctic: An Opportunity to Cooperate and Demonstrate Statesmanship, The. Vand J Transnatl L 42, 1065–1079.

Crossman, N.D., Burkhard, B., Nedkov, S., Willemen, L., Petz, K., Palomo, I., Drakou, E.G., Martín-Lopez, B., McPhearson, T., Boyanova, K., Alkemade, R., Egoh, B., Dunbar, M.B., Maes, J., 2013. A blueprint for mapping and modelling ecosystem services. Ecosyst. Serv. 4, 4–14. doi:10.1016/j.ecoser.2013.02.001

Cuba, L., Hummon, D.M., 1993. A place to call home: Identification with dwelling, community, and region. Sociol. Q. 34, 111–131.

Cunningham, C., Stanley, F., 2003. Indigenous by definition, experience, or world view. BMJ 327, 403–404.

Cunsolo Willox, A., Stephenson, E., Allen, J., Bourque, F., Drossos, A., Elgarøy, S., Kral, M.J., Mauro, I., Moses, J., Pearce, T., MacDonald, J.P., Wexler, L., 2014. Examining relationships between climate change and mental health in the Circumpolar North. Reg. Environ. Change. doi:10.1007/s10113-014-0630-z

Daes, E.-I.A., 1996. Working Paper by the Chairperson-Rapporteur, Mrs. Erica-Irene A. Daes, on the Concept of“ indigenous People.” UN.

Dale, A., Armitage, D., 2011. Marine mammal co-management in Canada’s Arctic: Knowledge co-production for learning and adaptive capacity. Mar. Policy 35, 440–449. doi:10.1016/j.marpol.2010.10.019

Danielsen, F., Topp-Jørgensen, E., Levermann, N., Løvstrøm, P., Schiøtz, M., Enghoff, M., Jakobsen, P., 2014. Counting what counts: using local knowledge to improve Arctic resource management. Polar Geogr. 37, 69–91. doi:10.1080/1088937X.2014.890960

Danmarks Meteorologiske Institut, 2014. Klimanormaler for Grønland: Narsarsuaq [WWW Document]. DMI Vejr Klima Og Hav. URL http://www.dmi.dk/groenland/arkiver/klimanormaler/

Davidson-Hunt, I., Berkes, F., 2003. Learning as you journey: Anishinaabe perception of social-ecological environments and adaptive learning. Ecol. Soc. 8(1).

Davidson, J., Milligan, C., 2004. Embodying emotion sensing space: introducing emotional geographies. Soc. Cult. Geogr. 5, 523–532. doi:10.1080/1464936042000317677

Davidson, M.D., 2013. On the relation between ecosystem services, intrinsic value, existence value

and economic valuation. Ecol. Econ. 95, 171–177. doi:10.1016/j.ecolecon.2013.09.002
Degteva, A., Nellemann, C., 2013. Nenets migration in the landscape: impacts of industrial development in Yamal peninsula, Russia. Pastor. Res. Policy Pract. 3, 15. doi:10.1186/2041-7136-3-15
de La Fayette, L.A., 2008. Oceans governance in the Arctic. Int. J. Mar. Coast. Law 23, 531–566.
de Neergaard, E., Munk, L., Nielsen, S.L., 2014. First report of Potato leafroll virus , Potato virus A, Potato virus X and Potato virus Y in potato in Greenland. New Dis. Rep. 30, 20. doi:10.5197/j.2044-0588.2014.030.020
Dery, K., Hall, R., Wailes, N., Wiblen, S., 2013. Lost in translation? An actor-network approach to HRIS implementation. J. Strateg. Inf. Syst. 22, 225–237. doi:10.1016/j.jsis.2013.03.002
Det Norske Veritas, 2010. Shipping across the arctic Ocean. A feasible option in 2030 - 2050 as a result of global warming? Res. Innov. Position Pap. 04 - 2010.
de Ville, F., 2012. Explaining the Genesis of a Trade Dispute: the European Union's Seal Trade Ban. J. Eur. Integr. 34, 37–53. doi:10.1080/07036337.2011.566331
de Waal, F.B.M., 2008. Putting the Altruism Back into Altruism: The Evolution of Empathy. Annu. Rev. Psychol. 59, 279–300. doi:10.1146/annurev.psych.59.103006.093625
Discharges to Water [WWW Document], 2010. . Gov. Can. Transp. Can. URL https://www.tc.gc.ca/eng/marinesafety/debs-arctic-environment-discharges-355.htm (accessed 4.15.15).
Division for Ocean Affairs and the Law of the Sea, 2014. Submissions, through the Secretary-General of the United Nations, to the Commission on the Limits of the COntinental Shelf, pursuant to article 76, paragraph 8, of the United Nations Convention on the Law of the Sear of 10 December 1982.
Dixon, E.J., 2001. Human colonization of the Americas: timing, technology and process. Quat. Sci. Rev. 20, 277–299.
Dodds, K., 2013. The Ilulissat Declaration (2008): The Arctic States, "Law of the Sea," and Arctic Ocean. SAIS Rev. Int. Aff. 33, 45–55. doi:10.1353/sais.2013.0018
Dodds, K., 2010. Flag planting and finger pointing: The Law of the Sea, the Arctic and the political geographies of the outer continental shelf. Polit. Geogr. 29, 63–73. doi:10.1016/j.polgeo.2010.02.004
Dodds, K.J., 2013. Anticipating the Arctic and the Arctic Council: pre-emption, precaution and preparedness. Polar Rec. 49, 193–203. doi:10.1017/S0032247412000198

Dorn, M.L., 1998. Beyond nomadism: the travel narratives of a “cripple,” in: Nast, H.J., Pile, S. (Eds.), Places through the Body. Routledge, London; New York, pp. 136–159.

Droseltis, O., Vignoles, V.L., 2010. Towards an integrative model of place identification: Dimensionality and predictors of intrapersonal-level place preferences. J. Environ. Psychol. 30, 23–34. doi:10.1016/j.jenvp.2009.05.006

Ebinger, C.K., Zambetakis, E., 2009. The geopolitics of Arctic melt. Int. Aff. 85, 1215–1232.

Edgar, J.L., Nicol, C.J., Clark, C.C.A., Paul, E.S., 2012. Measuring empathic responses in animals. Appl. Anim. Behav. Sci. 138, 182–193. doi:10.1016/j.applanim.2012.02.006

Eibl-Eibesfeldt, I., 2009. Human ethology, Second Paperback Printing. ed. Transaction Publishers, New Brunswick (U.S.A.), London (U.K.).

Eibl-Eibesfeldt, I., 1979. Human ethology: methods and limits. Behav. Brain Sci. 2, 50–57. doi:10.1017/S0140525X00060696

Eira, I.M.G., Jaedicke, C., Magga, O.H., Maynard, N.G., Vikhamar-Schuler, D., Mathiesen, S.D., 2013. Traditional Sámi snow terminology and physical snow classification—Two ways of knowing. Cold Reg. Sci. Technol. 85, 117–130. doi:10.1016/j.coldregions.2012.09.004

Eitzinger, J., Utset, A., Trnka, M., Zalud, Z., Nikolaev, M., Uskov, I., 2007. Weather and climate and optimization of farm technologies at different input levels, in: Sivakumar, M.V.K., Motha, R.P. (Eds.), Managing Weather and Climate Risks in Agriculture. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 141–170.

Endlicher, W., 2012. Einführung in die Stadtökologie: Grundzüge des urbanen Mensch-Umwelt-Systems. UTB.

Epstein, R., Roberts, G., Beber, G. (Eds.), 2008. Parsing the turing test: philosophical and methodological issues in the quest for the thinking computer. Springer, New York.

Eskeland, G.S., Flottorp, L.S., 2006. Climate change in the Arctic: A discussion of the impact on economic activity, in: Glomsrød, S., Aslaksen, I. (Eds.), The Economy of the North. Statistics Norway, Oslo, Norway.

Exner-Pirot, H., 2012. Non-Arctic States: The Observer Question at the Arctic Council, in: Heininen, L. (Ed.), Arctic Yearbook 2012. Northern Research Forum, Akureyri, pp. 48 – 51.

Falloon, P., Betts, R., 2010. Climate impacts on European agriculture and water management in the context of adaptation and mitigation—The importance of an integrated approach. Sci. Total Environ. 408, 5667–5687. doi:10.1016/j.scitotenv.2009.05.002

FAO, 2009. International Treaty on Plant Genetic Resources for Food and Agriculture. FAO, Rome.

FAO, IFAD, WFP, 2014. State of food insecurity in the world 2014: strengthening the enabling environment for food security and nutrition. FAO, Rome.

Fay, G., Karlsdóttir, A., 2011. Social indicators for arctic tourism: observing trends and assessing data. Polar Geogr. 34, 63–86. doi:10.1080/1088937X.2011.585779

Fergurson, H., 2011. Inuit food (in) security in Canada: assessing the implications and effectiveness of policy. Queens Policy Rev 2, 54–79.

Ferrari, J.R., Drexler, T., Skarr, J., 2015. Finding a Spiritual Home: A Pilot Study on the Effects of a Spirituality Retreat and Loneliness among Urban Homeless Adults. Psychology 06, 210–216. doi:10.4236/psych.2015.63020

Fiedel, S.J., 2002. Initial human colonization of the Americas: An overview of the issues and the evidence. Radiocarbon 44, 407–436.

Fienup-Riordan, A., 1994. Boundaries and passages: rule and ritual in Yup'ik Eskimo oral tradition, The Civilization of the American Indian series. University of Oklahoma Press, Norman.

Filimonova, N., 2013. Scramble for the Arctic Offshore Oil & Gas Resources in Russia, in: Heininen, L. (Ed.), Arctic Yearbook 2013. Northern Research Forum, Akureyri.

Finlayson, J.D., Betteridge, K., MacKay, A., Thorrold, B., Singleton, P., Costall, D.A., 2002. A simulation model of the effects of cattle treading on pasture production on North Island, New Zealand, hill land. N. Z. J. Agric. Res. 45, 255–272.

Fischer-Kowalski, M., 2011. Analyzing sustainability transitions as a shift between socio-metabolic regimes. Environ. Innov. Soc. Transit. 1, 152–159. doi:10.1016/j.eist.2011.04.004

Fischer-Kowalski, M., Amann, C., 2001. Beyond IPAT and Kuznet Curves: Globalization as a Vital Factor in Analysing the Environmental Impact of Socio-Economic Metabolism. Popul. Environ. 23, 7 – 47.

Fischer-Kowalski, M., Erb, K., 2006. Epistemologische und konzeptionelle Grundlagen der Sozialen Ökologie. Mitteilungen Österr. Geogr. Ges. 148, 33 – 56.

Fischer-Kowalski, M., Haberl, H., 1997. Tons, joules, and money: Modes of production and their sustainability problems. Soc. Nat. Resour. 10, 61–85.

Fischer-Kowalski, M., Hüttler, W., 1999. Society's Metabolism. The Intellectual History of Materials Flow Analysis, Part II, 1970-1998. J. Ind. Ecol. 2, 107 – 136.

Fischer-Kowalski, M., Krausmann, F., Giljum, S., Lutter, S., Mayer, A., Bringezu, S., Moriguchi, Y., Schütz, H., Schandl, H., Weisz, H., 2011. Methodology and Indicators of Economy-wide Material Flow Accounting: State of the Art and Reliability Across Sources. J. Ind. Ecol. 15,

855–876. doi:10.1111/j.1530-9290.2011.00366.x
Fischer-Kowalski, M., Steinberger, J.K., 2011. Social Metabolism and Hybrid Structures. J. Ind. Ecol. 15, 642–644. doi:10.1111/j.1530-9290.2011.00373.x
Fischer-Kowalski, M., Weisz, H., 2008. Das industrielle sozialökologische Regime und globale Transitionen, in: Gleich, A., Gößling-Reisemann, S. (Eds.), Industrial Ecology. Vieweg+Teubner, Wiesbaden, pp. 181–201.
Fischer-Kowalski, M., Weisz, H., 2005. Society as hybrid between material and symbolic realms: Toward a theoretical framework of society-nature interaction, in: Redclift, M.R., Woodgate, G. (Eds.), New Developments in Environmental Sociology, Reprinted from Advances in Human Ecology 8, Pp. 215-251. Edward Elgar, Cheltenhem and Northampton, pp. 113 – 149.
Fitter, A.H., 2013. Are Ecosystem Services Replaceable by Technology? Environ. Resour. Econ. 55, 513–524. doi:10.1007/s10640-013-9676-5
Fitzgerald, P.L., 2011. "Morality" May Not Be Enough to Justify the EU Seal Products Ban: Animal Welfare Meets International Trade Law. J. Int. Wildl. Law Policy 14, 85–136.
Flint, C.G., Robinson, E.S., Kellogg, J., Ferguson, G., BouFajreldin, L., Dolan, M., Raskin, I., Lila, M.A., 2011. Promoting Wellness in Alaskan Villages: Integrating Traditional Knowledge and Science of Wild Berries. EcoHealth 8, 199–209. doi:10.1007/s10393-011-0707-9
Foley, J.A., 2005. Global Consequences of Land Use. Science 309, 570–574. doi:10.1126/science.1111772
Forbes, B.C., 2010. Reindeer herding, in: Arctic Biodiversity Trends 2010 - Selcted Indicators of Change. CAFF International Secretariat, Akureyri, Iceland, pp. 86–88.
Forbes, B.C., Stammler, F., Kumpula, T., Meschtyb, N., Pajunen, A., Kaarlejärvi, E., 2009. High resilience in the Yamal-Nenets social–ecological system, West Siberian Arctic, Russia. Proc. Natl. Acad. Sci. 106, 22041–22048.
Ford, J.D., 2012. Indigenous health and climate change. Am. J. Public Health 102, 1260–1266.
Ford, J.D., Berrang-Ford, L., Paterson, J., 2011. A systematic review of observed climate change adaptation in developed nations: A letter. Clim. Change 106, 327–336. doi:10.1007/s10584-011-0045-5
Ford, J.D., Pearce, T., 2010. What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic: a systematic literature review. Environ. Res. Lett. 5, 014008. doi:10.1088/1748-9326/5/1/014008

Ford, J.D., Smit, B., 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. Arctic 389–400.

Ford, J.D., Smit, B., Wandel, J., 2006. Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. Glob. Environ. Change 16, 145–160. doi:10.1016/j.gloenvcha.2005.11.007

Ford, J.D., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusarjuat, H., Qrunnut, K., 2008. Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. Geogr. J. 174, 45–62.

Ford, J., Pearce, T., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusujurat, H., Qrunnut, K., 2007. Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. Arctic 150–166.

Fowler, C., 2008a. Crop Diversity: Neolithic Foundations for Agriculture's Future Adaptation to Climate Change. AMBIO J. Hum. Environ. 37, 498–501. doi:10.1579/0044-7447-37.sp14.498

Fowler, C., 2008b. The Svalbard Global Seed Vault: Securing the Future of Agriculture.

Fox, S., 2000. Communities Of Practice, Foucault And Actor-Network Therory. J. Manag. Stud. 37, 853–868. doi:10.1111/1467-6486.00207

Franckx, E., Boone, L., 2012. New Developments in the Arctic: Protecting the Marine Environment from Increased Shipping, in: The Law of the Sea Convention: US Accession and Globalization. Leiden: Martinus Nijhoff Publishers.

Freeman, M.M., Wenzel, G.W., 2006. The nature and significance of polar bear conservation hunting in the Canadian Arctic. Arctic 21–30.

Fresque-Baxter, J.A., Armitage, D., 2012. Place identity and climate change adaptation: a synthesis and framework for understanding. Wiley Interdiscip. Rev. Clim. Change 3, 251–266. doi:10.1002/wcc.164

Friborg, O., Rosenvinge, J.H., Wynn, R., Gradisar, M., 2014. Sleep timing, chronotype, mood, and behavior at an Arctic latitude (69°N). Sleep Med. 15, 798–807. doi:10.1016/j.sleep.2014.03.014

Fyke, J., Eby, M., Mackintosh, A., Weaver, A., 2014. Impact of climate sensitivity and polar amplification on projections of Greenland Ice Sheet loss. Clim. Dyn. 43, 2249–2260. doi:10.1007/s00382-014-2050-7

Garcia, R.A., Cabeza, M., Rahbek, C., Araujo, M.B., 2014. Multiple Dimensions of Climate Change and Their Implications for Biodiversity. Science 344, 1247579–1247579. doi:10.1126/science.1247579

Gauthier, E., Bichet, V., Massa, C., Petit, C., Vannière, B., Richard, H., 2010. Pollen and non-pollen palynomorph evidence of medieval farming activities in southwestern Greenland. Veg. Hist. Archaeobotany 19, 427–438. doi:10.1007/s00334-010-0251-5

Gautier, D.L., Bird, K.J., Charpentier, R.R., Grantz, A., Houseknecht, D.W., Klett, T.R., Moore, T.E., Pitman, J.K., Schenk, C.J., Schuenemeyer, J.H., Sorensen, K., Tennyson, M.E., Valin, Z.C., Wandrey, C.J., 2009. Assessment of Undiscovered Oil and Gas in the Arctic. Science 324, 1175–1179. doi:10.1126/science.1169467

Gazprom, 2014. Bovanenkovo [WWW Document]. Gazprom Prod. URL http://www.gazprom.com/about/production/projects/deposits/bm/ (accessed 12.2.14).

Gebhardt, H., Glaser, R., Radtke, U., Reuber, P., Meyer, S. (Eds.), 2011. Geographie physische Geographie und Humangeographie. Spektrum, Akad. Verl., Heidelberg.

Gebhardt, H., Ingenfeld, E., 2011. Die Arktis im Fokus geoökonomischer und geopolitischer Interessen. Geogr. Rundsch. 63, 26–32.

Gerhardt, H., Steinberg, P.E., Tasch, J., Fabiano, S.J., Shields, R., 2010. Contested Sovereignty in a Changing Arctic. Ann. Assoc. Am. Geogr. 100, 992–1002. doi:10.1080/00045608.2010.500560

Gill, S.E., Handley, J.F., Ennos, A.R., Pauleit, S., 2007. Adapting cities for climate change: the role of the green infrastructure. Built Environ. 1978- 115–133.

Girg, B., 2008. Tauwetter am Nordpol: Kalter Krieg um Rohstoffe? Die Arktis im Zeichen des Klimawandels. Diskuss. Forschungsgruppe Sicherheitspolitik Stift. Wiss. Polit. SWP.

Gladwell, M., 2000. The tipping point: how little things can make a big difference. Little Brown, New York.

Glasze, G., Mattissek, A., 2014. Diskursforschung in der Humangeographie, in: Angermuller, J., Nonhoff, M., Herschinger, E., Macgilchrist, F., Reisigl, M., Wedl, J., Wrana, D., Ziem, A. (Eds.), Diskursforschung. Ein Interdisziplinäres Handbuch. Band 1: Theorien, Mothodologien Und Kontroversen. Transcript Verlag, Bielefeld, pp. 208–223.

Global Crop Diversity Trust, 2014. Structure [WWW Document]. Svalbard Glob. Seed Vault. URL http://www.croptrust.org/content/structure (accessed 12.4.14).

Goldman, N., Bertone, P., Chen, S., Dessimoz, C., LeProust, E.M., Sipos, B., Birney, E., 2013. Towards practical, high-capacity, low-maintenance information storage in synthesized DNA.

Nature 494, 77–80. doi:10.1038/nature11875
Graczyk, P., Koivurova, T., 2014. A new era in the Arctic Council's external relations? Broader consequences of the Nuuk observer rules for Arctic governance. Polar Rec. 50, 225–236. doi:10.1017/S0032247412000824
Grad, F.P., 2002. The preamble of the constitution of the World Health Organization. Bull. World Health Organ. 80, 981–981.
Grant, B.W., Middendorf, G., Colgan, M.J., Ahmad, H., Vogel, M.B., 2011. Ecology of Urban Amphibians and Reptiles: Urbanophiles, Urbanophobes and the Urbanoblivious, in: Niemelä, J. (Ed.), Urban Ecology: Patterns, Processes, and Applications. Oxford University Press, New York, pp. 167 – 178.
Graumann, C.F., Kruse, L., 2003. Räumliche Umwelt. Die Perspektive der humanökologisch orientierten Umweltpsychologie, in: Meusburger, P., Schwan, T. (Eds.), Humanökologie. Ansätze Zur Überwindung Der Natur-Gesellschaft-Dichotomie. Franz Steiner Verlag, Stuttgart, pp. 239 – 256.
Green, D., Raygorodetsky, G., 2010. Indigenous knowledge of a changing climate. Clim. Change 100, 239–242. doi:10.1007/s10584-010-9804-y
Greenland :: Economy [WWW Document], 2014. . Encycl. Br. URL http://www.britannica.com/EBchecked/topic/245261/Greenland/2836/Economy (accessed 11.20.14).
Grønlund, A., 2009. Virkning av klimaendring p\a a arealbruk i norsk arktis. Bioforsk Rapp. 4, 109.
Grönmeier, K., Hönig, S.-M., Jentsch, I., Leib, S., Loskyll, J., Mayer, C., Rothardt, S., Seimetz, J., Tweraser, S., Villinger, F., Waldenmeyer, G., Norra, S., 2013. Assessment of Ecosystem Services in Urban Systems for the Example of Karlsruhe, in: Rauch, S., Morrison, G., Norra, S., Schleicher, N. (Eds.), Urban Environment. Proceedings of the 11th Urban Environment Symposium (UES), Held in Karlsruhe, Germany, 16-19 September 2012. Springer Netherlands, Dordrecht, pp. 133–142.
Groß, M., 2001. Die Natur der Gesellschaft. Eine Geschichte der Umweltsoziologie. Juventa Verlag, Weinheim.
Grunwald, A., 2002. Wenn Roboter planen: Implikationen und Probleme einer Begriffszuschreibung, in: Rammert, W., Schulz-Schaeffer, I. (Eds.), Können Maschinen Handeln? Soziologische Beiträge Zum Verhältnis von Mensch Und Technik. Campus Verlag, Frankfurt am Main, pp. 141 – 160.

Gunitskiy, V., 2008. On thin ice: water rights and resource disputes in the Arctic Ocean. J. Int. Aff.-COLUMBIA Univ. 61, 261–271.

Gyimóthy, S., Mykletun, R.J., 2004. Play in adventure tourism. Ann. Tour. Res. 31, 855–878. doi:10.1016/j.annals.2004.03.005

Haberl, H., 2008. Ein weiter Weg zur Nachhaltigkeit: Analysen sozialökologischer Übergänge zeigen das Ausmaß nötiger Veränderungen auf. J. Für Entwicklungspolitik 24, 36 – 55.

Haberl, H., Erb, K.-H., Krausmann, F., Loibl, W., Schulz, N., Weisz, H., 2001. Changes in ecosystem processes induced by land use: Human appropriation of aboveground NPP and its influence on standing crop in Austria. Glob. Biogeochem. Cycles 15, 929–942.

Haberl, H., Fischer-Kowalski, M., Krausmann, F., Martinez-Alier, J., Winiwarter, V., 2011. A socio-metabolic transition towards sustainability? Challenges for another Great Transformation. Sustain. Dev. 19, 1–14. doi:10.1002/sd.410

Haberl, H., Fischer-Kowalski, M., Krausmann, F., Weisz, H., Winiwarter, V., 2004a. Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer. Land Use Policy 21, 199–213. doi:10.1016/j.landusepol.2003.10.013

Haberl, H., Schulz, N.B., Plutzar, C., Erb, K.H., Krausmann, F., Loibl, W., Moser, D., Sauberer, N., Weisz, H., Zechmeister, H.G., Zulka, P., 2004b. Human appropriation of net primary production and species diversity in agricultural landscapes. Agric. Ecosyst. Environ. 102, 213–218. doi:10.1016/j.agee.2003.07.004

Häkkinen, S., Hall, D.K., Shuman, C.A., Worthen, D.L., DiGirolamo, N.E., 2014. Greenland ice sheet melt from MODIS and associated atmospheric variability: GIS MELT AND ATMOSPHERIC VARIABILITY. Geophys. Res. Lett. 41, 1600–1607. doi:10.1002/2013GL059185

Hale, A., 2002. Whose Celtic Cornwall? The ethnic Cornish meet Celtic spirituality, in: Harvey, D., Jones, R., McInroy, N., Milligan, C. (Eds.), Celtic Geographies: Old Culture, New Times. Routledge, London; New York, pp. 157–170.

Hall, C.M., 2001. Trends in ocean and coastal tourism: the end of the last frontier? Ocean Coast. Manag. 44, 601–618.

Hall, C.M., Saarinen, J., 2010. Polar Tourism: Definitions and Dimensions. Scand. J. Hosp. Tour. 10, 448–467. doi:10.1080/15022250.2010.521686

Hall, K.R.L., 1963. Tool-using performances as indicators of behavioral adaptability. Curr.

Anthropol. 479–494.

Hamilton, L.C., Brown, B.C., Rasmussen, R.O., 2003. West Greenland’s cod-to-shrimp transition: local dimensions of climatic change. Arctic 271–282.

Hansen, B.U., 1991. Monitoring Natural Vegetation in Southern Greenland Using NOAA AVHRR and Field Measurements. Arctic 44, 94–101.

Harmon, P., 2007. Business process change: a guide for business managers and BPM and six sigma professionals, 2nd ed. ed. Elsevier/Morgan Kaufmann Publishers, Amsterdam ; Boston.

Harrison, S., Massey, D., Richards, K., Magilligan, F.J., Thrift, N., Bender, B., 2004. Thinking across the divide: perspectives on the conversations between physical and human geography. Area 36, 435–442. doi:10.1111/j.0004-0894.2004.00243.x

Harsem, Ø., Eide, A., Heen, K., 2011. Factors influencing future oil and gas prospects in the Arctic. Energy Policy 39, 8037–8045. doi:10.1016/j.enpol.2011.09.058

Härtling, J., Zielhofer, C., Lechner, A., 2011. Klimawandel in den Polargebieten. Geogr. Rundsch. 63, 4–10.

Heikkinen, H.I., Sarkki, S., Nuttall, M., 2012. Users or producers of ecosystem services? A scenario exercise for integrating conservation and reindeer herding in northeast Finland. Pastor. Res. Policy Pract. 2, 11. doi:10.1186/2041-7136-2-11

Heineberg, H., 2007. Einführung in die Anthropogeographie, Humangeographie, 3. Auflage. ed. Schöningh, Paderborn; München [u.a.].

Heleniak, T., Bogoyavlensky, D., 2015. Arctic Populations and Migration, in: Arctic Human Development Report: Regional Processes and Global Linkages. Nordic Council of Ministers.

Helle, T., Kojola, I., 2008. Demographics in an alpine reindeer herd: effects of density and winter weather. Ecography 0, 080227084236895–0. doi:10.1111/j.2008.0906-7590.04912.x

Helle, T., Kojola, I., 1993. Reproduction and mortality of Finnish semi-domesticated reindeer in relation to density and management strategies. Arctic 72–77.

Helle, T.P., Jaakkola, L.M., 2008. Transitions in herd management of semi-domesticated reindeer in northern Finland, in: Annales Zoologici Fennici. BioOne, pp. 81–101.

Hicks, C.C., Graham, N.A.J., Cinner, J.E., 2013. Synergies and tradeoffs in how managers, scientists, and fishers value coral reef ecosystem services. Glob. Environ. Change 23, 1444–1453. doi:10.1016/j.gloenvcha.2013.07.028

Hinch, T., 1998. Ecotourists and Indigenous Hosts: Diverging Views on Their Relationship With

Nature. Curr. Issues Tour. 1, 120–124. doi:10.1080/13683509808667834

Hinrichs, W., 1991. Heimatbildung, Heimatkunde, Ökologie im nationalen und eurpäischen Kontext. Standortprobleme in Erziehung und Wissenschaft, Natur und Kultur. Kulturstiftung deutscher Vertriebener, Bonn.

Hoag, H., 2010. Inuit concerns stall seismic testing. Nature. doi:10.1038/news.2010.403

Hoffmann, A., 2010. Can Machines Think? An Old Question Reformulated. Minds Mach. 20, 203–212. doi:10.1007/s11023-010-9193-z

Hong, N., 2014. Emerging interests of non-Arctic countries in the Arctic: a Chinese perspective. Polar J. 4, 271–286. doi:10.1080/2154896X.2014.954888

Hopkin, M., 2007. Norway unveils design of "doomsday" seed bank. Nature 445, 693–693. doi:10.1038/445693a

Hossain, K., 2013. The EU ban on the import of seal products and the WTO regulations: neglected human rights of the Arctic indigenous peoples? Polar Rec. 49, 154–166. doi:10.1017/S0032247412000174

Hovelsrud, G.K., McKenna, M., Huntington, H.P., 2008. Marine mammal harvests and other interactions with humans. Ecol. Appl. 18, 135–147.

Hovelsrud, G.K., Poppel, B., van Oort, B.E.H., Reist, J.D., 2011. Arctic Societies, Cultures, and Peoples, in: AMAP (Ed.), Snow, Water, Ice and Permafrost in the Arctic. Oslo, pp. 445–483.

Huang, K.-L., Chiao, C.-C., 2013. Can cuttlefish learn by observing others? Anim. Cogn. 16, 313–320. doi:10.1007/s10071-012-0573-z

Huebert, R., 2013. Cooperation or Conflict in the New Arctic? Too Simple of a Dichotomy!, in: Berkman, P.A., Vylegzhanin, A.N. (Eds.), Environmental Security in the Arctic Ocean. Springer Netherlands, Dordrecht, pp. 195–203.

Huebert, R.N., 2008. Climate change and Canadian sovereignty in the Northwest Passage, in: Ferris, J.R. (Ed.), Canadian Arctic Sovereignty and Security: Historical Perspectives. Centre for Military and Strategic Studies, University of Calgary, Calgary, AB, pp. 383 – 400.

Humpert, M., Raspotnik, A., 2012a. The Future of Arctic Shipping Along the Transpolar Sea Route. Arct. Yearb. 2012 281–307.

Humpert, M., Raspotnik, A., 2012b. The future of Arctic shipping. Port Technol. Int. 55.

Humrich, C., 2011. Vom Meltdown zum Showdown?: Herausforderungen und Optionen für Governance in der Arktis, HFSK-Report. Hessische Stiftung Friedens- und Konfliktforschung (HSFK), Frankfurt am Main.

Huntington, H., Braem, N.M., Brown, C.L., Hunn, E., Krieg, T.M., Lestenkof, P., Noongwook, G., Sepez, J., Sigler, M.F., Wiese, F.K., Zavadil, P., 2013. Local and traditional knowledge regarding the Bering Sea ecosystem: Selected results from five indigenous communities. Deep Sea Res. Part II Top. Stud. Oceanogr. 94, 323–332. doi:10.1016/j.dsr2.2013.04.025

Huntington, H., Callaghan, T., Fox, S., Krupnik, I., 2004a. Matching traditional and scientific observations to detect environmental change: a discussion on Arctic terrestrial ecosystems. Ambio 18–23.

Huntington, H., Fox, S., 2007. The changing Arctic: indigenous perspectives, in: ACIA (Ed.), Arctic Climate Impact Assessment Report. Cambride University Press.

Huntington, H.P., 2005. "We Dance Around in a Ring and Suppose": Academic Engagement with Traditional Knowledge. Arct. Anthropol. 42, 29–32.

Huntington, H.P., 2000. Using Traditional Ecological Knowledge in Science: Methods and Applications. Ecol. Appl. 10, 1270–1274. doi:10.1890/1051-0761(2000)010[1270:UTEKIS]2.0.CO;2

Huntington, H., Suydam, R.S., Rosenberg, D.H., 2004b. Traditional knowledge and satellite tracking as complementary approaches to ecological understanding. Environ. Conserv. 31, 177–180.

Imas, A., 2014. Working for the "warm glow": On the benefits and limits of prosocial incentives. J. Public Econ. 114, 14–18. doi:10.1016/j.jpubeco.2013.11.006

Inga, B., Danell, Ö., 2012. Traditional ecological knowledge among Sami reindeer herders in northern Sweden about vascular plants grazed by reindeer. Rangifer 32, 1–17.

Ingold, T., Kurttila, T., 2000. Perceiving the Environment in Finnish Lapland. Body Soc. 6, 183–196. doi:10.1177/1357034X00006003010

Intergovernmental Panel on Climate Change, 2007. Klimaänderung 2007: Zusammenfassungen für politische Entscheidungsträger. ProClim [u.a.], Bern.

Intergovernmental Panel on Climate Change (IPCC), 2014a. Climate Change 2014. Synthesis Report. Summary for Policymakers.

Intergovernmental Panel on Climate Change (IPCC), 2014b. Climate Change 2014. Synthesis Report. Longer report.

International Bank for Reconstruction and Development / The World Bank (Ed.), 2013. The Pirates of Somalia: Ending the Treat, Rebuilding a Nation. Washington, DC.

Isleib, J., 2012. Soil temperature, seed germination and the unusual spring of 2012 [WWW

Document]. Mich. State Univ. Ext. URL http://msue.anr.msu.edu/news/soil_temperature_seed_germination_and_the_unusual_spring_of_2012 (accessed 11.21.14).

Isted, K., 2009. Sovereignty in the Arctic: An Analysis of Territorial Disputes and Environmental Policy Considerations. J. Transnatl. Law Policy 18, 343–376.

Jahn, E., 2015. Geopolitik – Legitimationsideologie nationalsozialistischer Eroberungspolitik oder eine heute verkannte wissenschaftliche und politische Aufgabe?, in: Politische Streitfragen. Springer Fachmedien Wiesbaden, Wiesbaden, pp. 173–191.

Jasanoff, S., 2003. In a Constitutional Moment: Science and Social Order at the Millenium, in: Joerges, B., Nowotny, H. (Eds.), Social Studies of Science and Technology: Loocking Back, Ahead. Kluver Academic Publishers, London, pp. 155 – 182.

Jax, K., Barton, D.N., Chan, K.M.A., de Groot, R., Doyle, U., Eser, U., Görg, C., Gómez-Baggethun, E., Griewald, Y., Haber, W., Haines-Young, R., Heink, U., Jahn, T., Joosten, H., Kerschbaumer, L., Korn, H., Luck, G.W., Matzdorf, B., Muraca, B., Neßhöver, C., Norton, B., Ott, K., Potschin, M., Rauschmayer, F., von Haaren, C., Wichmann, S., 2013. Ecosystem services and ethics. Ecol. Econ. 93, 260–268. doi:10.1016/j.ecolecon.2013.06.008

Jensen, Ø., 2010. The IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters: From Voluntary to Mandatory Tool for Navigation Safety and Environmental Protection?

Johnsen, K., Alfthan, B., Hislop, L., Skaalvik, F. (Eds.), 2010. Protecting Arctic Biodiversity. United Nations Environmental Programme, GRID-Arendal, www.grida.no.

Johnsen, M.T., Wynn, R., Bratlid, T., 2012. Is there a negative impact of winter on mental distress and sleeping problems in the subarctic: The Tromsø Study. BMC Psychiatry 12, 225. doi:10.1186/1471-244X-12-225

Johnson, D., 2002. Environmentally sustainable cruise tourism: a reality check. Mar. Policy 26, 261–270.

Johnston, R.F., 2001. Synanthropic birds of North America, in: Marzluff, J.M., Bowman, R., Donnelly, R. (Eds.), Avian Ecology and Conservation in an Urbanizing World. Springer US, Boston, MA.

Jöns, H., 2003. Grenzüberschreitende Mobilität und Kooperation in den Wissenschaften. Deutschlandaufenthalte US-amerikanischer Humboldt-Forschungspreisträger aus einer erweiterten Akteursnetzwerkperspektive. Selbstverlag des Geographischen Instituts der Universität Heidelberg, Heidelberg.

Juday, G.P., Barber, V., Duffy, P., Linderholm, H., Rupp, S., Sparrow, S., Vaganov, E., Yarie, J., 2005. Forests, Land Management, and Agriculture, in: ACIA Secretariat and Cooperative Institute for Arctic Research, University of Alaska Fairbanks (Eds.), Arctic Climate Impact Assessment. Scientific Report. Cambridge University Press, New York, pp. 781–862.

Kaczan, D., Swallow, B.M., Adamowicz, W.L. (Vic), 2013. Designing a payments for ecosystem services (PES) program to reduce deforestation in Tanzania: An assessment of payment approaches. Ecol. Econ. 95, 20–30. doi:10.1016/j.ecolecon.2013.07.011

Kaiser, N., Ruong, T., Renberg, E.S., 2013. Experiences of being a young male Sami reindeer herder: a qualitative study in perspective of mental health. Int. J. Circumpolar Health 72. doi:10.3402/ijch.v72i0.20926

Kambites, C., Owen, S., 2006. Renewed prospects for green infrastructure planning in the UK 1. Plan. Pract. Res. 21, 483–496. doi:10.1080/02697450601173413

Kankaanpää, P., Young, O.R., 2012. The effectiveness of the Arctic Council. Polar Res. 31. doi:10.3402/polar.v31i0.17176

Kanwischer, D., 2006. Der Doppelcharakter der Geographie und andere Katastrophen nebst einigen Bemerkungen zur fachdidaktischen Umsetzung. Kunst Sich Einzumischen Vom Vielfältigen Kreat. Wirk. Geogr. Tilman Rhode-Jüchtern Von Freunden Weggefährten Zum 60 Geburtstag Zugeeignet, Geographische Revue. Online-Diskussionforum 127–142.

Kao, S.-M., Pearre, N.S., Firestone, J., 2012. Adoption of the arctic search and rescue agreement: A shift of the arctic regime toward a hard law basis? Mar. Policy 36, 832–838. doi:10.1016/j.marpol.2011.12.001

Kazig, R., Weichhart, P., 2009. Die Neuthematisierung der materiellen Welt in der Humangeographie. Berichte Zur Dtsch. Landeskd. 83, 109–128.

Khon, V.C., Mokhov, I.I., Latif, M., Semenov, V.A., Park, W., 2010. Perspectives of Northern Sea Route and Northwest Passage in the twenty-first century. Clim. Change 100, 757–768. doi:10.1007/s10584-009-9683-2

Khoury, C., Laliberté, B., Guarino, L., 2010. Trends in ex situ conservation of plant genetic resources: a review of global crop and regional conservation strategies. Genet. Resour. Crop Evol. 57, 625–639. doi:10.1007/s10722-010-9534-z

Kitchen, A., Miyamoto, M.M., Mulligan, C.J., 2008. A Three-Stage Colonization Model for the Peopling of the Americas. PLoS ONE 3, e1596. doi:10.1371/journal.pone.0001596

Klein, D.R., Shulski, M., 2011. The Role of Lichens, Reindeer, and Climat ein Ecosystem Change

on a Bering Sea Island. ARCTIC 64, 353–361.
Kleist, K.V., 2014. New Year Adress 2013 [WWW Document]. Naalakkersuisut Gov. Greenl. URL http://naalakkersuisut.gl/en/Naalakkersuisut/News/2013/01/Nytaarstale
Kneafsey, M., 2002. Tourism images and the construction of Celticity in Ireland and Brittany. Celt. Geogr. Old Cult. New Times Routledge Lond. 123–138.
Knox, P.L., Marston, S.A., 2008. Humangeographie, 4. Aufl. ed. Springer/Spektrum Akad. Verl, Heidelberg.
Köck, H., 2008. Thesen zur innergeographischen Integration von Natur-und sozialwissenschaftlicher Dimension als Voraussetzung für eine mögliche Brückenfunktion. Geogr. Rev. 10, 31–40.
Koivurova, T., 2011. The Actions of the Arctic States Respecting the Continental Shelf: A Reflective Essay. Ocean Dev. Int. Law 42, 211–226. doi:10.1080/00908320.2011.592470
Koivurova, T., 2010. Limits and possibilities of the Arctic Council in a rapidly changing scene of Arctic governance. Polar Rec. 46, 146. doi:10.1017/S0032247409008365
Koivurova, T., 2008a. Alternatives for an Arctic treaty–Evaluation and a new proposal. Rev. Eur. Community Int. Environ. Law 17, 14–26.
Koivurova, T., 2008b. The Limits of the Arctic Council, in: Heininen, L., Laine, K. (Eds.), The Borderless North: Publication of the Fourth Northern Research Forum. The Thule institute, University of Oulu, Northern Research Forum, [Oulu], pp. 166–173.
Koivurova, T., VanderZwaag, D., 2007. The Arctic Council at 10 Years: Retrospect and Prospects. Univ. Br. Columbia Law Rev. 40, 121–194.
Kontogianni, A., Tourkolias, C., Machleras, A., Skourtos, M., 2012. Service providing units, existence values and the valuation of endangered species: A methodological test. Ecol. Econ. 79, 97–104. doi:10.1016/j.ecolecon.2012.04.023
Kozlowski, J., Bandi, H.-G., 1984. The paleohistory of circumpolar arctic colonization. Arctic 359–372.
Krausmann, F., Fischer-Kowalski, M., Schandl, H., Eisenmenger, N., 2008. The Global Sociometabolic Transition: Past and Present Metabolic Profiles and Their Future Trajectories. J. Ind. Ecol. 12, 637–656. doi:10.1111/j.1530-9290.2008.00065.x
Krausmann, F., Haberl, H., Erb, K.-H., Wackernagel, M., 2004. Resource flows and land use in Austria 1950–2000: using the MEFA framework to monitor society–nature interaction for sustainability. Land Use Policy 21, 215–230.

Krausmann, F., Haberl, H., Erb, K.-H., Wiesinger, M., Gaube, V., Gingrich, S., 2009. What determines geographical patterns of the global human appropriation of net primary production? J. Land Use Sci. 4, 15–33. doi:10.1080/17474230802645568

Kubiszewski, I., Costanza, R., Dorji, L., Thoennes, P., Tshering, K., 2013. An initial estimate of the value of ecosystem services in Bhutan. Ecosyst. Serv. 3, e11–e21. doi:10.1016/j.ecoser.2012.11.004

Kuhn, I., Brandl, R., Klotz, S., 2004. The flora of German cities is naturally species rich. Evol. Ecol. Res. 6, 749–764.

Kullerud, L., Beaudoin, Y.C., Poussart, J.-N., Prokosch, P., Sund, H., 2013. The Arctic Ocean and UNCLOS Article 76: Are There Any Commons?, in: Berkman, P.A., Vylegzhanin, A.N. (Eds.), Environmental Security in the Arctic Ocean. Springer Netherlands, Dordrecht, pp. 185–194.

Kumpula, J., Colpaert, A., 2009. Snow conditions and usability value of pastureland for semi-domesticated reindeer (Rangifer tarandus tarandus) in northern boreal forest area. Rangifer 27, 25–39.

Kürner, F., Kramer, C., Klüver, H., Norra, S., 2015. Combining Actor-Network Theory and the Concept of Ecosystem Services to Assess the Development of Arctic Shipping Routes: Int. J. Actor-Netw. Theory Technol. Innov. 7, 1–18. doi:10.4018/ijantti.2015040101

Langley, P., Pearce, C., Barley, M., Emery, M., 2014. Bounded rationality in problem solving: Guiding search with domain-independent heuristics. Mind Soc. 13, 83–95. doi:10.1007/s11299-014-0143-y

Larkin, J.E., 2009. UNCLOS and the Balance of Environmental and Economic Resources in the Arctic. 22 Geo Intl Envtl Rev 307.

Larsen, J.N., Anisimov, O.A., Constable, A., Hollowed, A.B., Maynard, N.G., Prestrud, P., Prowse, T.D., Stone, J.M.R., 2014. Polar Regions, in: Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Billir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fith Assessment Report of the Intergovernmental Panel on Climate Change. Cambride University Press, Cambridge, U.K. ; New York, N.Y, USA, pp. 1567–1612.

Lasserre, F., 2014a. Simulations of shipping along Arctic routes: comparison, analysis and

economic perspectives. Polar Rec. 1–21. doi:10.1017/S0032247413000958
Lasserre, F., 2014b. Case studies of shipping along Arctic routes. Analysis and profitability perspectives for the container sector. Transp. Res. Part Policy Pract. 66, 144–161. doi:10.1016/j.tra.2014.05.005
Lassury, D., Lewis, P.N., 2010. Invasive species (human induced), in: Arctic Biodiversity Trends 2010 - Selcted Indicators of Change. CAFF International Secretariat, Akureyri, Iceland, pp. 45–48.
Latour, B., 2013. Biography of an inquiry: On a book about modes of existence. Soc. Stud. Sci. 43, 287–301. doi:10.1177/0306312712470751
Latour, B., 2010a. Eine neue Soziologie für eine neue Gesellschaft: Einführung in die Akteur-Netzwerk-Theorie. Suhrkamp, Berlin.
Latour, B., 2010b. An Attempt at a“ Compositionist Manifesto.” New Lit. Hist. 41, 471–490.
Latour, B., 2010c. Networks, societies, spheres: Reflections of an actor-network theorist. Presented at the International Seminar On Network Theory: Network Multidimensionality In The Digital Age, Annenberg School for Communication and Journalism, Los Angeles.
Latour, B., 2009a. Will non-humans be saved? An argument in ecotheology. J. R. Anthropol. Inst. 15, 459–475. doi:10.1111/j.1467-9655.2009.01568.x
Latour, B., 2009b. A collective of humans and non-humans following Daedalus's labyrinth, in: Kaplan, D.M. (Ed.), Readings in the Philosophy of Technology. Rowman & Littlefield Publishers, Maryland, pp. 156 – 168.
Latour, B., 2009c. Spheres and networks: two ways to reinterpret globalization. Harv. Des. Mag. 30, 138–144.
Latour, B., 2009d. Politics of nature. Harvard University Press.
Latour, B., 2009e. Perspectivism: "Type" or "bomb"? Anthropol. Today 25, 1–2. doi:10.1111/j.1467-8322.2009.00652.x
Latour, B., 2008a. Wir sind nie modern gewesen: Versuch einer symmetrischen Anthropologie. Suhrkamp, Frankfurt am Main.
Latour, B., 2008b. A cautious prometheus? A few steps toward a philosophy of design (with special attention to Peter Sloterdijk), in: Proceedings of the 2008 Annual International Conference of the Design History Society. pp. 2–10.
Latour, B., 2008c. What is the style of matters of concern?: two lectures in empirical philosophy. Koninklijke Van Gorcum, Assen.

Latour, B., 2007. Turning Around Politics: A Note on Gerard de Vries' Paper. Soc. Stud. Sci. 37, 811–820. doi:10.1177/0306312707081222

Latour, B., 2005. Von der "Realpolitik" zur "Dingpolitik" oder wie man Dinge öffentlich macht. Merve-Verl., Berlin.

Latour, B., 2004. Why has critique run out of steam? From matters of fact to matters of concern. Crit. Inq. 30, 225–248.

Latour, B., 2003. Atmosphere, atmosphere. Olafur Eliasson Weather Proj. 29–41.

Latour, B., 2000a. Die Hoffnung der Pandora: Untersuchungen zur Wirklichkeit der Wissenschaft. Suhrkamp, Frankfurt am Main.

Latour, B., 2000b. THE BERL1N KEY OR HOW TO DO WORDS W1TH TH1NGS'. Matter Mater. Mod. Cult. 10 – 21.

Latour, B., 1999a. On recalling ANT, in: Hassard, J., Law, J. (Eds.), Actor Networt Theory and after. Blackwell Publishers, Oxford, pp. 15 – 25.

Latour, B., 1999b. For David Bloor... and Beyond: A Reply to David Bloor's' Anti-Latour'. Stud. Hist. Philos. Sci. 30, 113–130.

Latour, B., 1998. Über technische Vermittlung. Philosophie, Soziologie, Genealogie, in: Rammert, W. (Ed.), Technik Und Sozialtheorie. Campus Verlag, Frankfurt am Main, pp. 83 – 120.

Latour, B., 1996a. On actor-network theory: a few clarifications plis more than a few complications. Soz. Welt 47, 369–381.

Latour, B., 1996b. Aramis, or, the love of technology. Harvard University Press Cambridge, MA.

Latour, B., 1994a. Pragmatogonies: A mythical account of how humans and nonhumans swap properties. Hum. Concept Agency Its Attrib. Spec. Issue Am. Behav. Sci., 37 6, 791 – 808 (third modified part of Article (54)).

Latour, B., 1994b. On technical mediation. Common Knowl. 3, 29–64.

Latour, B., 1993. We have never been modern. Harvester Weatsheaf, Harlow, UK.

Latour, B., 1991. Materials of Power. Technology is society made durable, in: Law, J. (Ed.), A Sociology of Monsters. Essays on Power, Technology and Domination. Routledge, London, pp. 103 – 131.

Latour, B., 1988a. How to write "The Prince" for machines as well as for machinations, in: Elliott, B. (Ed.), Technology and Social Change. Edinburgh University Press, pp. 20–43.

Latour, B., 1988b. The pasteurization of France. Harvard University Press, Cambridge, Mass.

Latour, B., 1987. Science in action: how to follow scientists and engineers through society. Harvard

University Press, Cambridge, Mass.
Latour, B., 1986a. Laboratory life: the construction of scientific facts. Princeton University Press, Princeton, N.J.
Latour, B., 1986b. The powers of association. Sociol. Rev. [Monogr.] 264–280.
Latour, B., Jensen, P., Venturini, T., Grauwin, S., Boullier, D., 2012. "The whole is always smaller than its parts"–a digital test of Gabriel Tardes' monads. Br. J. Sociol. 63, 590–615.
Latour, B., Mauguin, P., Teil, G., 1992. A note on socio-technical graphs. Soc. Stud. Sci. 22, 33–57.
Latour, B., Venn, C., 2002. Morality and Technology The End of the Means. Theory Cult. Soc. 19, 247–260.
Lauster, G., Mildner, S.-A., 2009. Wem gehört der Meeresboden? Int. Polit. 30 – 37.
Law, J., 2009. Actor network theory and material semiotics, in: Turner, B.S. (Ed.), The New Blackwell Companion to Social Theory. pp. 141–158.
Law, J., 1990. Power, discretion and strategy. Sociol. Rev. 38, 165–191. doi:10.1111/j.1467-954X.1990.tb03352.x
Law, J., Bauin, S., Courtial, J.-P., Whittaker, J., 1988. Policy and the mapping of scientific change: A co-word analysis of research into environmental acidification. Scientometrics 14, 251–264. doi:10.1007/BF02020078
Law, J., Callon, M., 1994. The Life and Death of an Aircraft: A Network Analysis of Technical Change, in: Bijker, W.E., Law, J. (Eds.), Shaping Technology / Building Society: Studies in Sociotechnical Change. The MIT Press, Cambridge, Mass.
Law, J., Mol, A., 1995. Notes on Materiality and Sociality. Sociol. Rev. 274–294.
Law, J., Singleton, V., 2013. ANT and Politics: Working in and on the World. Qual. Sociol. 36, 485–502.
Leary, D., 2008. Bi-polar Disorder? Is Bioprospecting an Emerging Issue for the Arctic as well as for Antarctica? Rev. Eur. Community Int. Environ. Law 17, 41–55. doi:10.1111/j.1467-9388.2008.00584.x
Lee, R.B., 1998. What Hunters Do for a Living, or, How to Make Out on Scarce Resources, in: Gowdy, J. (Ed.), Limited Wants, Unlimited Means: A Reader On Hunter-Gatherer Economics And The Environment. Island Press, Washington, D.C., Covelo, California, pp. 43 – 64.
Lefebvre, L., Nicolakakis, N., Boire, D., 2002. Tools and Brains in Birds. Behaviour 139, 939–973.
Leser, H., Haas, H.-D., Mosimann, T., Paesler, R., Huber-Fröhli, J., 1998. Wörterbuch Allgemeine

Geographie, 10. Auflage. ed. Deutscher Taschenbuch Verlag GmbH & Co KG, München.
Lewicka, M., 2010. What makes neighborhood different from home and city? Effects of place scale on place attachment. J. Environ. Psychol. 30, 35–51. doi:10.1016/j.jenvp.2009.05.004
Lewis, A.E., Hammill, M.O., Power, M., Doidge, D.W., Lesage, V., 2009. Movement and aggregation of eastern Hudson Bay beluga whales (Delphinapterus leucas): A comparison of patterns found through satellite telemetry and Nunavik traditional ecological knowledge. Arctic 13–24.
Li, D.-Z., Pritchard, H.W., 2009. The science and economics of ex situ plant conservation. Trends Plant Sci. 14, 614–621. doi:10.1016/j.tplants.2009.09.005
Linderholm, H.W., 2006. Growing season changes in the last century. Agric. For. Meteorol. 137, 1–14. doi:10.1016/j.agrformet.2006.03.006
Locatelli, T., Binet, T., Kairo, J.G., King, L., Madden, S., Patenaude, G., Upton, C., Huxham, M., 2014. Turning the Tide: How Blue Carbon and Payments for Ecosystem Services (PES) Might Help Save Mangrove Forests. AMBIO. doi:10.1007/s13280-014-0530-y
Lorentzen, K.F., 2002. Luhmann goes Latour - Zur Soziologie hybrider Beziehungen, in: Rammert, W., Schulz-Schaeffer, I. (Eds.), Können Maschinen Handeln? Soziologische Beiträge Zum Verhältnis von Mensch Und Technik. Campus Verlag, Frankfurt am Main, pp. 101 – 118.
Magga, O., Mathiesen, S.D., Corell, R.W., Oskal, A. (Eds.), 2011. Reindeer herding, traditional knowledge and adaptation to climate change and loss of grazing land. A project led by Norway and Association of World Reindeer Herders (WRH) in Arctic Council, Sustainable Development Working Group (SDWG), Ministerial Report 2011, International Centre for Reindeer Husbandry and Association of World Reindeer Herders. International Centre for Reindeer Husbandry Report 1:2011. Fagtrykk Idé AS, Alta, Norway.
Malakoff, D., 2014. 25 Years After the Exxon Valdez, Where Are the Herring? Science 343, 1416–1416. doi:10.1126/science.343.6178.1416
Maldonado, J.K., Shearer, C., Bronen, R., Peterson, K., Lazrus, H., 2013. The impact of climate change on tribal communities in the US: displacement, relocation, and human rights. Clim. Change 120, 601–614. doi:10.1007/s10584-013-0746-z
Malsch, T., 1995. Problembegriff und "problem solving". Ein Essay über künstliche Intelligenz und Wissensgenese, in: Rammert, W. (Ed.), Soziologie Und Künstliche Intelligenz. Produkte Und Probleme Einer Hochtechnologie. Campus Verlag, Frankfurt am Main, pp. 133–160.
Markussen, A.H., 2012. Sketch for an Arctic cuisine. Anthropol. Food.

Marsh, J., Staple, S., 1995. Cruise tourism in the Canadian Arctic and its implications., in: Hall, C.M., Johnston, M.E. (Eds.), Polar Tourism: Tourism in the Arctic and Antarctic Regions. Wiley, Chichester, pp. 63–72.

Martello, M.L., 2008. Arctic Indigenous Peoples as Representations and Representatives of Climate Change. Soc. Stud. Sci. 38, 351–376. doi:10.1177/0306312707083665

Mason, P., Johnston, M., Twynam, D., 2000a. The World Wide Fund for Nature Arctic Tourism Project, in: Bramwell, B., Lane, B. (Eds.), Tourism Collaboration and Partnerships: Politics, Practice and Sustainability, Aspects of Tourism. Channel View Publications, Clevedon Tonawanda, North York, Artarmon.

Mason, P., Johnston, M., Twynam, D., 2000b. The World Wide Fund for Nature Arctic Tourism Project. J. Sustain. Tour. 8, 305–323. doi:10.1080/09669580008667366

Masson-Delmotte, V., Swingedouw, D., Landais, A., Seidenkrantz, M.-S., Gauthier, E., Bichet, V., Massa, C., Perren, B., Jomelli, V., Adalgeirsdottir, G., Hesselbjerg Christensen, J., Arneborg, J., Bhatt, U., Walker, D.A., Elberling, B., Gillet-Chaulet, F., Ritz, C., Gallée, H., van den Broeke, M., Fettweis, X., de Vernal, A., Vinther, B., 2012. Greenland climate change: from the past to the future. Wiley Interdiscip. Rev. Clim. Change 3, 427–449. doi:10.1002/wcc.186

Matz-Lück, Nele, 2009. Planting the Flag in Arctic Waters: Russia's Claim to the North Pole. Gött. J. Int. Law 1 235–255. doi:10.3249/1868-1581-1-2-matz-lueck

Mazumdar, S., Mazumdar, S., 2012. Place identity and religion: a study of Hindu immigrants in America, in: Casakin, H., Bernardo, F. (Eds.), The Role of Place Identity in the Perception, Understanding, and Design of the Built Environment. Bentham eBooks, pp. 133–145.

McBride, M.M., Dalpadado, P., Drinkwater, K.F., Godo, O.R., Hobday, A.J., Hollowed, A.B., Kristiansen, T., Murphy, E.J., Ressler, P.H., Subbey, S., Hofmann, E.E., Loeng, H., 2014. Krill, climate, and contrasting future scenarios for Arctic and Antarctic fisheries. ICES J. Mar. Sci. 71, 1934–1955. doi:10.1093/icesjms/fsu002

McKinney, M.L., 2006. Urbanization as a major cause of biotic homogenization. Biol. Conserv. 127, 247–260. doi:10.1016/j.biocon.2005.09.005

McLean, C., Hassard, J., 2004. Symmetrical Absence/Symmetrical Absurdity: Critical Notes on the Production of Actor-Network Accounts. J. Manag. Stud. 41, 493–519. doi:10.1111/j.1467-6486.2004.00442.x

McNutt, M., 2014. Exxon Valdez: 25 Years Later. Science 343, 1289–1289.

doi:10.1126/science.1253412
Mertens, G., 1998. Umwelten: Eine humanökologische Pädagogik. Schöningh, München.
Messerli, B., Grosjean, M., Hofer, T., Núñez, L., Pfister, C., 2001. From Nature-Dominated to Human-Dominated Environmental Changes, in: Ehlers, E., Krafft, T. (Eds.), Understanding the Earth System. Compartments, Processes and Interactions. Springer Verlag, Berlin, pp. 195–208.
Meusburger, P., 2013. Relations Between Knowledge and Economic Development: Some Methodological Considerations, in: Meusburger, P., Glückler, J., Meskioui, M. el (Eds.), Knowledge and the Economy. Springer Netherlands, Dordrecht, pp. 15–42.
Meusburger, P., 2004. Regionale Unterschiede des Wissens. Neue Herausforderungen an die Humangeographie. Mitteilungen Fränkischen Geogr. Ges. Erlangen 50/51, 27–54.
Meusburger, P., 2001. Geography of Knowledge, Education, and Skills, in: International Encyclopedia of the Social & Behavioral Sciences. Elsevier, pp. 8120–8126.
Micheli, F., Mumby, P.J., Brumbaugh, D.R., Broad, K., Dahlgren, C.P., Harborne, A.R., Holmes, K.E., Kappel, C.V., Litvin, S.Y., Sanchirico, J.N., 2014. High vulnerability of ecosystem function and services to diversity loss in Caribbean coral reefs. Biol. Conserv. 171, 186–194. doi:10.1016/j.biocon.2013.12.029
Michelsen, C.F., Pedas, P., Glaring, M.A., Schjoerring, J.K., Stougaard, P., 2014. Bacterial diversity in Greenlandic soils as affected by potato cropping and inorganic versus organic fertilization. Polar Biol. 37, 61–71. doi:10.1007/s00300-013-1410-9
Michelsen, C.F., Stougaard, P., 2011. A Novel Antifungal Pseudomonas fluorescens Isolated from Potato Soils in Greenland. Curr. Microbiol. 62, 1185–1192. doi:10.1007/s00284-010-9846-4
Middleton, B.A., 2011. Multidisciplinary Approaches to Climate Change Questions, in: LePage, B.A. (Ed.), Wetlands. Springer Netherlands, Dordrecht, pp. 129–136.
Millennium Ecosystem Assessment (Program), 2005. Ecosystems and human well-being: synthesis. Island Press, Washington, DC.
Millennium Ecosystem Assessment Program, 2005. Ecosystems and human well-being: current state and trends: findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment, The millennium ecosystem assessment series. Island Press, Washington, DC.
Miller, A.W., Ruiz, G.M., 2014. Arctic shipping and marine invaders. Nat. Clim. Change 4, 413–416. doi:10.1038/nclimate2244

Misa, T., J., 1994. Controversy and closure in technological change: Constructing “steel,” in: Bijker, W.E., Law, J. (Eds.), Shaping Technology/building Society : Studies in Sociotechnical Change. MIT Press, Cambridge, Mass.

Mittelstraß, J., 2012. Transdisziplinarität oder: von der schwachen zur starken Interdisziplinarität. Zwischen Den Wiss. Inter- Multi- Transdisziplinarität Gegenworte Hefte Für Den Disput Über Wissen 28, 11–13.

Moe, A., 2010. Russian and Norwegian petroleum strategies in the Barents Sea. Arct. Rev. Law Polit. 1, 225–248.

Moen, J., 2008. Climate change: effects on the ecological basis for reindeer husbandry in Sweden. AMBIO J. Hum. Environ. 37, 304–311.

Montanarella, L., 2007. Trends in Land Degradation in Europe, in: Sivakumar, M.V.K., Ndegwa, N. (Eds.), Climate and Land Degradation. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 83–104.

Moolenaar, S.W., Lexmond, T.M., 1998. Heavy metal balances, Part I. General Aspects of Cadmium, Copper, Zinc and Lead Balance Studies in Agro-Ecosystems. J. Ind. Ecol. 2, 45–60.

Moore, S.E., Huntington, H.P., 2008. Arctic Marine Mammals and Climate Change: Impacts and Resilience. Ecol. Appl. 18, 157–165.

Moreno, A., Amelung, B., 2009. Climate Change and Coastal & Marine Tourism: Review and Analysis. J. Coast. Res. Special Issue No. 56. Proceedings of the 10th Internationl Coastal Symposim ICS 2009, 1140–1144.

Morton, J.F., 2007. The impact of climate change on smallholder and subsistence agriculture. Proc. Natl. Acad. Sci. 104, 19680–19685.

Moser, I., Law, J., 1999. Good passages, bad passages. Sociol. Rev. 47, 196–219.

Müller, M.J., 1996. Handbuch ausgewählter Klimastationen der Erde, 5th ed, Forschungsstelle Bodenerosion der Universität Trier Mertesdorf (Ruwetal). Merziger druckerei und Verlag GmbH & Co KG, Trier.

Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., Corbera, E., Ezzine de Blas, D., Farley, J., Froger, G., Garcia-Frapolli, E., Gómez-Baggethun, E., Gowdy, J., Kosoy, N., Le Coq, J.F., Leroy, P., May, P., Méral, P., Mibielli, P., Norgaard, R., Ozkaynak, B., Pascual, U., Pengue, W., Perez, M., Pesche, D., Pirard, R., Ramos-Martin, J., Rival, L., Saenz, F., Van Hecken, G., Vatn, A., Vira, B., Urama, K., 2013. Payments for ecosystem services and the fatal attraction of win-win solutions: PES & fatal attraction of win-win solutions. Conserv. Lett. 6, 274–279. doi:10.1111/j.1755-263X.2012.00309.x

Neergaard, E. de, Stougaard, P., Høegh, K., Munk, L., 2009. Climatic changes and agriculture in Greenland: Plant diseases in potatoes and grass fields. IOP Conf. Ser. Earth Environ. Sci. 6, 372013. doi:10.1088/1755-1307/6/7/372013

Nentwig, W., 1995. Humanökologie. Fakten - Argumente - Ausblicke. Springer Verlag, Berlin.

Newell, A., Shaw, J.C., Simon, H.A., 1960. Report on a general problem-solving program for a computer, in: Proceedings of the International Conference on Information Processing. UNESCO House, Paris, pp. 256–264.

Newell, A., Shaw, J.C., Simon, H.A., 1958. Elements of a theory of human problem solving. Psychol. Rev. 65, 151–166. doi:10.1037/h0048495

Newell, A., Simon, H.A., 1976. Computer science as empirical inquiry: Symbols and search. Commun. ACM 19, 113–126.

Newman, O., 1972. Defensible space. Macmillan New York, New York.

Nilsen, T., 2009. Welcome to the new Arctic. Barents Obs.

Nordic Council of Ministers, 2014. Nordic Statistical Yearbook 2014. Nordic Council of Ministers.

Nordic Council of Ministers, 2013. Nordic Statistical Yearbook 2013. Nordisk Ministerråd, Copenhagen.

Norra, S., 2014. The biosphere in times of global urbanization. J. Geochem. Explor. doi:10.1016/j.gexplo.2014.06.004

Northern Sea Route Information Office, 2015. Transit Statistics [WWW Document]. North. Sea Route Inf. Off. URL http://www.arctic-lio.com/nsr_transits (accessed 2.28.15).

Notzke, C., 2004. Indigenous tourism development in southern Alberta, Canada: Tentative engagement. J. Sustain. Tour. 12, 29–54.

Notzke, C., 1999a. Indigenous tourism development in the Arctic. Ann. Tour. Res. 26, 55–76.

Notzke, C., 1999b. Aboriginal community involvement in wildlife tourism: The Canadian experience, in: Treseder, L., Honda-McNeil, J., Berkes, M., Berkes, F., Dragon, J., Notzke, C., Schramm, T., Hudson, R.J. (Eds.), Community Based Wildlife Management in Canada, International Institute for Environment and Development. Canadian Circumpolar Institute, pp. 45–62.

Nuttall, M., 2008. Self-rule in Greenland-towards the world's first independent Inuit state. Indig. Aff. 8, 64–70.

Nuttall, M., 2000. Indigenous peoples, self-determination, and the Arctic environment, in: Nuttall, M., Callaghan, T.V. (Eds.), The Arctic: Environment, People, Policy. Hardwood Academic Publishers, Amsterdam, pp. 377–409.

O'Brien, K., Eriksen, S., Sygna, L., Naess, L.O., 2006. Questioning complacency: climate change impacts, vulnerability, and adaptation in Norway. AMBIO J. Hum. Environ. 35, 50–56.

Official Statistics of Finland (OSF), 2014. Accommodation statistics [e-publication]. ISSN=1799-6325. Appendix table 4. Nights spend in hotels in 2014 [WWW Document]. Stat. Finl. URL http://www.stat.fi/til/matk/2014/matk_2014_2015-04-29_tau_004_en.html (accessed 10.30.15).

Østreng, W., 2012. Shipping and Resources in the Arctic Ocean: A Hemispheric Perspective1. Arct. Yearb. 2012 247.

Østreng, W., Eger, K.M., Fløistad, B., Jørgensen-Dahl, A., Lothe, L., Mejlænder-Larsen, M., Wergeland, T., 2013. Shipping in Arctic Waters: A comparison of the Northeast, Northwest and Trans Polar Passages. Springer Science & Business Media.

Ó Tuathail, G., 1996. Critical geopolitics: the politics of writing global space. Routledge, London.

Øygarden, L., 2003. Rill and gully development during an extreme winter runoff event in Norway. Catena 50, 217–242.

Pacione, M., 2003. Urban environmental quality and human wellbeing—a social geographical perspective. Landsc. Urban Plan. 65, 19–30. doi:10.1016/S0169-2046(02)00234-7

Pagano, S.J., Huo, Y.J., 2007. The Role of Moral Emotions in Predicting Support for Political Actions in Post-War Iraq. Polit. Psychol. 28, 227–255.

Parkinson, C.L., Comiso, J.C., 2013. On the 2012 record low Arctic sea ice cover: Combined impact of preconditioning and an August storm: 2012 RECORD LOW ARCTIC SEA ICE COVER. Geophys. Res. Lett. 40, 1356–1361. doi:10.1002/grl.50349

Parsell, C., 2011. Homeless identities: enacted and ascribed1: Homeless identities. Br. J. Sociol. 62, 442–461. doi:10.1111/j.1468-4446.2011.01373.x

Pateli, A., Philippidou, S., 2011. Applying Business Process Change (BPC) to Implement Multi-agency Collaboration: The Case of the Greek Public Administration. J. Theor. Appl. Electron. Commer. Res. 6, 127–142. doi:10.4067/S0718-18762011000100009

Paul, M.A., Love, R.J., Hawton, A., Brett, K., McCreary, D.R., Arendt, J., 2015. Light Treatment Improves Sleep Quality and Negative Affectiveness in High Arctic Residents During Winter. Photochem. Photobiol. 91, 567–573. doi:10.1111/php.12418

Pearce, T., Ford, J., Willox, A.C., Smit, B., 2015. Inuit Traditional Ecological Knowledge (TEK) Subsistence Hunting and Adaptation to Climate Change in the Canadian Arctic. ARCTIC 68, 233–245. doi:10.14430/arctic4475

Pedersen, T., 2012. Debates over the Role of the Arctic Council. Ocean Dev. Int. Law 43, 146–156. doi:10.1080/00908320.2012.672289

Pedersen, T., 2006. The Svalbard Continental Shelf Controversy: Legal Disputes and Political Rivalries. Ocean Dev. Int. Law 37, 339–358. doi:10.1080/00908320600800960

Pelaudeix, C., Rodon, T., 2014. The European Union Arctic Policy and National Interests of France and Germany: Internal and External Policy Coherence at Stake? North. Rev. Fall 2013, 57–85.

Pelly, D.F., 2001. Sacred Hunt. Heritage House Publishing Co Ltd.

Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., Irons, D.B., 2003. Long-term ecosystem response to the Exxon Valdez oil spill. Science 302, 2082–2086.

Petrasek MacDonald, J., Harper, S.L., Cunsolo Willox, A., Edge, V.L., Rigolet Inuit Community Government, 2013. A necessary voice: Climate change and lived experiences of youth in Rigolet, Nunatsiavut, Canada. Glob. Environ. Change 23, 360–371. doi:10.1016/j.gloenvcha.2012.07.010

Pettersen, T., 2014. Snow crabs have found niche in Barents Sea ecosystem. Barents Obs.

Pettersen, T., 2012. 46 vessels through Northern Sea Route. Barents Obs.

Pettersen, T., 2011. Russia to have ten Arctic rescue centers by 2015. Barents Obs.

Pfaffenbach, C., 2011. Methoden qualitativer Feldforschung in der Geographie, in: Gebhardt, H., Glaser, R., Radtke, U., Reuber, P., Meyer, S. (Eds.), Geographie. Physische Geographie und Humangeographie. Spektrum, Akad. Verl., Heidelberg, pp. 157–165.

Pharo, E.J., Vitt, D.H., 2000. Local variation in bryophyte and macro-lichen cover and diversity in montane forests of western Canada. The Bryologist 103, 455–466.

Pickering, C., Byrne, J., 2014. The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. High. Educ. Res. Dev. 33, 534–548. doi:10.1080/07294360.2013.841651

Pitulko, V.V., Nikolsky, P.A., Girya, E.Y., Basilyan, A.E., Tumskoy, V.E., Koulakov, S.A., Astakhov, S.N., Pavlova, E.Y., Anisimov, M.A., 2004. The Yana RHS Site: Humans in the Arctic Before the Last Glacial Maximum. Science 303, 52–56. doi:10.1126/science.1085219

Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Policy 33, 118–129.

Plummer, M.L., Harvey, C.J., Anderson, L.E., Guerry, A.D., Ruckelshaus, M.H., 2013. The Role of Eelgrass in Marine Community Interactions and Ecosystem Services: Results from Ecosystem-Scale Food Web Models. Ecosystems 16, 237–251. doi:10.1007/s10021-012-9609-0

Poland, J.S., Riddle, M.J., Zeeb, B.A., 2003. Contaminants in the Arctic and the Antarctic: a comparison of sources, impacts, and remediation options. Polar Rec. 39, 369–383. doi:10.1017/S0032247403002985

Prowse, T.D., Furgal, C., Chouinard, R., Melling, H., Milburn, D., Smith, S.L., 2009. Implications of Climate Change for Economic Development in Northern Canada: Energy, Resource, and Transportation Sectors. Ambio 38, 272–281.

Pulsifer, P.L., Huntington, H.P., Pecl, G.T., 2014. Introduction: local and traditional knowledge and data management in the Arctic. Polar Geogr. 37, 1–4. doi:10.1080/1088937X.2014.894591

Purushothaman, S., Thomas, B., Abraham, R., Dhar, U., 2013. Beyond money metrics: Alternative approaches to conceptualising and assessing ecosystem services. Conserv. Soc. 11, 321. doi:10.4103/0972-4923.125739

Putkonen, J., Roe, G., 2003. Rain-on-snow events impact soil temperatures and affect ungulate survival. Geophys. Res. Lett. 30.

Qvenild, M., 2008. Svalbard Global Seed Vault: a "Noah"s Ark' for the world's seeds. Dev. Pract. 18, 110–116. doi:10.1080/09614520701778934

Raghavan, M., DeGiorgio, M., Albrechtsen, A., Moltke, I., Skoglund, P., Korneliussen, T.S., Gronnow, B., Appelt, M., Gullov, H.C., Friesen, T.M., Fitzhugh, W., Malmstrom, H., Rasmussen, S., Olsen, J., Melchior, L., Fuller, B.T., Fahrni, S.M., Stafford, T., Grimes, V., Renouf, M.A.P., Cybulski, J., Lynnerup, N., Lahr, M.M., Britton, K., Knecht, R., Arneborg, J., Metspalu, M., Cornejo, O.E., Malaspinas, A.-S., Wang, Y., Rasmussen, M., Raghavan, V., Hansen, T.V.O., Khusnutdinova, E., Pierre, T., Dneprovsky, K., Andreasen, C., Lange, H., Hayes, M.G., Coltrain, J., Spitsyn, V.A., Gotherstrom, A., Orlando, L., Kivisild, T., Villems, R., Crawford, M.H., Nielsen, F.C., Dissing, J., Heinemeier, J., Meldgaard, M., Bustamante, C., O'Rourke, D.H., Jakobsson, M., Gilbert, M.T.P., Nielsen, R., Willerslev, E., 2014. The genetic prehistory of the New World Arctic. Science 345, 1255832–1255832. doi:10.1126/science.1255832

Rammert, W., Schulz-Schaeffer, I., 2002a. Vorwort der Herausgeber, in: Rammert, W., Schulz-

Schaeffer, I. (Eds.), Können Maschinen Handeln? Soziologische Beiträge Zum Verhältnis von Mensch Und Technik. Campus Verlag, Frankfurt am Main, pp. 7 – 10.

Rammert, W., Schulz-Schaeffer, I., 2002b. Technik und Handeln. Wenn soziales Handeln sich auf menschliches Verlalten und technische Abläufe verteilt, in: Rammert, W., Schulz-Schaeffer, I. (Eds.), Können Maschinen Handeln? Soziologische Beiträge Zum Verhältnis von Mensch Und Technik. Campus Verlag, Frankfurt am Main, pp. 11 – 64.

Rees, W.G., Stammler, F.M., Danks, F.S., Vitebsky, P., 2008. Vulnerability of European reindeer husbandry to global change. Clim. Change 87, 199–217. doi:10.1007/s10584-007-9345-1

Regulation (EC) No. 1007/2009 of the European Parliament and of the Council of 16 September 2009 on trade in seal products, 2009. . Off. J. Eur. Union L 286/36.

Rennert, K.J., Roe, G., Putkonen, J., Bitz, C.M., 2009. Soil Thermal and Ecological Impacts of Rain on Snow Events in the Circumpolar Arctic. J. Clim. 22, 2302–2315. doi:10.1175/2008JCLI2117.1

Reuber, P., 2000. Conflict studies and critical geopolitics — theoretical concepts and recent research in political geography. GeoJournal 50, 37–43. doi:10.1023/A:1007155730730

Reuber, P., Gebhardt, H., 2011. Kapitel 5: Wissenschaftliches Arbeiten in der Geographie. Einführende Gedanken., in: Gebhardt, H., Glaser, R., Radtke, U., Reuber, P., Meyer, S. (Eds.), Geographie. Physische Geographie und Humangeographie. Spektrum, Akad. Verl., Heidelberg, pp. 88–101.

Reuber, P., Wolkersdorfer, G., 2004. Geopolitische Weltbilder als diskursive Konstruktionen — Konzeptionelle Anmerkungen und Beispiele zur Verbindung von Macht, Politik und Raum, in: Gebhardt, H., Kiesel, H. (Eds.), Weltbilder. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 367–387.

Reuters, 2013. Northern Sea Route Slated for Massive Growth. Mosc. Times.

Riedlinger, D., Berkes, F., 2001. Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. Polar Rec. 37, 315. doi:10.1017/S0032247400017058

Riseth, J.Å., Tømmervik, H., Helander-Renvall, E., Labba, N., Johansson, C., Malnes, E., Bjerke, J.W., Jonsson, C., Pohjola, V., Sarri, L.-E., Schanche, A., Callaghan, T.V., 2011. Sámi traditional ecological knowledge as a guide to science: snow, ice and reindeer pasture facing climate change. Polar Rec. 47, 202–217. doi:10.1017/S0032247410000434

Rosbakh, S., Poschlod, P., 2014. Initial temperature of seed germination as related to species occurrence along a temperature gradient. Funct. Ecol.

Rosenzweig, C., Parry, M.L., 1994. Potential impact of climate change on world food supply. Nature 367, 133–138.

Rotmans, J., Kemp, R., van Asselt, M., 2001. More evolution than revolution: transition management in public policy. foresight 3, 15–31. doi:10.1108/14636680110803003

Rottem, S.V., 2014. The Arctic Council and the Search and Rescue Agreement: the case of Norway. Polar Rec. 50, 284–292. doi:10.1017/S0032247413000363

Ruddiman, W.F., 2005. Plows, plagues, and petroleum: how humans took control of climate. Princeton University Press, Princeton, NJ.

Russill, C., Nyssa, Z., 2009. The tipping point trend in climate change communication. Glob. Environ. Change 19, 336–344. doi:10.1016/j.gloenvcha.2009.04.001

Ryd, Y., Rassa, J., 2007. Snö: renskötaren Johan Rassa berättar.

Sachs, M.M., 2009. Cereal Germplasm Resources. Plant Physiol. 149, 148–151. doi:10.1104/pp.108.129205

Samson, C., Pretty, J., 2006. Environmental and health benefits of hunting lifestyles and diets for the Innu of Labrador. Food Policy 31, 528–553. doi:10.1016/j.foodpol.2006.02.001

Sandström, U.G., 2002. Green Infrastructure Planning in Urban Sweden. Plan. Pract. Res. 17, 373–385. doi:10.1080/02697450216356

Sarker, S., Sarker, S., Sidorova, A., 2006. Understanding business process change failure: An actor-network perspective. J. Manag. Inf. Syst. 23, 51–86.

Savage, M., 2005. Globalization and belonging, Theory, culture & society. SAGE, London ; Thousand Oaks, Calif.

Schickhoff, U., 2012. Wie reagiert die Vegetation in der Arktis auf den Klimawandel? Geogr. Rundsch. 64, 52–57.

Schmidhuber, J., Tubiello, F.N., 2007. Global food security under climate change. Proc. Natl. Acad. Sci. 104, 19703–19708.

Schøyen, H., Bråthen, S., 2011. The Northern Sea Route versus the Suez Canal: cases from bulk shipping. J. Transp. Geogr. 19, 977–983. doi:10.1016/j.jtrangeo.2011.03.003

Schulz-Schaeffer, I., 2000. Akteur-Netzwerk-Theorie. Zur Koevolution von Gesellschaft, Natur und Technik, in: Weyer, J. (Ed.), Soziale Netzwerke. Konzepte Und Methoden Der Sozialwissenschaftlichen NEtzwerkforschung. Oldenbourg Wissenschaftsverlag, München, pp. 187 – 210.

Schuur, E.A.G., Abbott, B., 2011. Climate change: High risk of permafrost thaw. Nature 480, 32–

33. doi:10.1038/480032a

Schwarz, F., 2009. Stadt und Land. Ein Vergleich aus ökologischer Sicht, in: Bundesministerium für Land- und Forstwirtschaft (Ed.), Stadt und Land: zwei Lebenswelten und ihre Bewohner. Böhlau Verlag Wien, Wien, Köln, Weimar.

Scrutton, A., 2013. FEATURE-Tomatoes, peppers, strawberries in Greenland's Arctic valleys. Reuters.

Seidler, C., 2008. Saatguttresor in Permafrost: Arktisberg zu warm für Pflanzen-Arche-Noah. Spieg. Online.

Sellheim, N., 2012. The Establishment of the Permanent Arctic Council Secretariat: Challenges and Opportunities, in: Axworthy, T.S., Koivurova, T., Hasanat, W. (Eds.), The Arctic Council: Its Place in the Future of Arctic Governance. Presented at the The Arctic Council: its Place in the Future of Arctic Governance.

Sheehan, R., 2010. "I"m protective of this yard': long-term homeless persons' construction of home place and workplace in a historical public space. Soc. Cult. Geogr. 11, 539–558. doi:10.1080/14649365.2010.497912

Sieferle, R.P., 2001. The subterranean forest: energy systems and the industrial revolution. The White Horse Press, Cambridge.

Simonsen, K., 2007. Practice, Spatiality and Embodied Emotions: An Outline of a Geography of Practice. Hum. Aff. 17. doi:10.2478/v10023-007-0015-8

Simpson, L., 2001. Aboriginal peoples and knowledge: Decolonizing our processes. Can. J. Native Stud. 21, 137–148.

Slobodin, S., 1999. Northeast Asia in the late Pleistocene and early Holocene. World Archaeol. 30, 484–502.

Smith, Bentley-Condit, V., 2010. Animal tool use: current definitions and an updated comprehensive catalog. Behaviour 147, 185–32A. doi:10.1163/000579509X12512865686555

Smith, L.T., 1999. Decolonizing methodologies: research and indigenous peoples. Zed Books ; University of Otago Press ; Distributed in the USA exclusively by St. Martin's Press, London ; New York : Dunedin, N.Z. : New York.

Smith, V.L., 1996. Indigenous tourism: the four Hs., in: Butler, R., Hinch, T. (Eds.), Tourism and Indigenous Peoples. International Thomson Business Press, Toronto, pp. 283–307.

Solomon, M., 2005. Peer Review Report on WIPO Documents:"The Protection of Traditional

Cultural Expressions/Expression of Folklore: Revised Objectives and Principles (WIPO/GRTKF/IC/8/4)"; and "The Protection of Traditional Knowledge: Revised Objectives and Principles (WIPO/GRTKF/IC/8/5)". Appendix to: WIPO, Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore, Secretariat (2007) The protection of traditional cultural expressions/expression of folklore: table of written comments on revised objectives and principles. Elev. Sess. WIPO Doc WIPOGRTKFIC114 B.

Somerton, D., Goodman, S., Foy, R., Rugolo, L., Slater, L., 2013. Growth per Molt of Snow Crab in the Eastern Bering Sea. North Am. J. Fish. Manag. 33, 140–147. doi:10.1080/02755947.2012.732671

Sørensen, A.T., 2013. From International Governance to Region Building in the Arctic? New Glob. Stud. 7. doi:10.1515/ngs-2013-014

Spence, J., 2013. Strengthening the Arctic Council: Insights From the Architecture Behind Canadian Participation. North. Rev. 37, 37–56.

Staalesen, A., 2014. Territorial expansion on Arctic agenda. Barentsobserver.

Staeger, T., 2014. Arktisches Meereisminimum [WWW Document]. www.tagesschau.de. URL http://wetter.tagesschau.de/wetterthema/2014/09/18/arktisches-meereisminimum.html

St Amant, R., Horton, T.E., 2008. Revisiting the definition of animal tool use. Anim. Behav. 75, 1199–1208. doi:10.1016/j.anbehav.2007.09.028

Star, S.L., 1992. The trojan door: Organizations, work, and the "open black box." Syst. Pract. 5, 395–410. doi:10.1007/BF01059831

State of Alaska, Alaska Departement of Commerce, Community, and Economic Development, Division of Economic Development, 2015. Economic impact of Alaska's Visitor Industry. 2013-14 update.

Statistics Greenland, Vahl, B., Kleemann, N. (Eds.), 2015. Greenland in Figures 2015, 12 th revised edition. ed. Statistics Greenland.

Statistics Iceland, 2015. Overnight stays in hotels and guesthouses 1998-2014 [WWW Document]. Stat. Icel. URL http://px.hagstofa.is/pxen/pxweb/en/Atvinnuvegir/Atvinnuvegir__ferdathjonusta__gisting__1_hotelgistiheimili/SAM01201.px/table/tableViewLayout1/?rxid=ec284a84-abb2-4dc5-b02a-fce7ac6838c6 (accessed 10.30.15).

Statistics Norway, 2015. Hotels and similar establishments. Guest nights, by region, nationality, time and contents [WWW Document]. StatBank Nor. Database. URL https://www.ssb.no/statistikkbanken/selectvarval/saveselections.asp (accessed 10.30.15).

Steiner, D., 2003. Humanökologie. Von hart zu weich. Mit Spurensuche bei und mit Peter Weichhart, in: Meusburger, P., Schwan, T. (Eds.), Humanökologie. Ansätze Zur Überwindung Der Natur-Gesellschaft-Dichotomie. Franz Steiner Verlag, Stuttgart, pp. 45–80.

Steinicke, S., Albrecht, S., 2012. Search and Rescue in the Arctic. Work. Pap. Res. Div. EU Extern. Relat. Stift. Wiss. Polit. SWP.

Stephenson, S.R., Smith, L.C., Agnew, J.A., 2011. Divergent long-term trajectories of human access to the Arctic. Nat. Clim. Change 1, 156–160.

Stevenson, C., 2007. Hans Off: The Struggle for Hans Island and the Potential Ramifications for International Border Dispute Resolution. BC Intl Comp Rev 30, 263–275.

Stewart, E., Dawson, J., Draper, D., 2010. Monitoring patterns of cruise tourism across Arctic Canada, in: Lück, M., Maher, P.T., Stewart, E.J. (Eds.), Cruise Tourism in Polar Regions: Promoting Environmental and Social Sustainability. Earthscan, London, pp. 133–145.

Stewart, E.J., Dawson, J., Howell, S.E.L., Johnston, M.E., Pearce, T., Lemelin, H., 2013. Local-level responses to sea ice change and cruise tourism in Arctic Canada's Northwest Passage. Polar Geogr. 36, 142–162. doi:10.1080/1088937X.2012.705352

Stewart, E.J., Draper, D., 2008. The Sinking of the MS Explorer: Implications for Cruise Tourism in Arctic Canada. Arct. InfoNorth 61, 224–228.

Stewart, E.J., Draper, D., Johnston, M.E., 2005. A Review of Tourism Research in the Polar Regions. Arctic 58, 383–394.

Stewart, E.J., Howell, S.E.L., Draper, D., Yackel, J., Tivy, A., 2007. Sea ice in Canada's Arctic: Implications for cruise tourism. Arctic 60, 370–380.

Stoll, P.-T., von Hahn, A., 2008. Indigenous peoples, indigenous knowledge and indigenous resources in international law, in: von Lewinski, S. (Ed.), Indigenous Heritage and Intellectual Property: Genetic Resources, Traditional Knowledge, and Folklore. Kluwer Law International, The Netherlands, pp. 7– 59.

Suez Canal Authority, 2014. Yearly Number & Net Tone by Ship Type, Direction & Ship Status (2013) [WWW Document]. URL http://www.suezcanal.gov.eg/TRstat.aspx?reportId=3

Sundet, J., 2014. The red king crab (Paralithodes camschaticus) in the Barents Sea, in: Marine Invasive Species in the Arctic. Nordic Council of Ministers.

Swaminathan, M.S., Kesavan, P.C., 2012. Agricultural Research in an Era of Climate Change. Agric. Res. 1, 3–11. doi:10.1007/s40003-011-0009-z

Syroechkovski, E.E., 2000. Wild and semi-domesticated reindeer in Russia: status, population dynamics and trends under the present social and economic conditions. Rangifer 20, 113–126.

Tagesschau, 2014. Rekord-Eisschmelze in der Arktis [WWW Document]. tagesschau.de. URL https://www.tagesschau.de/ausland/meldung494420.html (accessed 10.21.14).

Takei, Y., 2013. Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic: an assessment. Aegean Rev. Law Sea Marit. Law 2, 81–109. doi:10.1007/s12180-013-0026-9

Tatnall, A., Lepa, J., 2003. The Internet, e-commerce and older people: an actor-network approach to researching reasons for adoption and use. Logist. Inf. Manag. 16, 56–63.

Taubman, A., Leistner, M., 2008. Analysis of different areas of indigenous resources. Section 1: Traditional knowledge, in: von Lewinski, S. (Ed.), Indigenous Heritage and Intellectual Property: Genetic Resources, Traditional Knowledge, and Folklore. Kluwer Law International, The Netherlands, pp. 60 – 91.

Tengberg, A., Fredholm, S., Eliasson, I., Knez, I., Saltzman, K., Wetterberg, O., 2012. Cultural ecosystem services provided by landscapes: Assessment of heritage values and identity. Ecosyst. Serv. 2, 14–26. doi:10.1016/j.ecoser.2012.07.006

Tester, F.J., Irniq, P., 2008. Inuit Qaujimajatuqangit: Social History, Politics and the Practice of Resistance. Arctic 61, 48–61.

The European Cultivated Potato Database [WWW Document], 2014. URL http://www.europotato.org/display_description.php?variety_name=SOLIST

The Swedish Agency for Economic and Regional Growth, Statistics Sweden, 2015. Norbotten - Number of nights by region, country of residence and year [WWW Document]. Stat. Swed. URL http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START__NV__NV1701__NV1701A/NV1701T910Ar/table/tableViewLayout1/?rxid=47d82dd6-d8ae-4413-82b4-41e7da01160c (accessed 10.30.15).

The World Bank (Ed.), 2005. World Bank Operational Directive 4.10 - Indigenous peoples.

Thien, D., 2005. After or beyond feeling? A consideration of affect and emotion in geography. Area 37, 450–454.

Thornton, A., Samson, J., 2012. Innovative problem solving in wild meerkats. Anim. Behav. 83, 1459–1468. doi:10.1016/j.anbehav.2012.03.018

Thostrup, L., Rasmussen, R.O. (Eds.), 2009. Climate Change and the North Atlantic. NORA, Tórshavn.

Thrift, N., 2002. The future of geography. Geoforum 33, 291–298.

Tomita, M., Aoki, S., 2014. Visual Discrimination Learning in the Small Octopus *Octopus ocellatus*. Ethology 120, 863–872. doi:10.1111/eth.12258

Tondu, J.M.E., Balasubramaniam, A.M., Chavarie, L., Gantner, N., Knopp, J.A., Provencher, J.F., Wong, P.B.Y., Simmons, D., 2014. Working with Northern Communities to Build Collaborative Research Partnerships: Perspectives from Early Career Researchers. ARCTIC 67, 419 – 429.

Torkington, K., 2012. Place and Lifestyle Migration: The Discursive Construction of "Glocal" Place-Identity. Mobilities 7, 71–92. doi:10.1080/17450101.2012.631812

Turing, A.M., 1950. Computing machinery and intelligence. Mind 433–460.

Tyler, N.J.C., 2010. Climate, snow, ice, crashes, and declines in populations of reindeer and caribou (Rangifer tarandus L.). Ecol. Monogr. 80, 197–219.

Tyler, N.J.C., Turi, J.M., Sundset, M.A., Strøm Bull, K., Sara, M.N., Reinert, E., Oskal, N., Nellemann, C., McCarthy, J.J., Mathiesen, S.D., others, 2007. Saami reindeer pastoralism under climate change: applying a generalized framework for vulnerability studies to a sub-Arctic social–ecological system. Glob. Environ. Change 17, 191–206.

Tyler, N.J., Forchhammer, M.C., Øritsland, N.A., 2008. Nonlinear effects of climate and density in the dynamics of a fluctuating population of reindeer. Ecology 89, 1675–1686.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., James, P., 2007. Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landsc. Urban Plan. 81, 167–178. doi:10.1016/j.landurbplan.2007.02.001

United Nations, 1994. United Nations Convention of the Law of the Sea (UNCLOS).

United Nations Convention on the Law of the Sea, Commission on the Limits of the Continental Shelf (Eds.), 2013. Progress of work in the Commission on the Limits of the Continental Shelf. Statement by the Cair.

United Nations Environment Programme, International Ecotourism Society, 2007. Tourism in the Polar regions: the sustainability challenge. UNEP DTIE ; International Ecotourism Society, Paris, France; Washington, D.C.

USGS Cicrum-Arctic Resource Appraisal Assessment Team, 2008. Circum-Arctic resource appraisal: Estimates of undiscovered oil and gas north of the Arctic Circle. US Department of the Interior, US Geological Survey.

Usher, P.J., 2000. Traditional ecological knowledge in environmental assessment and management. Arctic 53, 183–193.

van Berkel, D.B., Verburg, P.H., 2014. Spatial quantification and valuation of cultural ecosystem services in an agricultural landscape. Ecol. Indic. 37, 163–174. doi:10.1016/j.ecolind.2012.06.025

van der Voet, E., 2011. Metabolic Side Effects of Transitions: An Industrial-Ecology-Based Exploration. J. Ind. Ecol. 15, 646–648. doi:10.1111/j.1530-9290.2011.00387.x

Van Kamp, I., Leidelmeijer, K., Marsman, G., De Hollander, A., 2003. Urban environmental quality and human well-being: Towards a conceptual framework and demarcation of concepts; a literature study. Landsc. Urban Plan. 65, 5–18.

Van Lawick-Goodall, J., 1970. Tool-using in primates and other vertebrates, in: Lehrman, D.S., Hinde, R.A., Shaw, E. (Eds.), Advances in the Study of Behavior. Academic Press, New York, NY, pp. 195–249.

Vasil'ev, S.A., Kuzmin, Y.V., Orlova, L.A., Dementiev, V.N., 2002. Radiocarbon-based chronology of the Paleolithic of Siberia and its relevance to the peopling of the New World. Radiocarbon 44, 503–530.

Velicogna, I., Sutterley, T.C., Broeke, M.R., 2014. Regional acceleration in ice mass loss from Greenland and Antarctica using GRACE time-variable gravity data. Geophys. Res. Lett.

Vernadsky, W.I., 1945. The biosphere and the noösphere. Am. Sci. xxii–12.

Verny, J., Grigentin, C., 2009. Container shipping on the Northern Sea Route. Int. J. Prod. Econ. 122, 107–117. doi:10.1016/j.ijpe.2009.03.018

Vidya, T.N.C., 2014. Novel behaviour shown by an Asian elephant in the context of allomothering. Acta Ethologica 17, 123–127. doi:10.1007/s10211-013-0168-y

Vitebsky, P., Alekseyev, A., 2014. What is a reindeer? Indigenous perspectives from northeast Siberia. Polar Rec. 1–9. doi:10.1017/S0032247414000333

Vladimirova, V.K., 2011. "We are Reindeer People, We Come from Reindeer." Reindeer Herding in Representations of the Sami in Russia. Acta Boreal. 28, 89–113. doi:10.1080/08003831.2011.575661

Vokuev, A., 2013. Russia opens first Arctic search and rescue center. Barents Obs.

von Hahn, A., 2004. Traditionelles Wissen indigener und lokaler Gemeinschaften zwischen geistigen Eigentumsrechten und der public domain = Traditional knowledge of indigenous and local communities between intellectual property rights and the public domain, Beiträge zum ausländischen öffentlichen Recht und Völkerrecht. Springer, Berlin ; New York.

von Heland, J., Folke, C., 2014. A social contract with the ancestors—Culture and ecosystem services in southern Madagascar. Glob. Environ. Change 24, 251–264. doi:10.1016/j.gloenvcha.2013.11.003

Vors, L.S., Boyce, M.S., 2009. Global declines of caribou and reindeer: Caribou Reindeer Decline. Glob. Change Biol. 15, 2626–2633. doi:10.1111/j.1365-2486.2009.01974.x

Vuojala-Magga, T., Turunen, M., Ryyppo, T., Tennberg, M., 2011. Resonance strategies of Sámi reindeer herders in northernmost Finland during climatically extreme years. Arctic 227–241.

Vuojala-Magga, T., Turunen, M., Tennberg, M., 2010. Practical skills and tacit knowledge of Sámi reindeer herders in the context of extreme weather events. Extended Abstract. Presented at the Fifth Symposium on Policy and Socio-economic Research. Second AMS Conference on International Cooperation in the Earth System Sciences and Services, Atlanta, Geogrgia, United States of America.

Walck, J., Dixon, K., 2009. Time to future-proof plants in storage. Nature 462, 721–721.

Walker, G., 2006. Climate change: The tipping point of the iceberg. Nature 441, 802–805. doi:10.1038/441802a

Wallace, J.M., Gutzler, D.S., 1981. Teleconnections in the geopotential height field during the Northern Hemisphere winter. Mon. Weather Rev. 109, 784–812.

Ware, C., Berge, J., Sundet, J.H., Kirkpatrick, J.B., Coutts, A.D.M., Jelmert, A., Olsen, S.M., Floerl, O., Wisz, M.S., Alsos, I.G., 2014. Climate change, non-indigenous species and shipping: assessing the risk of species introduction to a high-Arctic archipelago. Divers. Distrib. 20, 10–19. doi:10.1111/ddi.12117

Watt, S., 2008. Can People Think? Or Machines? A Unified Protocol for Turing Testing, in: Epstein, R., Roberts, G., Beber, G. (Eds.), Parsing the Turing Test: Philosophical and Methodological Issues in the Quest for the Thinking Computer. Springer, New York, pp. 301–318.

Weatherhead, E., Gearheard, S., Barry, R.G., 2010. Changes in weather persistence: Insight from Inuit knowledge. Glob. Environ. Change 20, 523–528. doi:10.1016/j.gloenvcha.2010.02.002

Webb, J., Anthony, S.G., Brown, L., Lyons-Visser, H., Ross, C., Cottrill, B., Johnson, P., Scholefield, D., 2005. The impact of increasing the length of the cattle grazing season on emissions of ammonia and nitrous oxide and on nitrate leaching in England and Wales. Agric. Ecosyst. Environ. 105, 307–321.

Weichhart, P., 2009a. Humangeographie–quo vadis. Mensch Raum Umw. Entwicklungen Perspekt. Geogr. Österr. Wien 63–77.

Weichhart, P., 2009b. Ökologische Doktrin und Innovationen von Arbeitsprozessen als Medien der Kopplung von gesellschaftlichen und naturalen Systemen. Salzburger Geogr. Arb. 45, 93 – 105.

Weichhart, P., 2008a. Der Mythos vom "Brückenfach." Geogr. Rev. 10, 59–69.

Weichhart, P., 2008b. Entwicklungslinien der Sozialgeographie: von Hans Bobek bis Benno Werlen. Steiner, Stuttgart.

Weichhart, P., 2005. Auf der Suche nach der „dritten Säule ". Gibt es Wege von der Rhetorik zur Pragmatik, in: Müller-Mahn, D., Wardenga, U. (Eds.), Möglichkeiten Und Grenzen Integrativer Forschungsansätze in Physischer Geographie Und Humangeographie. Forum Ifl. pp. 109–136.

Weichhart, P., 2003. Physische Geographie und Humangeographie–eine schwierige Beziehung: Skeptische Anmerkungen zu einer Grundfrage der Geographie und zum Münchner Projekt einer „Integrativen Umweltwissenschaft ". Integr. Ansätze Geogr. Oder Trugbild 17–34.

Weichhart, P., 2001. Humangeographische Forschungsansätze. Beitr. Zur Didakt. „Geographie Wirtsch. "-Unterr. 182–198.

Weichhart, P., 1989. Die Rezeption des humanökologischen Paradigmas, in: Glaeser, B. (Ed.), Humanökologie. VS Verlag für Sozialwissenschaften, Wiesbaden, pp. 46–56.

Weiß, J., 2002. Technik handeln lassen?, in: Rammert, W., Schulz-Schaeffer, I. (Eds.), Können Maschinen Handeln? Soziologische Beiträge Zum Verhältnis von Mensch Und Technik. Campus Verlag, Frankfurt am Main, pp. 65 – 78.

Weisz, H., Fischer-Kowalski, M., Grünbühel, C.M., Haberl, H., Krausmann, F., Winiwarter, V., 2001. Global environmental change and historical transitions. Innovation 14, 117 – 142.

Weizsäcker, C.F. von, 1951. Kontinuität und Möglichkeit. Naturwissenschaften 38, 533–543.

Weladji, R.B., Holand, Ø., 2003. Global climate change and reindeer: effects of winter weather on the autumn weight and growth of calves. Oecologia 136, 317–323. doi:10.1007/s00442-003-1257-9

Wenzel, G., 2008. Sometimes hunting can seem like business: polar bear sport hunting in Nunavut, Occasional publication. Canadian Circumpolar Institute (CCI) Press, University of Alberta,

Edmonton.
Wenzel, G., 2005. Nunavut Inuit and polar bear: The cultural politics of the hunt, in: Kishigami, N., Savelle, J. (Eds.), Indigenous Use and Manadement of Marine Resources, Senri Ethnological Series. National Museum of Ethnology, Osaka, pp. 363–388.
Wenzel, G., 2004. From TEK to IQ: Inuit Qaujimajatuqangit and Inuit cultural ecology. Arct. Anthropol. 41, 238–250.
Wenzel, G., 2000. Animal rights, human rights ecology, economy and ideology in the Canadian Arctic. University of Toronto Press, Toronto, Ont.; Buffalo, N.Y.
Wenzel, G., 1999. Traditional Ecological Knowledge and Inuit: Reflections on TEK Research and Ethics. ARCTIC 52, 113 – 124. doi:10.14430/arctic916
Wenzel, G., 1996. Inuit sealing and subsistence managing after the EU sealskin ban. Geogr. Z. 130–142.
Wenzel, G., 1987. " I Was Once Independent": The Southern Seal Protest and Inuit. Anthropologica 195–210.
Werlen, B., 2011. Kritischer Rationalismus, in: Gebhardt, H., Glaser, R., Radtke, U., Reuber, P., Meyer, S. (Eds.), Geographie. Physische Geographie und Humangeographie. Spektrum, Akad. Verl., Heidelberg, p. 95.
Werlen, B., 2010. Gesellschaftliche Räumlichkeit 1. Orte der Geographie. Steiner, Stuttgart.
Werlen, B., 2000. Sozialgeographie: eine Einführung, 3. Auflage. ed. Haupt, Bern [u.a.].
Werlen, B., 1999. Handlungszentrierte Sozialgeographie. Replik auf die Kritiken, in: Meusburger, P. (Ed.), Handlungsorientierte Sozialgeographie: Benno Werlens Entwurf in Kritischer Diskussion, Stuttgart. pp. 247–268.
Werlen, B., 1997. Gesellschaft, Handlung und Raum: Grundlagen handlungstheoretischer Sozialgeographie, 3. Auflage. ed. Steiner, Stuttgart.
Werlen, B., Weingarten, M., 2003. Zum forschungsintegrativen Gehalt der (Sozial)Geographie. Ein Diskussionsvorschlag, in: Meusburger, P., Schwan, T. (Eds.), Humanökologie. Ansätze Zur Überwindung Der Natur-Gesellschaft-Dichotomie. Franz Steiner Verlag, Stuttgart, pp. 197 – 216.
Westengen, O.T., Jeppson, S., Guarino, L., 2013. Global Ex-Situ Crop Diversity Conservation and the Svalbard Global Seed Vault: Assessing the Current Status. PLoS ONE 8, e64146. doi:10.1371/journal.pone.0064146
Weyer, J., 2008. Techniksoziologie: Genese, Gestaltung und Steuerung sozio-technischer Systeme.

Juventa, Weinheim.
Weyer, J., 2006. Die Kooperation menschlicher Akteure und nicht-menschlicher Agenten.
Weyer, J., 1997a. Konturen einer netzwerktheoretischen Techniksoziologie, in: Weyer, J., Kirchner, U., Riedl, L., Schmidt, J.F.K. (Eds.), Technik, Die Gesellschaft Schafft. Soziale Netzwerke Als Ort Der Technikgenese. Edition Sigma Rainer Bohn Verlag, Berlin, pp. 23 – 52.
Weyer, J., 1997b. Weder Ordnung noch Chaos. Die Theorie sozialer Netzwerke zwischen Institutionalismus und Selbstorganisationstheorie, in: Weyer, J., Kirchner, U., Riedl, L., Schmidt, J.F.K. (Eds.), Technik, Die Gesellschaft Schafft. Soziale Netzwerke Als Ort Der Technikgenese. Edition Sigma Rainer Bohn Verlag, Berlin, pp. 53 – 100.
Wharton, C.R., 1970. Subsistence Agriculture: Concepts and Scope, in: Wharton, C.R. (Ed.), Subsistence Agriculture and Economic Development. Transaction Publishers, New Brunswick, pp. 12 – 22.
White, G., 2006. Cultures in Collision: Traditional Knowledge and Euro-Canadian Governance Processes in Northern Land-Claim Boards. Arctic 59, 401 – 414.
Williams, T., Hardison, P., 2013. Culture, law, risk and governance: contexts of traditional knowledge in climate change adaptation. Clim. Change 120, 531–544. doi:10.1007/s10584-013-0850-0
Winkelmann, I., 2009a. Arktische Ressourcen nutzen und arktische Umwelt schützen: Quadratur des Kreises? Jahrb. Ökol. Httpwww Jahrb.-Oekologie DeWinkelmann2009 Pdf Stand 3011 2010.
Winkelmann, I., 2009b. Klimawandel und Sicherheit in der arktischen Region. Diskuss. Forschungsgruppe Glob. Frag. Stift. Wiss. Polit. SWP.
Winkelmann, I., 2008. „Feste Spielregeln für die Aufteilung des Arktischen Ozeans “. Stift. Wiss. Polit. SWP-Aktuell 53.
Winkelmann, I., 2007. Wem gehört die Arktis. Stift. Wiss. Polit. Berl. Novemb. 1–8.
Winner, L., 1993. Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology. Sci. Technol. Hum. Values 18, 362–378. doi:10.1177/016224399301800306
Wissink, B., 2013. Enclave urbanism in Mumbai: An Actor-Network-Theory analysis of urban (dis)connection. Geoforum 47, 1–11. doi:10.1016/j.geoforum.2013.02.009
Wittig, R., Diesing, D., Gödde, M., 1985. Urbanophob-Urbanoneutral-Urbanophil. Das Verhalten der Arten gegenüber dem Labensraum Stadt. Flora 177, 265–282.

Wolfe, R.J., Walker, R.J., 1987. Subsistence economies in Alaska: Productivity, geography, and development impacts. Arct. Anthropol. 56–81.

Wolkersdorfer, G., 2008. Zur Geschichte der Geopolitik in Deutschland, in: Gebhardt, H., Meusberger, P., Wastl-Walter, D. (Eds.), Humangeographie. Springer/Spektrum Akad. Verl, Heidelberg, pp. 578–579.

World Tourism Oranization, 1991. Resolutions of International Conference on Travel and Tourism, Ottawa, Canada. World Tourism Organization, Madrid.

Young, O.R., 2011a. If an Arctic Ocean treaty is not the solution, what is the alternative? Polar Rec. 47, 327–334. doi:10.1017/S0032247410000677

Young, O.R., 2011b. The future of the Arctic: cauldron of conflict or zone of peace? Int. Aff. 87, 185–193. doi:10.1111/j.1468-2346.2011.00967.x

Young, O.R., 2009a. The Arctic in Play: Governance in a Time of Rapid Change. Int. J. Mar. Coast. Law 24, 423–442. doi:10.1163/157180809X421833

Young, O.R., 2009b. Whither the Arctic? Conflict or cooperation in the circumpolar north. Polar Rec. 45, 73. doi:10.1017/S0032247408007791

Young, O.R., 2000. The structure of Arctic cooperation: Solving problems/seizing opportunities, in: A Paper Prepared at the Request of Finland in Preparation for the Fourth Conference of Parliamentarians of the Arctic Region, Rovaniemi. pp. 27–29.

Yu, Q., Epstein, H.E., Walker, D.A., Frost, G.V., Forbes, B.C., 2011. Modeling dynamics of tundra plant communities on the Yamal Peninsula, Russia, in response to climate change and grazing pressure. Environ. Res. Lett. 6, 045505. doi:10.1088/1748-9326/6/4/045505

Zierhofer, W., 1999. Die fatale Verwechslung. Zum Selbstverständnis der Geographie, in: Meusburger, P. (Ed.), Handlungsorientierte Sozialgeographie: Benno Werlens Entwurf in Kritischer Diskussion, Stuttgart. Franz Steiner Verlag, Stuttgart, pp. 163–186.

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